

Goulburn Broken Catchment **Willow Management Strategy**



2004

ACKNOWLEDGEMENTS

The Authority wishes to acknowledge the contribution to this document by Judy Frankenberg, of R & J Frankenberg Ecologists

This strategy has been built on a wide range of previous documents, including strategies, discussion papers and general articles. In particular, material has been drawn from the very comprehensive 'Willows along Victorian Waterways' (Ladsen 1992) and the national publication, 'Weeds of National Significance - Willow Strategic Plan'. A number of papers by Kurt Cremer have also been an important source of information. These sources have not been acknowledged in detail through the text but are listed in the references.

The staff of the GBCMA has contributed their expertise and experience. Particular thanks are due to Wayne Tennant and Gordon O'Brien for their strategic input and support, and Rebecca Nichol, Tom O'Dwyer, Dustin Lavery, Keith Yates and Geoff Brennan for giving their time and experience and for guided tours to highlight the issues. In addition the following are acknowledged for their input to the content of this strategy: - Nick Roberts, Geoff Lodge, Kurt Cremer and Alex Sislov.

Photographs contained within this report have been submitted by Rebecca Nicoll, Joanne Gaudion, Christine Glassford, Janette Currie & Gordon O'Brien.

REGIONAL CONTEXT

From the irrigated Goulburn and Murray Valleys to the dryland grazing and cropping regions and the alpine high country valued for its tourism and recreational uses, the Goulburn Broken catchment is a major component of the Victorian and Murray Darling Basin water resources and contributes substantially to the economic wealth of the State and the Nation. Although only 2% of the Murray Darling Basin's land area, the catchment generates 11% of the basin's water resources. In addition the catchment generates 26% of the rural export earnings for the State of Victoria. Downstream users including the environment, rely heavily on the water exported from the catchment.

Streams within the region are highly rated for a range of values related to irrigation, industry, potable water supply, stock and domestic water supply, recreation (both passive and active), the presence of threatened and vulnerable fish species, aesthetic beauty and biodiversity. Stream health in the region is of vital importance to these values, not only for the local region but also for communities over 500km downstream. (See Figure 1.1)



Figure 1.1 – The Goulburn Broken Catchment

The **Goulburn Broken Regional River Health Strategy** has been prepared by the River Health and Water Quality Committee of the Goulburn Broken Catchment Management Authority.

The Strategy builds on existing river-related action plans, implementation plans and strategic documents and is supported by a series of sub-strategies and discussion papers. The Strategy provides a framework for integration of actions which will enable rivers of high quality to be protected and others to be improved in quality for current and future generations.

The Strategy relies on four key objectives:

- Protecting the rivers that are of highest community value from any decline in condition;
- Maintaining the condition of ecologically healthy rivers;
- Achieve an 'overall improvement' in the environmental condition of the remainder of rivers;
- Preventing damage from future management activities.

The Strategy identifies a number of High Priority Waterways within the Goulburn Broken catchment. These include rivers that are "of greatest value to the community", and rivers that are currently "ecologically healthy". It also identifies waterways within the catchment that can potentially be improved to ecologically healthy condition. The Strategy identifies opportunities for restoration or improving the environmental condition of other rivers throughout the catchment, ***including the eradication or management of exotic vegetation in waterways and within the riparian zone.***

Key threats to high value assets in the Goulburn Broken Catchment waterways were identified using a risk analysis. These threats determined the range of management actions to be implemented in various parts of the catchment. Threats to the health of the region's waterway systems include:

Physical Threats	Bed erosion, bank erosion, channel modification, loss of in stream habitat and stock access
Flow Threats	Flow deviation and loss of wetland connectivity
Water Quality Threats	WQ Signal, WQ level, WQ trend, temperature and Algal blooms
Biological Threats	Introduced flora and fauna, barriers to fish migration and degraded riparian vegetation

This ***Willow Management Strategy*** addresses the specific threats to channel form, instream and riparian vegetation diversity and habitat, flow deviation, and water quality in the regions waterways.

State and Regional Strategies

In addition to the Draft Regional River Health Strategy the following strategic studies and guidelines are relevant to the Region and the issue of willow management and control:

- Goulburn Broken Regional Catchment Strategy (2004)
- Draft Goulburn Broken Water Quality Strategy (2003)
- Victorian River Health Strategy (2002)
- Victorian Nutrient Management Strategy (1995)
- Geomorphology of the Goulburn River Basin
- Index of Stream Condition (1999 and 2004)
- Waterway Action Plans for specific waterways throughout the catchment
- Revegetation Guide for the Goulburn-Broken Catchment
- Riparian Vegetation Guidelines for the Upper Goulburn Catchment
- Goulburn Broken Region Weed Action Plan (2001-2005)

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EXECUTIVE SUMMARY

A major aim of the Goulburn-Broken Regional Catchment Strategy is the protection and enhancement of riparian health. River management techniques have advanced to the degree that bank stabilisation with willows is no longer necessary as a tool to be included with River Health and Water Quality programs. In recent years the adverse impacts of willow have been widely recognised. Willows are the most significant weeds of the riparian environment and their management and control is critical to the improvement of riparian health where they occur in the rivers and streams of the Goulburn-Broken Catchment. This document provides a strategic approach to the management of willows in the catchment, which will prevent further spread of willows, and progressively reduce their impact on rivers and streams. It is based on the following principles:

- All works should ***improve stream and riparian health***
- ***Protect the best first***: high quality riparian environment is not easily replaced once lost
- ***Eradicate the highly invasive species*** (eg Black Willow, Grey Sallow) throughout the Goulburn Broken Catchment
- ***Prevent further spread*** of all invasive willow species and progressively remove willows from high priority streams
- ***Manage and control the spread of other species*** where they threaten stream health or other stream related values
- ***Control the importation, propagation, sale and transport*** of willows.
- ***Engage community participation and understanding*** of the works proposed

Key components for effective management of willows include:

- A **sound knowledge base**. An early priority is to develop a data base on species distribution which will enable identification of issues and opportunities for action. Identification of knowledge gaps and a process for continual maintenance of the database is needed.
- A **process of priority setting**. This requires consideration of long term and short term priorities, based on risk to assets, likelihood of increased cost with delay, and achievement of long term goals.
- **Long term strategic programs**. These will achieve a sustainable improvement in riparian and stream health within sub-catchments, by permanent removal of target willows on a reach by reach basis.
- A **capacity for short term response** to highly threatening outbreaks or the emergence of new issues. A portion of the annual budget is needed for urgent action on unforeseen issues as they arise.
- **Monitoring of outcomes** and maintenance of the database. Follow up, monitoring and assessment of earlier work must be included as an important part of the annual program. Documentation of projects and outcomes should be incorporated in the database to allow for improved management skills
- An **adaptive management** approach. Some capacity for experimentation and acceptance of uncertain outcomes should be included in planning of willow management programs.

- An **effective communication** program. Long term management of most riparian land depends on adjacent land use and landholder good will. Successful communication with stakeholders is an important component of any willow management program
- **Strategic resource allocation.** Resources should be allocated between long term programs providing significant improvement in riparian health, and some capacity to respond to immediate issues as they arise. A quick response capacity may prevent the development of a more expensive problem if left untreated.

This Document provides a background discussion on the asset values and liabilities associated with willows and an overview of willow biology relevant to their management. Section 2 discusses current GBCMA policy on willows and the strategic principles which underpin the proposed management program. Section 3 details the eight components of the management Plan, and Section 4 on 'Implementation of Field Works' provides recommended steps in planning a willow removal program, and a discussion of available control methods. The choice of control method in any particular project depends on factors including species present and situation. A range of common scenarios is presented with comment or relevant considerations and prioritisation. A summary of the activities and tasks to be carried out in a Willow Management Action Plan is given in Section 5, together with a preliminary cost estimate and a prioritisation of these activities.

A proposed goal for the Willow Management Strategy is to:

Goal *Manage the willows of the Goulburn-Broken Catchment in a way that will maintain the condition of existing high value riparian environments, while steadily improving those of lesser value, in a strategic way, so that overall stream and riparian health improves and this change is measurable and valued by the community.*

It is recommended that:

the GBCMA adopt the following policy position with regard to willows in the Goulburn Broken Catchment

Policy *The GBCMA will not carry out or support in any way the planting of willows of any species in waterways or riparian zones throughout the Goulburn Broken Catchment. The GBCMA will support within its waterways program any measures which effectively and strategically contribute to the management of the risks to waterway assets arising from the real or prospective presence of willows*

1. Introduction

Willows have been planted on rivers and streams in Victoria since early settlement, but during the 1950s to 1970s they were widely used for 'river improvement' to control erosion of stream banks. During this time, when there was little funding available for river management, willows offered a low cost method of stabilising banks. Early work used the Weeping, Crack and Basket willows, but later in this period the Black Willow was introduced as a more upright species which appeared to be less likely to choke the waterways. At that time, the potential for seedling spread was not understood. A number of other species and hybrids have also become established in the Goulburn-Broken Catchment and willows are now very widespread. In the last 20 years, other techniques of erosion control in rivers have been developed, and the problems caused by extensive willow populations have become evident. The spread of seeding willows is now of major concern in areas where they occur, and the potential for other species to spread by seed is increasing, as additional compatible willow varieties have been introduced.

Willows are now declared 'Weeds of National Significance', under the National Weeds Strategy, with the exemption of *Salix babylonica* (Weeping Willow)¹², *S x reichardtii* (Pussy Willow)¹ and *S x calodendron* (Pussy Willow)¹ and importation of willows is controlled. The Australian Quarantine and Inspection Service (AQIS) currently prohibits the importation of plants or seeds of *Salix bebbiana* and *Salix exigua*, species with perceived high weed potential. Applications to import nursery stock or seeds of all other *Salix* species must be referred to the Animal and Plant Programs Branch for approval (ARMCANZ 2001). At the State and Territory level, some legislative barriers to willow management exist with only a few taxa specifically listed as weeds in two States. Willows are not declared in Victoria, Queensland, Tasmania or Western Australia, but are declared throughout NSW (W4 noxious) and in South Australia. This has effectively stopped planting in these states but landholders are not legally required to remove existing willows

A key component of the Goulburn-Broken Catchment Strategy is riparian health. A major cause of degradation of the riparian environment of rivers and streams in the Goulburn-Broken catchment is the occurrence and spread of willows. This document provides policy and strategic guidance for a planning process and implementation programmes for management of willows. The aim is to improve waterway health by reducing the impact of willows and allowing the rehabilitation of native plant and animal communities on degraded rivers and streams. However willows play a significant role in maintaining the stability of some degraded streams in the catchment and this must be taken into consideration when planning any willow control works.

¹ Where possible, common names will be used in this document for the different willow species. The difficulties of this approach are illustrated by the fact that several different taxa are commonly known as 'Pussy Willow'. The species mentioned in the text are listed in Table 3.1, giving common and Latin names. Latin names will also be used in the text where it is necessary to differentiate species.

1.1 A Brief Outline of Willow Biology

Willows are generally either male or female and most taxa in Australia, until recently, were single sex clones. In the past most reproduction and spread was therefore vegetative, by the rooting and establishment of detached branches and twigs. This is particularly prevalent in the Crack Willow and its hybrids which have brittle twigs, but all species can be propagated or spread vegetatively as a result of flood or other damage. Existing stands therefore become progressively more dense as aging trees collapse and the fallen branches take root and regrow.

There are now several species and varieties in the catchment which include plants of both sexes or which can hybridise with compatible species. As Cremer (1999) points out: 'Willows introduced into Australia have proved to be especially promiscuous. Probably all fertile willows within each sub-genus in Australia will hybridise, provided that their flowering times overlap'. Seeding has therefore become common on many streams. Many imported hybrid combinations have been introduced into Victoria, and new ones have arisen here. There is potential for additional hybrids to occur wherever opposite sexes with over-lapping flowering times occur close together. Willows are mainly pollinated by bees, and pollinating distance has been estimated as 300m (Cremer et al 1995) and possibly more - 'up to one kilometre'. Very large quantities of seed can be produced. Wind dispersal of seed may occur up to several kilometres, depending on wind strength and direction. Any progeny produced from seed will include both sexes so further seed production is then inevitable. Willows are rarely sterile, but sterility is reported to occur in *Salix purpurea* 'Booth', a form of Purple Osier, and *Salix x calodendron*, a tri-hybrid (Cremer (2001), Carr (1996)).

Seedlings require a damp bare seed bed, and are well adapted to colonising the wet margins of streams. Successful establishment depends on seasonal conditions which provide a period of low consistent flows to keep margins exposed but damp during the spring, and no flushing flows which would scour out the seedlings before they are well established. Ideal conditions would only occur every few years, but this is sufficient to enable rapid spread, as seedlings can flower and set seed by age 10yrs. Wild Pussy Willow, and maybe Black Willow, are able to establish in wetlands, and possibly on lake margins. Fortunately seed is very short lived (about 2 weeks) so seedlings can only establish from that year's seed set.

1.2 Asset or Liability?

There is not universal agreement on the need to control willows. While those involved in river management and resource management generally take the view that the advantages of willow use have now been outweighed by the problems they cause, the community is not unanimous on the subject. This may be because the problems are not fully understood, or that they are not seen as problems. It must be acknowledged that some peoples' values do not include aquatic biodiversity, or natural riparian environments. A change in community attitudes, in the face of mounting evidence, can be slow, and allowance needs to be made for this in community consultation. Landholders may have very particular reasons for wanting to maintain willows on their land, and these should be respected, even when it is necessary for willow removal to go ahead.

1.2.1 Advantages of willows

Many species of willows have grown very successfully in the Goulburn-Broken Catchment. They grow vigorously, have few pests and diseases (however are known to host Silverleaf Fungus which can effect stone and pome fruit trees), and many can reproduce and spread rapidly. Willows are easy to propagate and establish and they are usually effective at stabilising stream banks and preventing erosion. They provide a fresh green appearance to the landscape, and some display a golden leaf colour in autumn. In heavily cleared farmland they may be the only source of shade and shelter for stock, and shade and organic inputs for degraded streams. They could be regarded as better than nothing.

Many landholders and community members are accustomed to a landscape containing willows, and it appears quite normal to them. Even those who agree that a diversity of birds and animals is desirable do not always make the connection with *natural* habitat. They may have little experience of high quality natural riparian vegetation. Basic information at this level must still be provided in any communication campaign which may accompany a willow control program. It must also be recognised that managing native riparian vegetation in a farm landscape for biodiversity values is more complex and difficult than managing a willow lined stream.

1.2.2 Disadvantages of willows

Willows have been shown to cause significant problems on rivers and streams, as they have an impact on the riparian and aquatic health of streams, and also on the morphology of the bed and banks. The impacts of willows have been described in a number of publications, (listed in the Source material and reference list at the end of this Document), and are summarised here. Their growth habit and vigour allow them to dominate the riparian zone, reducing or eliminating the native riparian species and changing the associated faunal communities to an impoverished assemblage of species. They change the physical structure of the bank and bed and the energy and nutrient inputs to the stream.

The effects of dominant willows on the stream environment include:

- denser shade in summer
- changes in timing and quantity of leaf fall
- increased breakdown rates of leaf litter
- reduction of large woody debris in stream
- less insect fall into the river
- reduced dissolved oxygen concentrations, particularly after leaf fall
- accumulation of fine silt in the bed
- reduced bank undercut and loss of deep holes
- reduction in channel capacity
- reduction in aquatic biodiversity.
- reduced access to stream for recreation

Impacts on the riparian environment include:

- reduced diversity of vegetation
- exclusion of native understorey by heavy shading
- reduced faunal habitat and food supply for riparian and terrestrial fauna.

Many species of willows have naturalised into the Australian landscape and both seeding and brittle willows can spread downstream and form dense thickets on the banks and in the bed of streams, completely dominating the stream. Loss of channel capacity can cause flooding and avulsion of streams, or erosion as willows growing in the channel force water against the banks.

A specific example is Grey Sallow ('Wild Pussy Willow') which can invade wetlands, and poses a significant threat to wetland habitats, particularly in the upper parts of the catchment. This is already a very serious problem in Gippsland and in New Zealand.

While data is not available to quantify the effect, it is probable that willows use significantly more water than native riparian vegetation, and probably extract it directly from the stream flow, as trees growing on the edge of the bank have roots exposed in the water. This could significantly reduce stream flow, particularly in the summer when leaf area and transpiration rates are highest.

If not managed, willow impacts will increase as willows have not yet reached the full potential distribution in the Goulburn-Broken catchment.



Plate 1 – Seven Creek – Pussy Willow (extensive willow infestation causing stream blockage and impacting on stream health)



Plate 2 - Doolams Creek (Willow Management as part of riparian rehabilitation program)

1.3 Current Occurrence of Willows in the Goulburn-Broken Catchment

While twenty-three willow taxa have been recorded as naturalised in Victoria, possibly only about eleven are known at present in the Goulburn-Broken catchment. It may be that others are present, particularly Weeping Willows other than the true Weeping Willow, *Salix babylonica*. These eleven species have been listed in Table 3.1. Several species are of particular concern because of their reproductive capacity and proven ability to spread. Other taxa have the potential to be invasive but are presently restricted in population size. This may change if suitable reproductive partners become available. It is very important that willows are identified correctly, and the distribution of the important taxa is known.

Willow species causing the most problems are the seeding willows, Grey Sallow (Wild Pussy Willow) and Black Willow, and the brittle willows Crack Willow and Basket Willow. The Upright Golden Willow is also of concern because of its capacity to produce seed in the presence of the Brittle Willows. These are discussed in more detail below (Section 3.2.2).

The present distribution of willows in the Goulburn-Broken Catchment is probably fairly well known by field staff, but has not been accurately documented. The distribution of the different species may not be so well known. In general terms, the greatest willow numbers occur in the upper reaches and on the Goulburn River below Eildon, while the lower reaches are less affected. It is important that a process for mapping willows be put in place, with information on species present, density, risks presented by willow presence, and the quality of other riparian vegetation in the reach. Aerial surveys are best done when the willows are yellow.

In the workshop held at the commencement of the preparation of this strategy (Bonnie Doon 4 April 2003), some key areas were identified as having significant willow problem areas.

Lower Goulburn (Shepparton Irrigation Area)

- dense willows in Lake Nagambie and downstream in the Goulburn River. These have potential to spread further down into the irrigation channel system
- on-farm willows (Weeping and Hybrid Willows) at risk of seeding and spreading into channels and streams

Mid-Goulburn-Broken

- seeding willows (3-4 species)
- numerous willows on streams and in catchments

Upper Goulburn

- Delatite: full length has been mapped, identifying a mix of species.
- Howqua: full length has been mapped, identifying a mix of species.
- Jamieson and Goulburn upstream of Eildon: Grey Willow (Wild Pussy Willow) the most significant species

The Index of Stream Condition data base can provide some information, but it does not distinguish between willows and other exotic riparian species such as blackberries, or between different species of willows.

1.4 *Assets at risk.*

The Goulburn-Broken Catchment has, among its major assets, many streams with high quality riparian vegetation with associated wildlife, and many more streams with good remnant riparian zones which could improve in quality with more careful management. There are a number of rivers which have been identified as Culturally or Ecologically Significant in the Goulburn-Broken River Health Strategy.

Of the 18 **Heritage Rivers** in Victoria, there are three located in this catchment.

- The **Goulburn River** downstream from the Eildon Reservoir to the confluence with the Murray River near Echuca
- The **Big River** from the junction of Spring and Oaks Creek downstream to the junction with Fryer Creek; and
- The **Howqua River** from the junction of the north and south branches downstream to Lake Eildon.

One **Natural Catchment Area** is listed in the Goulburn Broken Catchment:

- **Williams Creek**, a 1010 ha sub-catchment of the Goulburn River upstream of Lake Eildon.

There is one **Waterway associated with Ramsar wetlands** listed in the Directory of Important Wetlands in Australia:

- **Lower Broken Creek** (associated with the Barmah Forest, a Ramsar wetland).

The Goulburn-Broken River Health Strategy identifies a number of **Ecologically Healthy Rivers**, based on the ISC and RiVERS databases. The analysis resulted in 5 reaches being identified:

- **Taggerty River** (Goulburn Basin Reach 64);
- **Goulburn River** (Goulburn Basin Reach 15);
- **Big River** (Goulburn Basin Reach 67);
- **Big River** (Goulburn Basin Reach 68);
- **Ryans Creek** (Broken Basin Reach 17).

A further 13 reaches came close to priority status for ecologically healthy, nearly achieving the criteria, or that could achieve the criteria with a single program (riparian restoration), and are included on the River Health Strategy list of secondary priority. These are:

- Goulburn River (Goulburn Basin Reach 16 – high priority reach);
- Bylands Creek (Goulburn Basin Reach 36);
- Dry Creek (Goulburn Basin Reach 48);
- Yea River (Goulburn Basin Reach 54-57);
- Murrindindi River (Goulburn Basin Reach 59);
- Acheron River (Goulburn Basin Reach 63);
- Rubicon River (Goulburn Basin Reach 65);
- Howqua River (Goulburn Basin Reach 69 – high priority reach);
- Howqua River (Goulburn Basin Reach 70 – high priority reach);
- Holland Creek (Broken Basin Reach 15).

The Goulburn-Broken Vegetation Plan aims to maintain and enhance all **remnant vegetation**. A significant threat to riparian vegetation is the spread of willows, which can quickly dominate and degrade the understorey by heavy shading and dense surface root cover. Brittle and seeding species of willow can rapidly extend their range by spreading downstream, so all rivers and streams downstream of these existing willow populations are at risk. Although willows are no longer used by river management authorities, they may still be introduced into new stream reaches or catchments by landholder planting. Formerly stable populations can be converted to seeding trees by the introduction to the area of new species which may be compatible, allowing seed production and hybridisation. The subsequent seedling population will be mixed sex and continue to seed prolifically.

A large population of willows can also place **structural assets** at risk. Willows along waterways can increase erosion resistance of the bed and banks, and change channel shape and capacity. Where this is excessive, the mass of roots and accumulated silt can:

- widen streams and make them more shallow
- accelerate bank erosion.
- cause streams to change course, and
- increase the likelihood of flooding

Large populations of willows can have social impacts. Access to streams can be significantly impeded by willows, both from the bank, or in-stream, for fishing or canoeing. The value of streams for recreational pursuits related to eco-tourism may also be significantly diminished as bird watching, for example, would generally be unrewarding along a willow dominated stream.

1.5 Likelihood of Further Spread

The present extent of willow infestation in the Goulburn-Broken catchment is not known reliably. There are many streams and reaches of streams which have no willows, and others where only scattered willows occur, in a mixture with other riparian vegetation. Virtually all streams and rivers in the catchment are suitable for willow growth, so there is the potential for significant increase in distribution. Cremer (2001) estimated that willows have so far reached less than 10% of all the environmental niches that are suited to their establishment in Victoria. This figure may be higher for the Goulburn-Broken catchment, but illustrates the potential for greater impact on riparian and aquatic environments if willows are not actively managed. For example Cremer (1999) describes the establishment of Black Willows on the shores of Blowering Dam, in seepage areas, where 'galleries' of willows, to 12 m high, grow down to 15 m below full storage level. There are probably many similar environments around the shores of Lake Eildon, and other smaller pondages within the catchment.

The major risk of spread is from the seeding willows, principally Black Willow, Grey Sallow (Wild Pussy Willow), Purple Osier and White Willows. The fragile willows – Crack Willow and Basket Willow, are also liable to increase in density and move steadily downstream by vegetative spread. The ability of Grey Sallow to invade wetlands is also likely to cause an increasing problem, particularly if the recent dry seasons are followed by a series of wet years, which would provide opportunities for spread. This species has a wider ecological latitude than any of the other willows. Its seedlings can establish in any damp site. In Gippsland and in New Zealand Grey Sallow is a serious problem in wetlands and in high rainfall forest areas (Cremer 1999). In Gippsland it has choked creeks, and invaded wet forests and wetlands. The risk this species represents is serious and its rate of spread may increase, particularly following widespread disturbance caused by fires and floods. It is also less 'willow-like' in appearance than other willow species and in low densities may not be readily recognised as a risk species.

Another potential source of increasing spread of willow is the introduction of breeding partners into areas where no seeding has previously occurred. A previously stable population of single sex willows may become a source of seed if compatible willows of the other sex are introduced. For example, the introduction of female Upright Golden Willows into a population of male Basket Willows can allow the Golden Willow to set seed. This has already occurred in a number of areas, such as on Brankeet Creek, Glen Creek and the Jamieson River in the upper Goulburn. Once a population of mixed sex seedlings are established, an increasing source of seed will be available and the population could quickly explode.

A further seeding risk could arise when an existing female population of Weeping Willows that has always been stable may begin to set seed following a nearby planting of male New Zealand Hybrids. This situation could occur in the irrigation areas, where Hybrid Willows are commonly planted, leading to a willow seedling invasion of irrigation and drainage channels. A mixture of male and female New Zealand Hybrids planted on farms present a similar risk.

There is also a risk of new introductions into the Catchment. A large number of willow taxa have been introduced into Australia by the Nursery Trade (ARMCANZ 2001) of which 30 taxa were available in Victoria in 1999). These would be marketed to domestic gardeners, and most may not be widely available. However there is a possibility that they could be planted by landholders in gardens close to stream banks, and have the potential to spread, or hybridise with wild willows. The level of risk posed by this possibility is completely unknown.

2. Strategy and Recommended Policy for Willows

2.1 Current and Recommended Policy for the Management of Willows

The GBCMA has not had any formal policy on the use of willows in practice, but does not plant or recommend the planting of willows. There may be willow species which are not invasive, and appear to present fewer problems than the species used in the past. However willow species identification is difficult and the use of some willows in stream works while considerable resources are committed to controlling others would send a mixed message to the community. There are indigenous species which can be used in most circumstances and it is recommended that no willows be planted by the GBCMA.

As there is currently no legislative control on willow use in Victoria, the introduction and propagation of new willow species and varieties into the Goulburn-Broken Catchment by private landholders cannot be prevented. This presents a risk of future establishment of new aggressive species that would present an additional threat to riparian health. While AQIS regulations screen the entry of new willow taxa into Australia, there are already a large number of taxa present in the horticultural industry, which have not been assessed for the likelihood of aggressive spread. The only mechanism presently available within the Goulburn-Broken Catchment to reduce the risk of such species being introduced into the area is to pursue a voluntary restraint agreement with retail plant nurseries, and promote general publicity about the potential for new weed species becoming established.

This document examines the present situation with regard to willows in the Goulburn-Broken Catchment, and recommends a strategy for reducing their impact in the most effective and efficient way.

The strategy is based on the principle that:

The purpose of all river management actions is to improve riparian and river health, while safe-guarding the environmental, economic and social assets associated with the river environment.

There will never be enough funds to achieve eradication of all willows from the catchment, but a system of strategic priorities will enable an effective program to make best use of funds as they become available. Willow management is a relatively recent activity and many different approaches are being tried by authorities, agencies and landholders involved in river and catchment management. Willow management must therefore be continually adapted on the basis of experience, increase of knowledge of the biology and ecology of the different taxa, and the available tools. Priorities may also change in the future, as infestation sites are treated, and with better understanding of the behaviour of different taxa. A process of regular review of this strategy is therefore recommended.

The Goulburn Broken Regional River Health Strategy has identified a vision for the rivers and streams in the catchment:

"Healthy rivers, streams, wetlands, floodplains and adjacent land that support a vibrant range and abundance of natural environments, provides water for human use, sustains our native flora & fauna and provides for our social, economic and cultural values".

While there are a number of other weed species which are of concern in riparian environments, willows are capable of the greatest impact, as they have the capacity to completely dominate a stream, almost to the exclusion of any other plants, and still have the potential to spread far beyond their present distribution across the Goulburn-Broken Catchment.

A suggested goal for the management of willows is to:

GOAL *Manage the willows of the Goulburn-Broken Catchment in a way that will maintain the condition of existing high value riparian environments, while steadily improving those of lesser value in a strategic way, so that overall stream and riparian health improves and this change is measurable and valued by the community.*

It is recommended that the GBCMA adopt the following policy position with regard to willows in the Goulburn Broken Catchment

POLICY *The GBCMA will not carry out or support in any way the planting of willows of any species in waterways or riparian zones throughout the Goulburn Broken Catchment. The GBCMA will (subject to available funding) support within its waterways program any measures which effectively and strategically contribute to the management of the risks to waterway assets arising from the real or prospective presence of willows*

2.2 Strategic Guidelines

The requirement is to establish a strategically sound willow management programme which is based on willow ecology (species), site specific considerations (situation) and the resultant risk to identified assets (risk to stream health).

The following principles underpin the proposed management Program:

- **All works should improve stream and riparian health**
- **Protect the best first** (high quality riparian environment is not easily replaced once lost)
- **Eradicate the highly invasive species** (eg Black Willow, Grey Sallow)
- **Prevent further spread of all invasive willow species**
- **Manage and control the spread of other species where they threaten stream health or other stream related values**
- **Control the importation, propagation, sale and transport of willows**
- **Engage community participation and understanding of the works proposed**

A detailed Management Plan incorporating these principles is developed in the following Section 3 by detailing the eight key components required to effectively address the problem.

3. Management Plan for Willows in the Goulburn Broken Catchment

The Seven Key Components for effective management of willows are:
(Not listed in order of importance or implementation sequence)

- 1 A sound knowledge base
- 2 A process of priority setting
- 3 Long term strategic programs
- 4 A capacity for short term response to highly threatening outbreaks or the emergence of new issues
- 5 Monitoring of outcomes, maintenance of the database and the adoption of an Adaptive Management Approach.
- 6 An effective communication program
- 7 Effective resource allocation

3.1 *Knowledge Base*

Effective strategic control of the willow population must be based on a good database identifying the present distribution of at least the important species of willows. As described below, some species are more aggressive than others in spreading into un-infested reaches of streams. If management is to be strategic and efficient, it must be planned so that funds are spent in the most effective way, and in areas where maximum long-term improvement can occur. While some reactive works will always need to be done in response to critical situations, it is important that steady progress is made towards the long term goal.

The distribution of willows in the catchment should be determined as a matter of priority, with information on species, density, native riparian vegetation quality and likelihood and mode of spreading. Decisions need to be made for each sub-catchment on which of the willows should be removed to prevent spread and whether total removal is desirable and feasible.

Most of this information may already be available amongst the works crews, and a summary of comments provided in the workshop held at Bonnie Doon in April 2003 indicates the amount of data available but it needs to be consolidated into an accessible database, species identifications confirmed, and the gaps filled. The Index of Stream Condition database provides a start but does not contain sufficient detail about willow species and density and is not available for smaller streams.

Training in willow identification should be provided where necessary, so that field staff are competent in identifying the species which are known to occur in the catchment, and will recognise any new willows which may appear.

The database should be routinely up-dated and should incorporate information about assets at risk, or potentially at risk, occurrence of high priority willow species and high value stream reaches or sub-catchments.

Action Plan – Activity and Tasks

Activity	Tasks	Comment
Develop knowledge base which will support strategic decisions	Compile database on species distribution giving priority to <ul style="list-style-type: none"> • High priority waterways 	This will enable identification of risks to assets (natural and structural), and risk of spread based on existing condition ranking. Species identification skill training should be provided to staff. Ensure that all staff are able to contribute verifiable information to database at regular intervals.
	<ul style="list-style-type: none"> • Secondary waterways 	
	<ul style="list-style-type: none"> • All other waterways 	

3.1.1 Knowledge Gaps

Knowledge gaps were identified in the workshop held at the commencement of this project. Topics mentioned included:

- the extent of infestation - need detailed mapping of willow distribution
- the source of spreading - high risk trees or populations
- methods of dispersal - are reasonably clear
- water use by willows
- likelihood of sex changes by trees - identification skills needed
- impact on water quality
- biodiversity impacts of willows
- ecosystem recovery following willow removal
 - spatially
 - temporally
 - laterally
- the real cost of willows
- alternative methods of control e.g. burning and bark painting

Some of the questions are specific to the Goulburn-Broken catchment and can be answered by the collection of more information by GBCMA, and the development and maintenance of an effective and accessible database. Other questions are broader and will require the resourcing of research projects targeted at the problem. All catchment authorities and organisations concerned with riparian and stream health will also have an interest in the question, and agencies such as Land and Water Australia may be the appropriate organisation to target these issues. A periodic workshop with willow control practitioners from other Catchment Management Authorities may be of value to enable the sharing of experience at a practical level.

3.1.2 Specific Goulburn-Broken Catchment Questions

Based on the comments made by staff at the workshop, and management issues connected with development of a willow management plan, the following questions have been formulated for consideration. Some of these should be answered by development of the database recommended as part of this strategy. Others could be considered as part of an adaptive management approach to program design.

- What is the present extent of willows in the catchment, particularly seeding species (Black Willow, Basket Willow, Golden Upright Willow and Grey Willow (Wild Pussy Willow)) and brittle species (Crack Willow and Basket Willow), the sex of willow populations in high priority areas and distance to potential compatible pollinators?
- What is the likelihood of NZ hybrid willows causing weeping willows to seed and to what extent is it already happening? (An issue in irrigation areas?)
- What is the best method of dealing with weed invasion of revegetation sites following willow removal? Progressive accumulation of knowledge and experience in re-establishment/restoration of native riparian vegetation is needed, with refining of site preparation/spacing/density/species composition for quick and effective revegetation.
- What is the best spacing for staged willow removal/retention to reduce the impact of broad scale removal and facilitate revegetation?
- Is use of some willows still necessary/advisable (ie sterile clones) – could these become a problem in the future?

3.1.3 Broader Questions Requiring Research

- What is the reliability of 'sterile' clones and the status of 47 new spp and varieties which were imported by a private plant arboretum in Victoria in ~1995
- Do fish populations use areas where willows have recently been removed? How long till they recolonise? Can in-stream rehabilitation substitute for willow shade in the short term?
- How do platypus populations respond to the replacement of willows with native riparian vegetation, in the short and long term?
- Water use by willows – what is the impact on small creeks and irrigation supply channels. Can the cost of willow removal be partly covered by reduced water transmission losses?
- Further research and development is needed on potential biological control agents for willows.

3.2 *Setting the Priorities*

The principal goal of this Willow Management Plan is to improve riparian health, and this should be the reference point in decisions about priorities of works. Improvement is a long term aim, and short term gains, while important, particularly for community perceptions or asset protection, must be tested against the sustainability of the changes that are being achieved. This is the background against which these priorities are proposed. It is also important to consider the ecological role that willows are currently playing where they are completely dominant, to the exclusion of all native species. It is essential that the impact of removal on the stream and the surrounding landscape is understood before works commence.

Willow management may be either reactive or proactive. Reactive management probably attracts most funds at present, as it involves responses to the impact willows are having on assets or the hydrological or ecological functioning of a stream. It may be described as crisis management. This is important, but it is also important that areas containing willows in small numbers should be part of the annual works program to avoid the need to manage future crises and to protect high value riparian areas before damage by willow domination occurs. A 'rehabilitated' riparian environment will never achieve the value of an undamaged remnant riparian community.

The annual riparian management works budget should be divided into:

1. Urgent works
2. Preventative works
3. Strategic works
4. Follow-up, monitoring and assessment of earlier work.

The management of willows requires a planned approach. However this must have some flexibility, to enable a quick response to urgent issues as they arise. These may include the discovery of a seeding population of willows, which had not previously been documented. A quick response may also be required if a new aquatic weed is located in the catchment. Rapid action before spread occurs could save significant cost later on, and may make the difference between complete eradication of the weed in the catchment, and a long term, expensive control program.



Plate 3 – Back Creek, Crack Willow

3.2.1 Works Priorities

Long term programs and short term projects have a different planning timeframe. By definition, the short term projects will be decided on an annual basis, generally as a response to immediate requirements for urgent works. The annual budget set aside for this component of the strategy would generally be less than for long term more strategic works. The amount required may have to be based on experience, but as a rule of thumb, it is suggested that 25-30% of the works budget should be devoted to short term projects. Many of these may also contribute to long term goals, and it would be useful to have a number of small, non urgent projects planned and ready to be executed at short notice, so that if the annual urgent project budget appears likely to be underspent in any year, resources could be used for these.

The practice of adaptive management provides for some experimentation and risk taking with respect to outcomes, where there is a need to obtain more information about control techniques or approaches to program execution. It may therefore be appropriate to set up small trials of different management practices, even if the outcome is uncertain.

Long term programs will be aimed at strategic improvement of riparian health, with a focus initially on high risk species, and high value riparian areas which are at risk of deterioration. Several such programs should be developed and run concurrently in different part of the catchment, to utilise the present employment structure. They may be 5-10 year programs, and focus on whole catchments or sub-catchments. For example it is recommended that complete eradication of Black Willow should be achieved within 5 years. If removal is slow, spread may outstrip removal.

The general priorities for willow management programs have been discussed above. A number of considerations must be taken into account when making decisions about long and short term projects. A general list of these is given below. This is not exhaustive and each case will have a different combination of circumstances.

3.2.1.1 Long Term Management Considerations

The following factors should be considered when evaluating a proposed long term willow management program:

- target Black Willow and Grey Sallow for total eradication
- complete eradication of high priority species (or all willows) from a reach or sub-catchment
- demonstrable improvement to riparian and stream health by willow removal
- small infestations in otherwise high quality native riparian vegetation
- local enthusiasm for riparian and stream regeneration
- Heritage / significant river / Ecologically Healthy Rivers or rivers nearing ecologically healthy condition
- long term viability of works (low risk of re-establishment)
- prevention of invasion into high quality riparian remnants
- Start at top of catchment and work down – low chance of re-invasion (unless spread is by seed)

3.2.1.2 Short to Medium Term Management Considerations

Factors to consider when assessing short term 'crisis management' projects

- off-site impact eg spread downstream – seeding or brittle willows
- risk of flooding or avulsion from loss of stream capacity– mid-stream or inside bend willows
- high risk combination of compatible species eg a few female willows in or close to a predominantly male population or vice versa.
- efficiency of early intervention, to prevent more expensive work later.
- opportunity for progress towards long-term goal of removal of a species from a catchment.

3.2.1.3 Low priority Projects

Examples of situations where work may not be justifiable when other higher priority situations are outstanding

- stable population of non invasive willows, with no native vegetation.
- doubtful landholder engagement or support
- low level of community acceptance or real conflict
- demands or impact on landholder/community out of proportion with CMA contribution to project or environmental value
- acknowledgement of limitations of strategy (can't get rid of all willows in 10 years) - need to maximise effectiveness of work.
- need for better information on species of willow present and their activity
- value of bank stability provided by willows in enlarging streams etc.
- risk of instability if removal occurs – may need to balance urgency of removal (eg invasive species adjacent to high quality native vegetation) against cost of river work required to stabilise bed and banks when willows are removed

3.2.2 Priority Setting on the basis of species

Two groups of willows present the greatest threat of rapid increase in numbers and spread downstream. In the case of seeding willows, this may not occur until a combination of environmental factors occurs, but very high numbers of seedlings can be produced under the right conditions. Delay in controlling these willows may result in a much greater and more expensive problem.

3.2.2.1 Seeding willows

Seeding willows may result from the presence of Grey Sallow (Wild Pussy Willow) or Black Willow, which have both male and female trees in the population, or from the presence of two compatible species (eg female Golden Upright Willow trees with male Crack Willow) or their seedling offspring. There is a possibility in the future of seeding Weeping Willows where compatible male Hybrid Willows have been planted nearby. Mixed sex Hybrid Willows may also seed. All willow populations that have grown from seed will be mixed sex and will continue to seed.

Primary Target Species in this category include

Grey Sallow - (*Salix cinerea*) (including *S cinerea* ssp. *cinerea* and *S. cinerea* ssp. *oleifolia*)

Also known as Wild Pussy Willow, Rusty Sallow, and Grey Willow: (need consistency in nomenclature).

This is a large spreading shrub or small tree, one of the most widespread of the willow taxa in Victoria. Both sexes are present and it reproduces almost entirely by seed which is capable of wide dispersal. This is the only willow species which commonly spreads away from the riparian zone, occurring in wetlands and drainage lines. It appears to be rapidly expanding its range in Victoria and is likely to become a major wetland and riparian weed species as it has in New Zealand. It can form hybrids with other shrub willows, some of which occur in Victoria.

In the Goulburn-Broken Catchment, Grey Sallow appears to be most common in the upper catchment, but does occur down as far as Broadford. It casts a dense shade once established, so prevents growth of any other riparian species. The potential for spread of this species along creeks and into wetlands, because of its ability to grow from seed which can be carried a long distance by air, places it as a top priority for complete removal throughout the catchment.

Black Willow - (*Salix nigra*)

This is a tree willow from North America, which has not been widely planted in the Goulburn-Broken catchment so far, and is limited to a few creeks and rivers. Both sexes are present and it seeds freely. Seedling establishment has occurred at some sites (eg Brankeet Ck). Black Willow is causing major problems in the Ovens Catchment, where it has been planted more widely. While not yet recorded off-stream, this species has the potential to behave as aggressively as Grey Sallow, and to spread into wetlands and other wet areas. As it is not yet widespread, Black Willow is a very high priority for complete removal from the catchment. It is very important that it is not planted in any new locations.

3.2.2.2 Brittle willows

Brittle willows can spread downstream following damage from flood or other disturbances. Removal of brittle willows can create a maintenance problem, as every small twig that is left behind can grow. Extensive follow-up will be avoided with these species (Crack Willows and Basket Willows) if the trees are poisoned and confirmed dead before removal.

Primary Target Species in this category include

Crack Willow - (*Salix fragilis* var. *fragilis*) and Basket Willow - (*S. x rubens*)

The Basket Willow is a hybrid of *S. fragilis* and *S. alba* but behaves very much like *S. fragilis*. Crack Willow and Basket Willow are single or multi-stemmed trees and are the most widespread and abundant willows in the catchment. They have been widely used for river management work, have naturalised and dominate many kilometres of streams in the Goulburn-Broken Catchment and in North-east and Eastern Victoria. Almost all plants are males, and they can be difficult to distinguish because of crosses and back crosses, where fertile combinations have occurred. They are both brittle, and twigs break off very easily, to be carried downstream, so vegetative spread occurs, generally only down the catchment. Plants grown from detached twigs will be the same sex as the parents, but plants grown from seed will be mixed sex.



Plate 4 – Pussy Willow



Plate 5 – Crack Willow

Table 3.1 Priority Setting on the basis of species

Species	Method of spread	Priority
Black Willow <i>Salix nigra</i>	Males & females present – spreading by seed. Potential to invade wetlands.	Very high priority – aim at complete eradication.
Wild Pussy Willow (Grey Sallow) <i>Salix cinerea</i>	Males and females present. Spreading by seed. Can invade wetlands as well as streams	Very high priority – aim at immediate containment, plan for eradication, catchment by catchment.
'Basket' willows <i>Salix x rubens</i> , (<i>S fragilis x S alba</i>)	Vegetative spread from broken twigs and branches. Can spread from seed where both sexes present (seedling grown plants)	Very high priority if seeding trees. Non-seeding high priority , work from upstream down with good follow up.
Crack Willow <i>Salix fragilis</i>	Vegetative spread from broken twigs and branches. Male trees, can pollinate the compatible Upright Golden Willow.	High priority , remove progressively from upstream down with good follow up.
Upright Golden Willow <i>Salix alba var vitellina</i>	Female trees, likely to set seed if near a male tree.	High priority , depending on proximity of other potential partner willow species (2000m safe distance from Crack Willow)
NZ Hybrid <i>Salix alba x S matsudana</i>	Many named hybrids of both sexes planted on farms. Risk of hybridising with each other and with Weeping Willow.	High Priority to remove if seeding found. Use of these hybrids near natural stands of willows should be discouraged – careful monitoring for seeding required.
Weeping willow <i>Salix babylonica</i>	Female. Some vegetative spread possible but not a serious problem. Potential for seeding with NZ hybrids but not recorded yet in GBC. Has occurred in W Victoria	Low priority . but monitoring necessary where a risk of seeding eg in vicinity of male NZ hybrids.
'Weeping' Willows <i>S x sepulcris & S x pendulina</i>	Similar to true Weeping Willow but more likely to set seed. Distribution not known.	High priority if risk of seed set. Presence and distribution of these willows in the catchment needs to be determined.
Tortured willow <i>Salix matsudana</i> 'Tortuosa'	Female, not invasive but can set seed with Crack Willow.	Low priority – remove if near compatible male trees.
Purple Osier <i>Salix purpurea</i> (?Booth)	Abundant seed can be set by this species (Carr 1996) but 'Booth' appears to be sterile. No vegetative or seeding spread yet noticed where used in catchment.	Low priority . Monitor very carefully in case sterility is not reliable. Limit use.
True Pussy Willow <i>Salix x reichardtii = S cinerea x caprea</i>	Possibility of seeding but not recorded.	Low priority . Monitor for seeding. Risk of breeding with Wild Pussy Willow or Purple Osier – should be kept apart.

3.2.3 Priority Setting on the Basis of Situation

Priorities will be established by a combination of the threat posed and the value of the threatened asset. The following examples present a range of scenarios, but every situation will have to be judged on the particular combination of circumstances.

Table 3.2 Priority by situation

Situation	Considerations	Priority
Willows spreading into previously un-infested areas	New area high quality native vegetation, or just upstream of a high quality reach.	High: need immediate control to prevent damage to native vegetation.
	Low quality vegetation	Medium: less urgent, but delay means greater cost
New outbreak of seedling willows	Identify parent trees – is male or female in greater numbers?	High: the minority parent trees should be removed to prevent further seeding
	Locate all seedlings down stream	High: seedlings will be mixed sex and must be removed before they start seeding.
Willows in isolated patch in high value vegetation	Invasive species	High - urgent before further spread
	Non-invasive species	Medium – desirable but not urgent
High risk of stream management problems eg avulsion	Significant assets at risk	High - urgent before damage to assets
	No significant assets at risk	Medium – but delay may mean greater cost
Female trees in area with compatible male trees.	Opportunity to remove before seedling establishment occurs	High priority
Site high in the catchment and there is a low likelihood of reinfestation from above	Invasive spp	High priority
	Non-invasive spp	Medium priority
Site low in catchment, no high quality vegetation in area, invasive species common upstream	No significant assets at risk, high likelihood of reinvasion.	Low priority
Populations of non-invasive willows in otherwise cleared farmland, no landholder interest.	No native vegetation,	Very Low priority
	Native veg still present,	Medium-Low priority
Populations of non-invasive willows in otherwise cleared farmland, local landholders enthusiastic about willow management.	Good native veg still present	High
	No native veg present	Medium
Ageing, non-invasive willows.	Need vegetation to replace willows as they collapse, to maintain bank stability.	Medium priority. May be appropriate to commence some revegetation and lop willows to reduce competition

Action Plan – Activity and Tasks

Activity	Task	Comment
Establish process of setting priorities for long term and short term works	Identify opportunities for maximum gains in riparian health through a balance between long term strategic improvements and urgent preventative work.	Long term strategic work is generally the most important, but the ability to respond to urgent preventative issues is also important to avoid more expense in the future Opportunities include complete removal of Black Willow and Grey Sallow from all catchments.



Plate 6 - Jamieson River (stream blockage)

3.3 Long Term Programs

Long term programs will be works which will have a lasting effect on riparian health in the catchment, by eradicating aggressive species, and where feasible, complete removal of all willows. These works may be 5-10 year programs and will include riparian restoration by regeneration or planting, with an associated communication program with all stakeholders so that there is community support for the long term goals. Once a reach or sub-catchment is cleared of willows, it will require few resources other than occasional check-monitoring to ensure that no re-introductions occur. A significant proportion of each annual budget should be committed to these long term projects.

The higher quality streams or reaches, with minor willow infestations, will initially give the greatest return on investment, although not necessarily high profile works. They will generally only involve willow poisoning with no requirement for removal or revegetation. A mix of these smaller low-key projects and larger willow control and removal projects should be developed.



***Plate 7 Riparian Restoration – Mollisons Creek
Crack Willow***



***Plate 8 Riparian Restoration – Mollisons Creek
Weeping Willow***

Eradication of the species which spread most aggressively is of very high priority for long-term programs. Black Willow is not widespread in the catchment, and it should be feasible to remove all plants within 5 years. Wild Pussy Willow is principally in the upper catchments and is capable of spreading into wetlands, as well as expanding its distribution down the streams. It will require a longer term eradication program in which it should be removed progressively from whole sub-catchments, commencing in the upper reaches first and moving down the catchment, so that reinfestation is less likely.

Crack Willow and Basket Willow should also be progressively removed from sub-catchments where total eradication is possible and from reaches where there is a risk of spread downstream to high quality reaches or where there is an opportunity for substantial improvement in riparian and stream health.

Landholder and community enthusiasm for willow removal should also give project proposals a higher priority.



Plate 9 Fallen and ageing Crack willows

Action Plan – Activity and Tasks

Activity	Task	Comment
Develop and Implement long term strategic programs	Use knowledge database to identify opportunities for long term riparian improvement	Long term works plans may be 5-10 year programs for priority reaches. Eradication programs should commence in upper reaches and move progressively down the catchment.
	Develop sub-catchment or regionally based works programs for willow management activity in high priority areas	Willow eradication may be initially of priority species, or of all willows, depending on desired outcomes for the reach. High quality riparian vegetation requiring minor resources will give the most immediate return.

3.4 Short-term Projects

There will always be a need to address willow issues which are not part of a long term program, and some capacity should be retained in the annual works program for quick response to these. Such issues may include:

- the discovery of seeding willows, with a crop of young seedlings which require quick removal before they become too large. Requires action to seek and destroy parent trees even if they are well away from the river,
- a risk of asset damage from willow growth such as flooding or avulsion, or loss of access.
- an opportunity for early preventative works which are minor but could develop into a more expensive problem if left unattended, such as compatible male and female willows, even if seeding has not yet been observed,
- small scale works in response to requests/proposals by landholders or community groups, provided they fit into the overall strategy, and will have long term benefits through capacity building.

Action Plan – Activity and Tasks

Activity	Task	Comment
Develop and implement shorter, annual, projects, in balance with long term goals	Maintain capacity for <i>reactive</i> works to willow issues and opportunities which may arise.	Opportunities to complete willow removal on sites where other work is being carried out, or where landowner support effectively gears up the project effectiveness
	Carry out <i>emergency</i> works in high risk situations where action in the short term can save a major outbreak and high expense later.	New seedling outbreaks or discovery of compatible seeding trees need a quick response capability

3.5 Monitoring, Database maintenance and Adaptive Management

3.5.1 Monitoring of outcomes and Maintenance of the database

The decision system which is used to set priorities for works will only be as good as the knowledge on which it is based. It is important that information about the condition of the rivers and streams in the Goulburn-Broken Catchment is continually being up-dated, so that new willow infestations or willow-induced impacts are detected while they can be easily and cheaply managed. This can be achieved by a variety of processes. It is recommended that all staff should have an understanding of the priorities for works, and the importance of information, so that they will recognise issues as they arise, even if willow and aquatic weed management is not part of the core responsibility of that staff member.

The knowledge base must also be continually updated by effective monitoring of the outcomes of riparian works, over a number of years. All works plans should incorporate a monitoring program, which requires documentation and assessment of the response of the riparian environment to the works, over a period of up to 10 years. This will enable any required follow up works to be incorporated into the annual program. There should also be a process whereby the experience gained from each project is incorporated into the knowledge base for future project planning. Documentation of this information should be sufficiently accessible that a change in staff will not involve a loss of 'memory' or experience with respect to riparian management.

The Index of Stream Condition process may be an appropriate method of quantifying change. However some additional scoring of riparian condition with details of species present and plant community structure should be added to the standard index score to make it more sensitive to the impact of willow removal. The existing ISC database for the Goulburn-Broken Catchment only covers the main streams, so for minor tributaries an ISC score would have to be generated for each works reach for the purpose of willow management monitoring.

A benchmark index should be recorded in each works reach prior to the project commencing and again after a standard period of time. Two, five and then ten years may be appropriate. While the ISC would be very useful as a standardised method of monitoring the Strategy outcomes, at the beginning of the project a general description of the reach, including a photographic record, should be used, as well as the Index, in case it is found that the Index in its present form is not sensitive enough to demonstrate changes which are otherwise recognisable.

At sites where an active local community group such as a landcare group is interested in the project, it may be possible for the group to carry out an annual monitoring exercise to document improving riparian and aquatic biodiversity over a number of years. Support from GBCMA in the form of required resources and a barbecue lunch would provide excellent community interaction and favourable publicity, as well as a valuable contribution to the database. (see also Section 3.7)

An annual workshop should be held, including all staff involved in riparian management, at which the previous year's works are described, and future work discussed. Experience should be shared across the whole team, so that successes and failures can be analysed and understood.

Action Plan – Activity and Tasks

Activity	Task	Comment
Monitor works outcomes and maintain database	Use a modified Index of Stream Condition assessment and written and photographic documentation at all project sites to establish a benchmark condition. Repeated two, five and ten years later.	A standardised record of riparian response to works is essential for an assessment of outcomes.
	Hold an annual workshop including all staff involved in riparian management, to review outcomes.	Inclusion of staff in an annual review of works will provide maximum input to the database and an ownership of outcomes.
	Establish process to maintain database	Insert new data and review and update existing data

3.5.2 Adaptive Management

'Adaptive Management' is a system for natural resource management, which acknowledges that our skills and understanding of natural resource management will change over time, and that the management approach must be responsive to this. The Victorian River Health Strategy is built on an adaptive framework, and emphasises the importance of a capacity to learn from management decisions and to change management strategies on the basis of improved knowledge. A similar approach is recommended for riparian management. However while many natural resource management organisations have embraced the principle of adaptive management, it is not easy to achieve (Allan and Curtis 2003).

Adaptive management emphasises learning from the implementation of policies and strategies.

(Passive) adaptive management involves systematic review of the outcome from implementation activities. **(Active) adaptive management** occurs where implementation is specifically designed to test hypotheses and to make learning more efficient (Allen and Curtis 2003).

Allen and Curtis point out that there are few documented examples of successful implementation of adaptive management of natural resources. One barrier to success has been identified as the absence of a culture which encourages experimentation and reflection. Some institutional changes may be necessary to overcome this. This Willow Management Strategy has a relatively simple focus, when compared to some broader natural resource management strategies. It may therefore be possible to successfully implement some aspects of adaptive management, increasing in scope with experience. The involvement of all staff in the maintenance of the database and monitoring should help to develop the reflective and questioning approach which is required for successful adaptive management.

Action Plan – Activity and Tasks

Activity	Task	Comment
Maintain an adaptive management approach	Monitor earlier works, to record outcomes and carry out necessary follow up actions	Monitoring of earlier projects may indicate changes which could be made to the implementation of future projects.
	Regularly evaluate outcomes of works and review programs .	Experience in successes and failures should be shared across the catchment.
	Involve all staff in works reviews	
	Accept some uncertainty of outcome if there is an opportunity of improving knowledge	Some carefully planned and documented experiments and trials can answer some don't know' questions.

3.6 Communication strategy

The GBCMA has the responsibility to manage the waterways within the catchment, and the resources to undertake necessary works. However the condition of the waterways is most influenced by the adjacent land management, which is in private hands over most of the catchment. The landholders, and the general population of the catchment, must therefore play a big part in successful waterway management. While many waterways have a crown frontage, this is generally leased to the adjoining landholder, who manages it as an integral part of the property. Even if the GBCMA had the resources to fence all frontages, appropriate day to day management would inevitably depend on the good will of the adjoining landholder. While most landholders can be expected to want a 'healthy' river or stream on their boundary, their understanding of what this means in practical management terms varies widely, and the financial resources available also play a part in developing best practice riparian management. A program of communication, information provision, education and sometimes practical support must therefore be an integrated part of waterway management in the catchment. Riparian management should be a partnership between the CMA, the individual landholders and community groups such as landcare and fishing groups.

This partnership must also include the wider community, which has a stake in maintaining healthy streams. The removal of willows is not automatically seen as good waterway management. There is a widely held view that willows are aesthetically pleasing, and many people, both landholders and tourists, assume that willows are a normal part of a riverine landscape. This is likely to result in opposition to willow removal in highly visible areas, or near farm houses. A program of consultation and information dissemination about the problems willows cause should be put in place where large scale willow removal is to occur. An assurance about revegetation programs is important, and some demonstration of other successful programs, with before and after photos, or visits to other sites for the key stakeholders, may be helpful. It is important that the community understands the time frames involved, as revegetation of a site may not be appropriate for 12 months or more after willow removal, to allow for adequate follow up willow and weed control. Care should be taken so that any unnecessary delay in revegetation doesn't give weeds an opportunity to get established as this would create a poor public perception of the project.

Many landholders and community members are accustomed to a landscape containing willows, and it appears quite normal to them. Even those who agree that a diversity of birds is desirable do not always make the connection with *natural* habitat. Basic information at this level must still be provided in any information campaign which may accompany a willow control program. Many anglers are aware of broad scale attempts to manage willows that have resulted in the total denuding of shade and cover from large reaches of streams. This has made them highly suspicious of willow management.

Many species of willows have been imported into Australia for the plant nursery trade, but have not yet been widely planted. There is an unknown risk presented by these species, some of which could naturalise and spread. Communication with the Nursery Trade and other plant retailers should be established and maintained, to emphasise this risk. Eradication of high priority species from sub-catchments could also be compromised if these species are still being distributed to landholders.

3.6.1 Developing Community Capacity

The Goulburn-Broken Catchment has recently been used as one of five study regions for a Land and Water Australia funded project: 'Assessing Community Capacity for Riparian Restoration'. A report of the project is presented in Rip Rap edition 24 (2003). In summary, the project investigated the capacity of individuals or communities to increase their 'human capital' (the knowledge, skills and abilities of people) with respect to riparian management and restoration. An outcome of this project was the development of a 'Capacity Assessment Tool' to help with the assessment of the capacity of the region to undertake riparian restoration. The project report and the 'tool' may be a valuable resource in developing and maintaining a good community involvement in willow management programs, and monitoring the success of communicating the vision and goals of the strategy.

Action Plan – Activity and Tasks

Activity	Task	Comment
Develop communication strategy to provide information about willow issues for stakeholders and general public.	Develop resource material to assist with public education about willows and to explain proposed works	Appropriate material will include general information and site specific details of the proposed works
	Carry out consultation with stakeholders as part of each works project, particularly with adjacent landholders Communicate long term goals for target areas	Maintain communication with stakeholders on an ongoing basis. Adjacent landholders can have the greatest influence on riparian quality
	Promote successful outcomes – improved riparian health resulting from willow management activities	Field days (learning by seeing), are the most effective form of communication for many stakeholders
	Establish process to share knowledge and experience with other CMAs	Invite participation in annual forums from other CMAs.
Encourage community involvement	Investigate and trial 'Capacity Assessment Tool'	Willow management will benefit from active, informed community involvement
Highlight the implications of the import, propagation, cultivation, sale and transport of willows;	Lobby for change in the importation law to prevent the introduction of new problem willows.	
	Establish communication with retail plant nurseries in the region, to explain potential risks associated with unknown willow species	Stakeholders include the Plant Nursery Industry, farmers and domestic gardeners
	Consider Willow Management in the review of the Goulburn Broken Region Weed Action Plan.	The status of willows as weeds has implications for Statutory powers and obligations.

3.7 Resource Allocation

The previous Chapters provide the key areas which should be addressed in willow management. All are critical contributions to the achievement of healthy waterways and the protection of social, economic and environmental values. Distribution of resources between the many components will have to be determined from time to time as needs arise. The development of the Knowledge Base is an early requirement which should be resourced adequately until it is well established, as it will be the basis of setting priorities for long term programs for effective willow eradication from target areas. The other actions will run concurrently and will all require a level of annual resource allocation, based on the specific long term requirement and the specific needs each year.

The long term and short term Field works programs will be the most demanding on financial resources. It would be desirable that the long term, more strategic programs should receive the major funding, as they are most effective in achieving sustainable outcomes.

Based on the Strategic approach outlined in this document, and the information obtained in the willow species and location data base, funding bids should be put forward to supplement the core funding from the state waterway program.

It is also necessary to ensure that the GBCMA develops and retains staff and contractors with the required knowledge and skills to carry out the willow management Program

Action Plan – Activity and Tasks

Activity	Task	Comment
Secure the necessary resources to carry out the program	Submit funding bids for strategic components of willow management program	Core management and administrative tasks could be funded from core state waterway program funding. Additional funds need to be sourced to deliver the major field work elements of the program
	Assign willow management tasks to staff and contractors	Data collection and data base maintenance should be carried out by staff. Contractors or Consultants could deliver specific field programs under CMA field staff supervision
	Provide appropriate training and equipment for staff/contractors to carry out the necessary tasks	All personnel involved in program will require willow identification skills and practical training in control techniques

4 Implementation of Field Activities.

The major references for this section are the Melbourne Water Standard Work Procedure 310, Willow Control & Management, and the National Strategy, with some amendments relevant to local circumstances..

The most effective and efficient willow management actions will remove problems that willows may be causing in such a manner that the problem will not recur. Ideally this will involve complete removal of target willows from a catchment or sub-catchment in a staged program, starting from upstream and working downstream. Effective follow-up over the next two years will ensure that no reinfestation occurs in treated reaches or that the riparian zone is not invaded by other weed species such as blackberries. The program should incorporate revegetation, to the extent that is necessary at each site. In the upper catchments, where native vegetation may still be present, revegetation may only be minor, involving fencing where necessary, and the introduction of a few over storey or under storey species which are considered unlikely to re-establish naturally. Natural regeneration should be encouraged where there is a seed source from upstream, or likely to be a native seed bank in the soils.

Willow management and control is already an established practice in the Goulburn-Broken Catchment. Good work has already been done and there is considerable experience with a range of techniques. The following discussion of available management techniques may not be exhaustive, and there is potential, with more experience and some experimentation to improve the effectiveness and economics of willow management.

4.1 Recommended steps in planning willow removal

This section discusses the recommended stages in a willow management program. They will not all be necessary in every project. They are summarised in the following check list which can be worked against when planning the procedures needed at each site. Documentation based on this check list will also improve the record of the project, and assist in maintaining the knowledge database and reviewing the outcomes of the project. The main activities are then discussed in more detail below.

Prior to works commencing:

- Assess and define the willow problem
- Confirm the species involved
- Identify the extent of the work area
- Understand the potential impact of the works : physical, biological, and social
- Determine land ownership and tenure of works site and neighbouring properties
- Consult with adjacent landholders and other stakeholders

Planning and Implementation:

- Select an appropriate method of control
- Plan site rehabilitation, fencing and revegetation, with alternative water points if required
- Develop a monitoring and maintenance program for assessment of outcomes
- Publicise project in general community
- Prepare works contract
- Carry out preliminary weed control if necessary
- Carry out works
- Commence site rehabilitation

Follow up:

- Hold field day to allow inspection of rehabilitated site
- Where appropriate, install signage to record activities.
- Implement monitoring and maintenance program, document outcomes
- Develop a simple management plan for the site in conjunction with neighbouring landholders or management authority which will identify their role in maintaining improved conditions.

4.2 Preliminary investigations.

Before a willow control program is commenced in any reach of stream it is necessary to identify the local problem willows and the actions required to deal with them. This will include the extent of works required and the appropriate techniques to be used. A general investigation should also be carried out to determine what special values or issues may apply to the river or stream involved. For example, there may be known populations of significant fish species, or platypus, which may require particular emphasis on protection of the stream bed and water quality. Flora or fauna populations may have some influence on seasonal timing of works. Any existing native vegetation should be identified and evaluated, to determine whether particular precautions need to be taken to protect native plant communities or individual plants. The presence of significant weed species other than willows may require control of these before works commence to prevent the replacement of one weed with another. An understanding of the stability of the stream morphology, and any morphological processes which may have been recognised in the past, is important to predict the likelihood of a change in the channel as a result of willow removal. Accessing some 'local knowledge', from GBCMA staff, local landholders and community groups should occur before any project is undertaken. Communication and consultation with stakeholders is also an important part of the planning process. This information can be used in deciding the most appropriate control techniques to be used.

4.3 Available Control Methods

A summary of available control techniques together with brief comments is provided in Table 4.1

Table 4.1 Available Control Methods for the Management of Willows

Technique	Comment
Removal of whole living tree, including root mass	This is rarely justifiable. Necessary when there is an urgent need to improve channel capacity. There is a risk to water quality and instream habitat from rapid mobilisation of silt and regrowth from stem fragments at site and downstream. Damage to adjacent areas from heavy machinery may also be an issue. Thorough follow up work is required to prevent establishment of a large population of new willows at the site and downstream.
Cut and paint stumps with herbicide (usually where trees are small and easily handled)	Risk of regrowth from fragments at site and downstream, particularly with brittle willows. Need measures such as boom nets to prevent movement of fragments downstream, and good follow up. Particularly suitable for non-brittle species such as Grey Sallow and White Willow. The outer 5 cm of the stump is the critical area to be painted, and painting the bark below the cut can increase effectiveness

<p>Prior poisoning (by stem injection through axe, chainsaw or drill cuts) then removal</p>	<p>Stem injection is efficient and low risk as there is little likelihood of herbicide affecting non-target plants. It can be very time consuming in willows with multiple small stems, and good follow up is required to poison any stems missed in the first treatment. Delay of several months before removal, reduces risk of regrowth and spread from fragments. Remove before dead wood becomes brittle. This is currently the most commonly used method in the Goulburn-Broken Catchment. The root mass should not be disturbed unless it is impeding flow and there is some urgency for change. As the dead roots rot away, the accumulated silt will gradually be mobilised as the stream flow establishes a more natural bed morphology. Removal of dead willows with heavy machinery should not occur where damage to native vegetation may occur. Follow up inspection is required the following season to ensure that no regrowth occurs.</p>
<p>Poison and leave standing</p>	<p>Stem injection as above. Suitable for isolated plants and where there is no risk of damage from dead stems in waterway or downstream, or hazard to public, particularly for use on large rivers or in isolated areas. The stems are then left to rot away naturally.</p> <p>This technique is less labour intensive and more economical than removal. However there are situations where it is not appropriate. Where stems are very dense, access is difficult, and could become dangerous during follow-up work to poison stems that were missed in the first stage, as the dead stems can become brittle and break easily. Willow timber is not long lasting, particularly in water, but on smaller streams there is the potential for log jams and obstruction to flow as the stems fall and become tangled across the bed. Larger trees could present a hazard to structures if they are moved downstream in floods, and access to the stream banks and bed will remain difficult for some time.</p> <p>Revegetation works can also be difficult if there is dense dead timber present along the bank for some years. The decision whether to leave or remove must be site specific, but generally it is most appropriate to leave stems when the willows to be treated are scattered, and the bulk of dead material will not become hazardous or obstructive.</p> <p>It is particularly to be used for isolated trees on upper catchment streams, where access is difficult and a single visit to poison willows may be made every few years. In some circumstances issues such as fire hazard or aesthetic impacts may also be relevant.</p>
<p>Foliar spraying</p>	<p>Foliar spraying should only use glyphosate formulated for aquatic environments, and be limited to dense seedlings or regrowth up to two metres high. It is important that seedlings are sprayed before they commence to set seed. Spraying should not be used where native vegetation may be affected, unless the native plants can be covered or screened to protect them from damage. Spray drift onto water should be minimised Limit use on small waterways.</p>

Pollarding or lopping with partial painting of cuts to prevent coppice	In some situations it may be appropriate to trim or lop willows, to improve access to the bank or stream, or to reduce competition with adjacent native vegetation, while maintaining bank stability. This will generally be a temporary solution to problems caused by willows, where complete removal may not be appropriate until other measures to maintain bank stability are in place. All the precautions with regard to dispersal of detached stems necessary during willow removal must also be observed during lopping, and the site must be checked in later seasons to remove any new plants that have established from stem fragments. When the willows are not to be poisoned after lopping, they should generally be lopped at least a metre above ground to make follow up work more accessible rather than creating multiple stems at ground level.
Hand pulling	The most effective way of removing seedlings is by hand pulling. While seedlings are young - in their first or second year, they are easy to remove. Pulled seedlings should be removed from the site and allowed to dry to ensure they cannot regrow. In reaches below stands of brittle willow species such as Crack and Basket Willows, regular monitoring for fragments that are taking root can prevent new problems arising. Newly rooting stems can also be easily removed by hand. This is particularly important in high value native riparian areas and where herbicide use is not appropriate. Early intervention by hand weeding can save expensive works later on.
Burning	Willows are very susceptible to fire, and burning the bark can effectively ringbark stems. This is not a widely used method, but may have an application in very dense fine-stemmed stands. Some experimentation may be appropriate. The stems should be burnt as close to the ground as possible. The amount of scorching required to be effective may have to be trialled. Follow up would be required. Would avoid herbicide use in sensitive areas. (eg in an organic farming area)
Biological control	Biological methods of control would be the most cost-effective control method for willow, and have considerable potential, as numerous insects and other invertebrates and pathogens eat or parasitise willows in their countries of origin (ARMCANZ 2001). Australia has no naturally occurring members of the family Salicaceae (willows and poplars) so there is little or no potential for adverse impact on indigenous flora and fauna. However impact on horticultural use of these species would have to be considered. The Keith Turnbull Research Institute (KTRI) has carried out a feasibility study into the possibilities of introducing biological agents for willow control. The study concluded that a large number of suitable species were available, and recommended that further work be carried out to investigate these. However KTRI is unlikely to commence the work unless sufficient funds can be assured to complete the project, which would take 10-12 years to isolate appropriate species and carry out the required protocols for their introduction (El Brazzese pers com).

4.4 Matching Appropriate Control Methods to Willow Problems

The choice of the most appropriate control method will depend on the species present and the context of the problem. It is more economical, and less damaging to the surrounding riparian vegetation, if willows can be poisoned and left to rot away naturally. This is particularly appropriate in isolated areas, and where there is no access for the general public. However dead willows become brittle, and shed branches readily. In any area where people may be at risk from falling branches or where woody debris falling into the river may create a hazard, it is necessary to remove poisoned willows once they are dead. Timing of removal is important as the hazard to workers increases as the stems become more brittle, but the willows must not retain enough life that debris left behind in the mud is able to grow.

Disposal of cut willows can be an issue, particularly in urban areas or on small properties where there is no room for the traditional stacking for later burning. Mulching in a chipper may be a potential technique, which can provide a resource with commercial value or for use in revegetation of the site. If live material is chipped it should be stored for some months before use to prevent growth of fragments.

Examples of recommended control methods for the management of willows in a range of situations is provided in Table 4.2

Table 4.2 Choice of Willow Management Methods

Willow problem	Recommended control	Follow up required
Scattered willows in native riparian area	Poison. Leave in situ if no risk from dead stems.	Monitor for satisfactory regeneration and further outbreaks.
Equal mix of native plants and willows	Poison. Remove unless there is no risk from dead trees.	Weed control for 12 months then plant, if no regeneration
Fully willow dominated reaches in forested areas	Poison and remove unless there is no risk from dead trees.	Monitor for regeneration. Introduce natives if no regeneration in 2 years. Control weeds.
Fully willow dominated in cleared farmland.	Poison in sections over several years, remove if necessary.	Plant progressively as willows die and clean up is complete.
Seeding willows spreading	Poison parent trees, remove if necessary. Hand pull or spray seedlings.	Revegetate as necessary. Find and remove seed sources up to 2 km from the river .
Willow seedlings on gravel bars in stream bed	Hand pull if small numbers, or foliar spray before too big (<2m).	Monitor for surviving seedlings.
Mixed willow species including high priority seeding or fragile species	Poison and remove fragile and seeding species as high priority, follow up with other species as budget allows.	Revegetate as space becomes available. <i>Note:</i> In some sites it may be more efficient to remove all willows rather than select invasive species.

Willow problem	Recommended control	Follow up required
Urban areas (where leaving willows to die may be too unsightly)	Cut and paint. Particular care needed to retrieve all fragments and prevent transport downstream.	Revegetate with local spp. Good follow up needed to control surviving fragments.
Ageing, non-invasive willows, important for stability.	Lop willows and leave in place to maintain stability while revegetation establishes. Paint some cuts to reduce coppicing.	Poison willows once native vegetation can provide stability



Plate 11 Goulburn River (Willow dominance)



Plate 12 Willow removed

4.5 Minimising the Impacts of Willow Removal

4.5.1 Protection of Sensitive Vegetation during Removal Work

If there is native vegetation in the vicinity of the works area, this must be protected from damage as far as possible, as it will be very important in the rehabilitation of the site. Such areas should be screened by protective fencing, such as para-webbing, to prevent accidental damage by machinery. Dead native trees should also be protected for their habitat value. Where standing dead trees provide a safety issue, if feasible, they should be fenced to restrict access into the danger area. When this is not an option, they should be felled, and left on site to provide 'fallen timber' habitat in the revegetation area.

4.5.2 Staged Removal

Removal of large numbers of willows, while aiming to improve the riparian environment, can have a detrimental effect on the condition of the stream in the short term. Particularly on streams which are heavily dominated by willows, to the exclusion of other vegetation, their removal may have a catastrophic, if temporary, impact on in-stream diversity. Willows do provide some shade, shelter and structure to the terrestrial and aquatic environment, and the change from this to a bare bank removes all habitat. At sites where willows are dense and dominant, replanting with native species will be necessary. To reduce the impact on the stream environment, it is recommended that large projects be staged over several years (up to 10 years), with removal of short sections of willows (up to 300 metres) each year and only one bank cleared in each reach. This will allow the revegetation to become established in each section while the remaining willows continue to provide some shade, structure and stability to the banks and bed of the stream. In particularly sensitive sites, (e.g. rare fish sites) sections as short as 30 metres in each 150 metres should be treated at one time, and as long as five years allowed for the revegetation to be effective before adjacent sections are cleared of willows. This will be a more expensive process than a complete clearing and revegetation project in a single exercise, but would have less impact on the aquatic environment. It will also reduce the impact on bank stability and lessen the visual impact. A return to the site each year for treatment of the next stage can be combined with follow up work on earlier stages.

4.6 Site Rehabilitation

Except for sites where risk to assets requires urgent work, all willow management and control should be carried out as part of a Riparian Vegetation Program, which aims to rehabilitate a natural riparian environment. The restoration of a native vegetation community must therefore be the goal in works carried out on rivers and streams in the catchment. While the riparian communities in the upper reaches of the catchment, particularly those in Crown Land, are generally in good condition, most others have suffered some degradation from grazing or other disturbance. Even when the dominant tree layers are still present, there has generally been loss of species in the shrub and ground layers, and invasion by exotic weeds. When willows are removed, the rehabilitation of the banks must be part of the works program. Adjacent landholders should be kept fully informed about the revegetation program, and encouraged to appreciate the value of a natural riparian zone to the property, as successful long term management will depend on his or her actions (see section 3.6).

Planning for revegetation should commence at the beginning of the project. The site should be surveyed to identify any existing native vegetation (including ground cover plants) which may require protection during works. At some sites, revegetation may involve no more than fencing for grazing control and control of weeds, while natural regeneration of the local suite of riparian species can occur. However where willows have been dominant for some time, it is probable that there are few or no native riparian plants left in the vicinity, the soil seed bank is depleted, and there is not sufficient movement of seed from upstream to reintroduce the range of species needed to restore the original riparian community. At these sites, it will be necessary to reintroduce a number of core species to rehabilitate the site. Only local species should be used, grown from local provenance, and the mix of trees, shrubs and ground covers should reflect the structure of the riparian vegetation in the locality. The Revegetation Guide for the Goulburn-Broken Catchment provides useful information on species distribution for the sub-catchments of the region, as does the Riparian Vegetation Guidelines for the Upper Goulburn Catchment.

Planting is generally carried out using tube stock or cell-grown plants (eg Hicos). If sufficient seed can be obtained, direct seeding, by hand or machine, can be a very effective way of achieving revegetation. The Revegetation Guide provides advice on direct seeding techniques. Trials should be undertaken at suitable sites, in conjunction with conventional tube stock planting, to gain experience and determine the suitability of the technique in a range of site conditions.

All rehabilitation works must involve fencing of the riparian zone. This fencing should be regarded as permanent, although it does not preclude grazing as a management tool. The practicalities of grazing management provide an argument for a wide riparian reserve, as grazing a 30-40 metre stream bank is more easily managed than a 6-10 metre strip. Access for weed management is also easier. A very wide fenced riparian zone can, in some circumstances, be regarded as a special management paddock, rather than an exclusion zone that harbours pests and is just a nuisance to adjoining landholders. However long term sympathetic management is essential and this is a case by case arrangement.

Where appropriate, simple management plans, or management agreements, should be drawn up with adjacent land managers, to clearly identify the role of the CMA and the land manager in the continued protection and rehabilitation of project sites.

4.7 Assessment of Project Effectiveness

The effectiveness of the Willow Management Strategy can be assessed at the level of individual projects, and also at a broader more general scale, in terms of improved health of the rivers and streams in the Catchment. An increased level of understanding and appreciation of healthy streams by the general community would also be a measure of effectiveness of willow management projects and the associated communications strategy.

At the individual project level, success is measured firstly by completion of the actual works involved, including the successful revegetation of the site and follow up inspections to confirm that willows have been successfully removed, with no regrowth.

Improved stream health will not be measurable for a few years, when riparian vegetation is well established and the stream morphology has stabilised following changes to the bank conditions. A description of the site can then be compared with the original survey prior to the works, including a photographic record, and/or a modified Index of Stream Condition assessment. The attitude to the project of the local landholders and community may also be a relevant measure of project effectiveness, as good long term management of the riparian zone often depends on the adjacent land management.

5 Summary of Tasks to be carried out in a Willow Management Action Plan

Activity	Task	Estimated Cost (\$k)	Priority	Comment
Develop knowledge base which will support strategic decisions	<ul style="list-style-type: none"> High priority waterways 	100	1	This will enable identification of risks to assets (natural and structural), and risk of spread based on existing condition ranking. Species identification skill training should be provided to staff. Ensure that all staff are able to contribute verifiable information to database at regular intervals.
	<ul style="list-style-type: none"> Secondary waterways 	200	2	
	<ul style="list-style-type: none"> All other waterways 	250	3	
Establish process of setting priorities for long term and short term works	Identify opportunities for maximum gains in riparian health through a balance between long term strategic improvements and urgent preventative work.	1-2/ann	1	Long term strategic work is generally the most important, but the ability to respond to urgent preventative issues is also important to avoid more expense in the future Opportunities include complete removal of Black Willow and Grey Sallow from all catchments.
Develop and Implement long term strategic programs	Use knowledge database to identify opportunities for long term riparian improvement	5/ann	1	Long term works plans may be 5-10 year programs for priority reaches. Eradication programs should commence in upper reaches and move progressively down the catchment.
	Develop sub-catchment or regionally based works programs for willow management activity in high priority areas	250-700/ann	1	Willow eradication may be initially of priority species, or of all willows, depending on desired outcomes for the reach. High quality riparian vegetation requiring minor resources will give the most immediate return.
Develop and implement shorter, annual, projects, in balance with long term goals	Maintain capacity for <i>reactive</i> works to willow issues and opportunities which may arise.	100-250/ann	2-3	Opportunities to complete willow removal on sites where other work is being carried out, or where landowner support effectively gears up the project effectiveness
	Carry out <i>emergency</i> works in high risk situations where action in the short term can save a major outbreak and high expense later.	50-100/ann	1	New seedling outbreaks or discovery of compatible seeding trees need a quick response capability

Monitor works outcomes and maintain database	Use a modified Index of Stream Condition assessment and written and photographic documentation at all project sites to establish a benchmark condition. Repeated two, five and ten years later.	1/work site	1	A standardised record of riparian response to works is essential for an assessment of outcomes.
	Hold an annual workshop including all staff involved in riparian management, to review outcomes.	2-3/ann	1	Inclusion of staff in an annual review of works will provide maximum input to the database and an ownership of outcomes.
	Establish process to maintain database	5-10/ann	1	Insert new data and review and update existing data
Maintain an adaptive management approach	Monitor earlier works, to record outcomes and carry out necessary follow up actions	Included above		Monitoring of earlier projects may indicate changes which could be made to the implementation of future projects.
	Regularly evaluate outcomes of works and review programs .	„		Experience in successes and failures should be shared across the catchment.
	Involve all staff in works reviews	„		
	Accept some uncertainty of outcome if there is an opportunity of improving knowledge	„		Some carefully planned and documented experiments and trials can answer some don't know' questions.
Develop communication strategy to provide information about willow issues for stakeholders and general public .	Develop resource material to assist with public education about willows and to explain proposed works	150	1	Appropriate material will include general information and site specific details of the proposed works
	Carry out consultation with stakeholders as part of each works project, particularly with adjacent landholders Communicate long term goals for target areas	Included in site work		Maintain communication with stakeholders on an ongoing basis. Adjacent landholders can have the greatest influence on riparian quality
	Promote successful outcomes – improved riparian health resulting from willow management activities	50/ann	1-2	Field days (learning by seeing), are the most effective form of communication for many stakeholders
	Establish process to share knowledge and experience with other CMAs	10/ann	1-2	Invite participation in annual forums from other CMAs.

Encourage community involvement	Investigate and trial 'Capacity Assessment Tool'	5	1	Willow management will benefit from active, informed community involvement
Highlight the implications of the import, propagation, cultivation, sale and transport of willows;	Lobby for change in the importation law to prevent the introduction of new problem willows.	10	1	
	Establish communication with retail plant nurseries in the region, to explain potential risks associated with unknown willow species	50/ann	1	Stakeholders include the Plant Nursery Industry, farmers and domestic gardeners
	Consider Willow Management in the review of the Goulburn Broken Region Weed Action Plan.	1	2-3	The status of willows as weeds has implications for Statutory powers and obligations.
Secure the necessary resources to carry out the program	Submit funding bids for strategic components of willow management program	5/ann	1	Core management and administrative tasks could be funded from core state waterway program funding. Additional funds need to be sourced to deliver the major field work elements of the program
	Assign willow management tasks to staff and contractors	2/ann	1	Data collection and data base maintenance should be carried out by staff. Contractors or Consultants could deliver specific field programs under CMA field staff supervision
	Provide appropriate training and equipment for staff/contractors to carry out the necessary tasks	10/ann	1	All personnel involved in program will require willow identification skills and practical training in control techniques

Cost Summary \$716k plus up to \$1220k/annum based on 50 work sites per year.

6 Source Material, References and Further Reading

Agriculture and Resource Management Council of Australia & New Zealand, Australian & New Zealand Environment & Conservation Council and Forestry Ministers, (2001) *Weeds of National Significance: Willow (Salix taxa, excluding S babylonica, S x calodendron and S x reichardtii) Strategic Plan*. National Weeds Strategy Executive Committee, Launceston.

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