STRATEGIC ACTION PLAN:

Willows in the North Central region, Victoria

July 2008

NORTH CENTRAL
Catchment Management Authority

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This Strategic Action Plan has been built on a wide range of previous documents, including strategies, discussion papers and general articles. These sources have been acknowledged in detail through the text and are listed in the references.

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Executive Summary

Willows *Salix* spp. trees are not native to Australia. In the early 1900's they were originally introduced as a land management tool to control erosion along rivers and streams. However, by the mid 1980's it was increasingly recognised that the natural spread of Willows was becoming a stream management problem. Willows can actually exacerbate stream erosion and flooding and contribute detrimentally to a number of stream health values and processes.

We also now have a greater understanding of the capacity of some Willow species to reproduce by seed, which through wind and water dispersal results in a more rapid expansion. Within the North Central region there are already established seeding Willow species plus an ongoing process of hybridisation with newly introduced species used for farm plantings. This process continues to develop new fertile hybrids which also reproduce by seed and further threaten the catchment.

These factors have changed our perception of willows as a risk rather than a benefit. As a result all Willows (except for Weeping Willows *Salix babylonica*, Pussy Willow *S. x calodendron* and Sterile Pussy Willow *S. x reichardtii*) are recognised by the Australian Weeds Committee as a Weed of National Significance (WONS). Under the Weeds of National Significance framework there is an obligation on natural resource managers around Australia, such as the North Central Catchment Management Authority (CMA), to undertake local planning and control activities to manage Willow populations.

This strategic action plan aligns with the North Central CMA Board's mission statement of "*Leading, coordinating and integrating sustainable natural resource management for the benefit of our rivers and the communities that depend on them"* and with the North Central CMA 's role as caretaker of river health for the North Central region.

The plan also aligns with the Investment Framework for Environmental Resources (INFER) utilised within the North Central region. This decision framework allows natural resource management investors to achieve the highest value natural resource management outcomes. The actions in this document will help direct investment into priority localised assets and are aligned with state and federal priorities for the management of willows.

An important part of developing this strategy was engagement with the community, and through this investigation it was determined that the perceived value and threat posed by Willows varies throughout the catchment. The community feedback suggested that there is not one universal view towards willows or priority locations and species for management. While those involved in natural resource management generally take the view that the advantages of Willows are outweighed by the problems they cause, the community in some areas attach a number of aesthetic and historical values that make consideration of willow management and control more complex.

This strategy aims to ensure that Willow management is undertaken in a strategic manner to ensure an effective, co-ordinated and value for money process outcome.

There are a number of issues that were considered in the formation of this Strategic Action Plan. Through the review of literature and discussion with the community and government stakeholders, a list of 13 key considerations for Willow management in the region was created and is presented in Figure 1.

Figure 1 - Key considerations for Willow management in the North Central region

Through the investigation of these considerations a number of Key Management Principles are drawn out. These Key Management Principles underpin the focus of activity and the actions for Willow management presented in this report. The Key Management Principles for Willow management in the North Central region include;

Principle 1 Address all high risk invasive species first (namely Grey Sallow, Gold-Crack (often called Basket Willow) and Crack Willow and seeding hybrid Willows).

Principle 2 To avoid the creation of new seeding hybrids, no new horticultural Willow plants or taxa should be introduced into the North Central catchment.

Principle 3 Where invasive species are present, Willow management should start at the top of catchments and work down.

Principle 4 Eradication of seeding willows must be complemented and coordinated with control works in the adjacent catchment.

Principle 5 Further data needs to be collected to inform the North Central CMA on where high risk species are, where they are having the greatest impacts, and where they may threaten high value natural assets.

Principle 6 Protect the best first (high value wetlands and high value waterways).

Principle 7 Prevent Willows invading downstream high value assets from upstream.

Principle 8 Poisoning in-situ should be the first consideration due to its limited impact on the surrounding environment and it is substantially cheaper, but where there is a monoculture of Willow

along the waterway then cutting and removal is required to protect downstream civil assets. Follow up revegetation is always required with the cut and removal process. In general the principles contained in National Willows Management Guide (DPI 2007) should be applied in the selection of removal techniques.

Principle 9 Management activity should be aligned with the intent of Weeds of National Significance status program.

Principle 10 Where there is major disturbance from removal activity, a holistic approach must be used and include funding for weed control, fencing, revegetation, maintenance and monitoring.

Principle 11 Monitoring of all sites post works is necessary and must be planned and budgeted for.

Principle 12 Recognise Willows around towns with high heritage and amenity value and engage with the community to manage accordingly.

Principle 13 Engage with local landowners and stakeholders to understand their level of support prior to any activity being initiated.

Principle 14 Recognise that some parts of the community have very strong feelings about Willows and that further consultation is required with all community members to understand their issues better.

Principle 15 Establish a transparent and collaborative decision making process to focus Willow control activity into the future.

This Plan does not attempt to provide a prescriptive list of priority sites for the management of Willows. Instead, through considering the Key Principles and establishing a transparent decision making process to guide site specific works sites, it allows progression of Willow management activities in the region. In this way Willow control works can be integrated and programmed with a range of waterway works planned by the North Central CMA.

This Plan intends to move away from a reactive Willow removal approach to a strategic approach and thus it aims to ensure the North Central CMA approach this issue with a considered, holistic management approach, resulting in multiple and sustainable benefits to the environment.

1 Introduction

This document has been produced to support the North Central Catchment Management Authority (CMA) in developing an approach to manage Willows in a manner that ensures effort is invested into the right areas and is supported by an informed community.

This document was produced through a review of relevant literature and engagement with the North Central community and other government stakeholders. This engagement provided an opportunity to capture feedback on the community's views of Willows, and where possible capture further data on the locations of known Willows.

The structure of this report has been considered to allow the development of an understanding of Willows and their impacts, followed by a discussion on the current condition of Willows in the North Central catchment. This background information feeds into a discussion on the key considerations for management and presents a number of actions that when implemented, will direct effort in a strategic and cost effective way. The structure of the report is described in Figure 1.

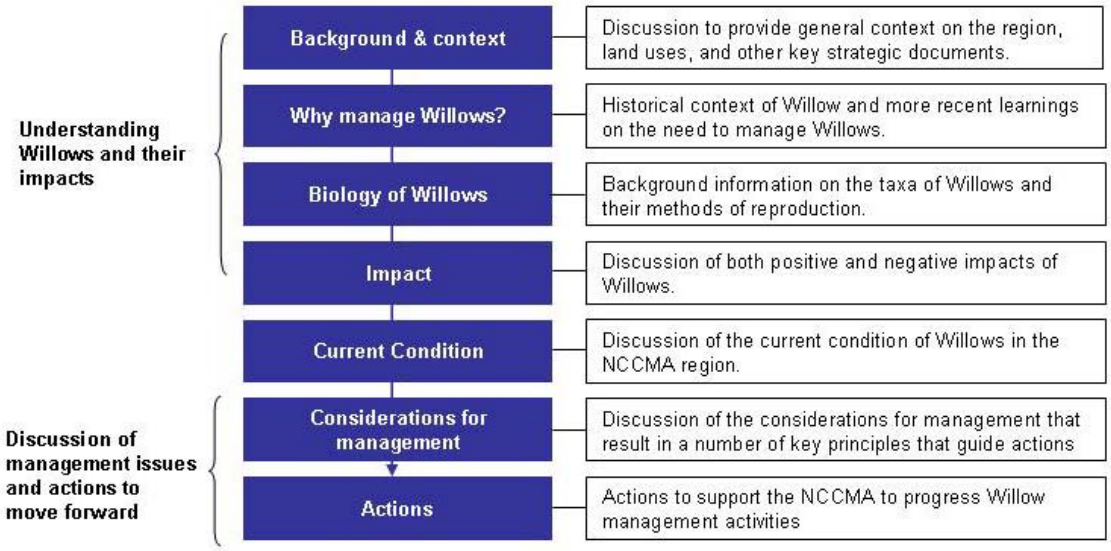

Figure 2 – Structure of document

Through implementation of this Plan the North Central CMA should ultimately achieve,

- a strategic approach to Willow management which results in multiple and sustainable benefits to the environment.
- a reduced threat to, and increased ecological diversity of high value riparian environments.
- a reduced threat of Willows which pose significant flooding or erosion risk.
- a program that works effectively with the community to harness local enthusiasm and support.
- improved effectiveness and transparency of expenditure.

2 Background and context

2.1 The Region

The North Central region is one of ten Catchment Management Authority (CMA) regions in Victoria. It comprises an area of almost three million hectares (ha), approximately 13% of Victoria. **Figure 2** provides a spatial view of the catchment and its sub catchments which include the Campaspe, Loddon, Avoca and Avon-Richardson.

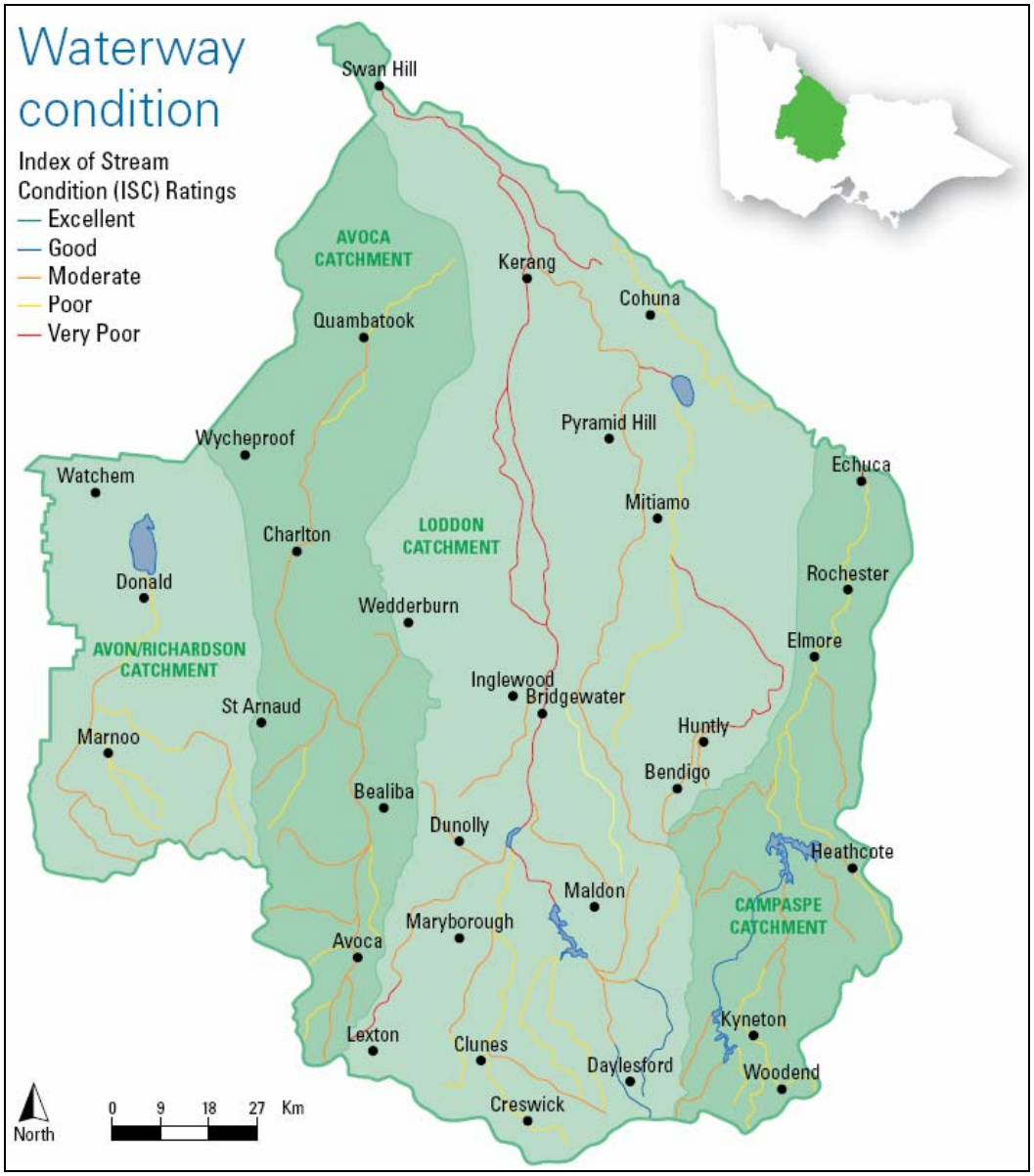

Figure 3 – North Central CMA Catchment Boundary (NCCMA. 2005a)

2.2 Landuse

The North Central region is agriculturally diverse with both dryland and irrigation farming systems present. The irrigation land use covers a large portion of the northern Loddon and Campaspe riverine plains where dairy farming and horticulture are the main enterprises.

The balance of the catchment is dryland agricultural incorporating broadacre land uses such as cropping and grazing, and public land areas which often provide an opportunity for commercial forestry. Intensive animal production industries are also represented in the catchment.

2.3 Natural Assets

The catchment has a number of key natural assets which are a focus for natural resource management activity in the region.

Waterways and wetlands

The region has a number of important waterways which contribute flows into the Murray River. These major waterways include the Campaspe River, Loddon River, Avon and Richardson Rivers and Avoca River. These rivers and their tributaries play an important role in the social and environmental fabric of the region. They provide drinking and irrigation water, contribute to biodiversity values, have strong cultural and historical associations and are a focal point for recreation and tourism.

The region also boasts high value wetland complexes including the Gunbower Forest and Kerang Lakes, and the Avoca Lakes(Lake Bael Bael and The Marsh) which are of international significance, and listed under the Ramsar convention. These and many of the region's other wetlands provide habitat for migratory birds protected under international agreements.

Native vegetation

Native vegetation is also an important natural asset and in general is quite degraded in all but the Central Victorian Uplands, Goldfields and Murray Fans bioregions. Although 19% of the region retains native vegetation coverage, Much of what remains is severally degraded and highly fragmented.

Through land clearance activity the catchment now has 100 species of native animal and around 300 species of native plant under threat. Woodlands and grassy woodlands which occupied the areas most readily developed for agriculture are especially poorly represented (NCCMA. 2003).

Nonetheless, the region does retain some of the most extensive Box-ironbark and River Red Gum forests in the State (NCCMA. 2003) and a substantial area of public land in the region has been set aside for nature conservation. The major reserves include the Terrick Terrick, Greater Bendigo, Castlemaine Diggings Heritage, St Arnaud Range and Heathcote-Graytown National Parks.

Together with State and Regional Parks such as the Hepburn and Creswick Regional Parks and other types of reserves around 100,000 ha of public land has been set aside for nature conservation and compatible land uses.

2.4 Context with other key Strategy Documents

It is important to note that this document has not been developed in isolation and is intended to be consistent with, and build on, the knowledge and principles captured in a number of local, state and national strategic documents. The following documents were considered in the development of this Plan.

- The National Strategy for the Conservation of Biological Diversity (DEST 1996), which provides a framework for the cooperative protection of Australia's biological diversity and includes key biodiversity protection principles.
- The Weeds of National Significance (WoNS) Strategic Plan for Willow (National Weeds Strategy Executive Committee, 2000), which provides direction of Willow management at a national level.
- Victoria's Native Vegetation Framework (DNRE 2002), which provides a number of guiding principles for the retention and management of native vegetation.
- North Central Regional Catchment Strategy (NCCMA 2003), which provides a vision for the future landscape of the North Central region and the management of its natural resources.
- The North Central River Health Strategy (NCCMA 2005) which establishes regional priorities for river protection over a five year period.
- The Australian Weeds Strategy (DEW, 2007; formerly National Weeds Strategy 1997), which provides national guidance to assist and complement state and regional weed management programs.
- The Victorian Weeds Strategy (DNRE 1998), which provides a state-wide framework for the control and management of weeds.
- The North Central Weed Action Plan (NRE, 2001), which provides a regional weed management plan.
- The North Central Native Vegetation Plan (NCCMA 2005), which provides a regional plan for the management and protection of remnant native vegetation. This plan also addresses weed issues.

2.5 Context with North Central investment framework

This strategic action plan aligns with the North Central CMA Board's mission statement of "*Leading, coordinating and integrating sustainable natural resource management for the benefit of our rivers and the communities that depend on them"* and with the North Central CMA 's role as caretaker of river health for the North Central region.

The North Central CMA region utilises an investment framework focussed on improved targeting of natural resource management with the aim of achieving enduring results. Central to this framework is identifying, and targeting investment towards, high priority localised and dispersed assets and maximising the public good outcomes of any interventions. A localised asset is a specific asset such as a river reach or wetland whilst a dispersed asset is an asset that occurs over a large area such as soil or an ecological vegetation class.

This decision making framework is known as 'Investment Framework for Environmental Resources' or INFFER and has been developed through research collaborations involving the Future Farm Industries Cooperative Research Centre for Dryland Salinity, government agencies and catchment management bodies including the North Central CMA

This strategic action plan is aligned with the INFFER decision making framework. The actions in this document will help direct investment into priority localised assets and are aligned with state and federal priorities for the management of willows.

Importantly the strategic action plan recognises and addresses the context that the impacts and risks of willows are not restricted spatially and that works to protect a high value localised asset may need to be undertaken upstream, downstream or in neighbouring sub catchments, this particularly applies to the risk posed by seeding willows.

3 Why manage Willows?

Historical context

Following settlement of Victoria land clearing was encouraged and combined with early agricultural practices, gold mining, rabbits, irrigation schemes, control burning and unfenced waterways, soil erosion became the overwhelming land management issue.

The concern over the extent of erosion problems led to a four week erosion control symposium in 1938 and resulted in the formation of the Victorian Soil Conservation Board, Soil Conservation Regional Advisory Committees and the *Soil Conservation Act* 1940. In 1949 the first river improvement trusts and land drainage trusts were introduced along with the Soil Conservation Authority. When introducing the Soil Conservation and Land Utilisation Bill in 1949 Henry Bolte stated "*we could not have made a bigger mess of the soil of the country if its destruction had been carried out under supervision*".

Willows were planted by river improvement trust work crews for almost 50 years from the 1940's to the 1990's. At the time it was hard to imagine a plant species better adapted to, and more capable of stabilising and capturing sediment in a waterway. Willows are easily propagated, fast growing, and spread quickly. They have few insect predators and possess a strong, extensive root system that is highly effective at binding soil. They also have aesthetic appeal, provide shelter from sun and wind, and can be used for fodder.

By the mid 1980's River Trusts began to recognise that the natural spread of Willows was becoming a waterway management problem. Willows were spreading into important conservation areas where they out-competed native species, reduced natural diversity and were responsible for diverting flows.

It was also thought at the time that only one gender of each species was originally introduced so that production of seed could not occur and that local spreading would only be by deliberate planting or detached branches taking root on gravel bars and stream banks. However, a number of varieties of Willows have now been found to be producing viable seed and more recently it is now understood that Willows are not only breeding with their own species, but are hybridising with some other species of the same group (i.e. tree species or shrub species) .

Changes in land management

Since the introduction of Willows as a waterway management tool a number of land and natural resource management factors have changed, including,

- large scale erosion has diminished and stabilised in many catchments. Where confined areas of erosion exist they are now controlled by a range of structural interventions including the use of rock structures, and revegetation with appropriate indigenous vegetation. Erosion is no longer the overwhelming threat to ecological systems and agricultural production that it was.
- stock is increasingly being excluded from waterways through fencing and provision of off stream watering, which is also contributing to less waterway erosion issues.
- our attitude to native species has changed and they are now recognised as providing habitat values and also shade and shelter value for stock.
- agricultural practices (e.g. stocking rates or minimum tillage) have improved, native and non-native perennial vegetation is being re-established in catchments and waterways.
- rabbit numbers have substantially reduced allowing the reestablishment of vegetation along waterways.

All these changes mean large scale erosion problems no longer exist at the scale they did in the 1940's and 1950's, and this has largely negated the principal reason why Willows were first introduced.

Recent learnings

In addition to the changes in large scale erosion problems, we now have a much better understanding of the interaction of Willows and our biological and geomorphic systems. We now understand the capacity to invade and degrade intact riparian waterway habitat and values.

While the primary colonising attributes of Willows bring stability, they can have a significant impact on the capacity of stream systems to discharge flows and have increased the occurrence of overbank flooding and the risk of scour. Willows are often responsible for changing stream morphology, effectively altering and compounding instream erosion.

Willows are also generally considered to reduce aquatic biodiversity, including platypus, fish and macro-invertebrates, impacting on the overall health of a waterway.

Willows did at an earlier stage play a useful role in waterway management. However, the changes in land and natural resource management factors combined with a better understanding of their biology and environmental risk have resulted in a focus on Willows as a key weed threat to the health of our waterways.

National obligation

As a result of this change in awareness of Willow risk, all Willows (except for Weeping Willows *Salix babylonica*, Pussy Willow *S. x calodendron* and Sterile Pussy Willow *S. x reichardtii*) are recognised by the Australian Weeds Committee as Weeds of National Significance (WoNS) as part of the Australian Weeds Strategy (DEW, 2007).

Of the 3000 non-native naturalised plants that are recorded in Australian environments there are only 20 taxa classified as Weeds of National Significance. Certain species of Willow along with 19 other flora species were selected due to their invasiveness, impacts, potential for spread, socio-economic and environmental impacts.

Under the Weeds of National Significance framework there is an expectation that natural resource managers around Australia, such as the North Central CMA , will undertake local planning and control activities to manage Willow populations at a local scale.

State obligation

The NCCMA has a legislative obligation to control noxious weeds. In Victoria all willows (except *Salix alba* var. *caerulea*, *Salix alba* x *matsudana*, *Salix babylonica*, *Salix* X *calodendron*, *Salix caprea* 'Pendula', *Salix matsudana* 'Aurea', *Salix matsudana* 'Tortuosa', *Salix myrsinifolia* and *Salix* X *reichardtii*) declared as noxious weeds and are classified as Restricted Weeds in the North Central region. This means that are a serious threat to primary production, Crown Land, the environment or community health and must not be sold or traded in Victoria (DPI, 2008a, DPI 2008b).

Trajectory for Willows in the North Central CMA region

The WoNS Willow strategy emphasises the need for ongoing control of willow and management, particularly highly invasive taxa such as Grey Sallow *S. cinerea* which are expanding their range exponentially in Victoria and New South Wales (National Weeds Strategy Executive Committee, 2000).

Without management intervention it is likely that Willows will eventually become the dominant overstorey riparian species along all waterways in the higher rainfall areas of the catchment. It is also likely that with the introduction of new Willow species on farm land and through hybridisation processes that there will be substantially increased Willow populations in the lower floodplain reaches.

Biology of Willows

It is useful to develop an understanding of the biology of Willows that will help to inform this Strategic Action Plan on priorities and management approaches.

3.1 General Habitat

Willows are deciduous plants that usually occur on or near permanently or seasonally waterlogged locations. Willows typically form large, dense, root-mats on the surface of the substrate either in shallow water or on wet sites.

Willows are commonly divided into two broad groups based on their general habit. Tree Willows grow large with one or more trunks and typically can reach 10–30 m in height. Tree Willows often have brittle or fragile twigs and branches which break off with slight pressure in winter. Shrub Willows (sallows) vary from shrubs to small trees and normally have multiple stems and twigs or branches which are typically harder to break than Tree Willow species.

Willows have soft, fragile leaves that fall in late autumn. The leaves vary considerably in their shape depending on the taxon and the decomposing leaves provide a large input of organic matter to aquatic systems (Schulze & Walker, 1997).

3.2 Reproduction

Reproduction in Willows occurs by either sexual (flowering, fertilisation and seed formation) or asexual (vegetative) means, although some species do reproduce both sexually and asexually. Many taxa of Willows occur as same sex clones or predominantly one sex over their range in Australia.

Vegetative

Ladson (1997) identified that vegetative propagation occurs naturally mainly by two processes.

- Branches or twigs break off in floods or in high winds and become lodged in water or wet ground (this means of propagation can lead to spread of Willows over long distances).
- Trunks with intact root systems collapse, form new roots where the trunk is in contact with the soil and new trunks grow from the collapsed stems (termed layering, this process leads to more localised spread of Willows and the formation of small patches).

In some species a single plant may develop hundreds of stems producing a thicket more than 10 metres in diameter making control extremely difficult. The level of fragility of twigs and stems is considered the single most important factor influencing the ease of colonisation by vegetative means.

The most abundant and vegetatively invasive Willows along Victorian waterways typically have the most brittle and fragile twigs and stems (Ladson, 1997).

Sexual

Some species of Willows reproduce almost exclusively by seed or by sexual reproductive processes. In Victoria the main flowering season is September and October, but the actual timing of seeding does vary between taxa, geographic locality and climatic conditions. Very large quantities of seed are normally produced by an individual plant and the progeny resulting from seed comprise both sexes.

Willows normally flower within two or three years after germinating, typically once the plant is 1 m tall (in Shrub Willows) or 2 m tall (in Tree Willows). In Australia, Willows are normally pollinated by insects, particularly European Bees and native bees, and possibly by wind. Cross-pollination typically occurs over distances of around 300 m *(Cremer et al., 1995)*, but is also known to occur over distances of up to 1 km (Cremer, 1999).

Willow seed is small with long, silky hairs and is dispersed by wind or water, often over large distances of up to 100 km meaning seeding Willow can invade both upstream and downstream environments. Willow seed is not adapted for transport by birds or other animals and transport by vehicles is not considered to be significant in their spread (Cremer, 1999).

Willow seeds have short life-spans, typically about two weeks (Cremer *et al*., 1995; Meikle, 1990) and for germination to occur the seed needs to lodge in wet ground or suitable bare, wet substrate. Germination is extremely rapid and occurs within 24 hours of lodgement (Ladson, 1997).

Massed recruitment of Willows by seed typically occurs on exposed wet sand, mud and less often gravel (Cremer *et al*., 1995; Ladson, 1997). Willow seedlings typically establish in swathes or 'galleries' along the wet edges of gravel bars or at the foot of river banks. Once sediments have accumulated to bury their bases, these Willows appear as though they are growing from higher, dry ground.

It has been noted that major disturbances within waterways such as floods or fires often open up large bare areas that provide a highly suitable bed for seed germination.

3.3 Taxonomy and Identification

There are estimated to be 28–32 different Willow taxa in Australia, including species, subspecies, varieties and primary hybrids (Ladson, 1997; National Weeds Strategy Executive Committee, 2000). Ladson (1997) estimated 23 taxa to be naturalised in Victoria, however, more recent studies reveal the presence of complex hybrids in Victoria which have not been historically recognised (Ecology Australia, 2007). Some of these complex hybrids are believed to have originated from recently introduced taxa used in the commercial Willow industry (Ecology Australia, 2007).

Willows are very promiscuous and hybridisation can apparently occur between any Willow of the same subgenus. The occurrence of bisexuality, particularly in hybrids, is a major problem for the management of Willow in Australia. Given the facility for hybridisation to occur, additional hybrids within subgenera will continue to appear in Australia and the chances of this are increasing as Willow hybrids are still being planted on farms primarily for shade and shelter of stock (Ladson, 1997).

Identification can sometimes be challenging and a good reference for identifying the main Victorian Willow species and hybrids is the WoNS resource sheet (No 2). This document is presented in Appendix E.

3.4 High Risk Taxa

Different Willow taxa vary in their ability to colonise areas, but there are certain taxa that are particularly invasive along Australian waterways. The following (largely from Ladson [1997]) provides an overview of willows that are generally considered the highest invasive threat in Australia.

Grey Sallow (Grey Willow or Pussy Willow)
***Salix cinerea* (including *S. cinerea var. cinerea* and *S. cinerea var. oleifolia*)**

Also known as Wild Pussy Willow, Rusty Sallow or Grey Willow, this large spreading shrub or small tree is 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. Grey Sallow can also form hybrids with other shrub Willows. This species is capable of spreading away from the riparian zone and often occurs in wetlands and drainage lines. This species appears to be rapidly expanding its range in Victoria and it has been estimated that about 2000 kilometres of waterways are infested with Grey Sallow in eastern Victoria alone.

Crack Willow (and Gold-crack Willow - also called Basket Willow)
Salix fragilis* var. *fragilis* and *S.* x *rubens

These species are single or multi-stemmed trees and are widespread across Victoria. They have been widely used for river stabilisation in the past and have now naturalised and dominate many thousands of kilometres of streams. Both species are very brittle and twigs break off the main plant very easily and can be carried downstream to vegetatively reproduce. Crack Willow readily forms hybrids with other Willow taxa in Australia which have the ability to produce viable seed. Please note that to align common names around Australia Basket Willow in this document is refereed to as Gold-crack Willow

Black Willow
Salix nigra

This species has been widely planted in north-east Victoria, the ACT and NSW by river management authorities. Both sexes are present in Australia and it sets seed freely. Fortunately Black Willow has not been recorded in the North Central Catchment Management Region.

Weeping Willow
***Salix babylonica* and hybrid *Salix* x *sepulcralis* var. *sepulcralis* (from cross of *S. babylonica* x *S. alba* var. *alba*)**

Whilst these taxa are not generally identified as a serious invasive Willow in Australia in their own right, more recently it has been found that they do have the potential to hybridise with other taxa to form rapidly expanding hybrid populations. The formation of these complex hybrids is a substantial threat and has greatly increased the potential for Willows to spread in Australia.

4 Impact on the aquatic and riparian environments

Willows have a range of effects on waterways and their surrounds and the following provides an overview of the documented detrimental effects and also their beneficial values.

4.1 Detrimental Effects

To understand the detrimental impacts of Willows it is useful to consider the five key components that contribute to waterway health as presented in Figure 3. These five components form the basis for the Index of Stream Condition (ISC) method of assessing waterway health which is the standard assessment tool used across Victoria.

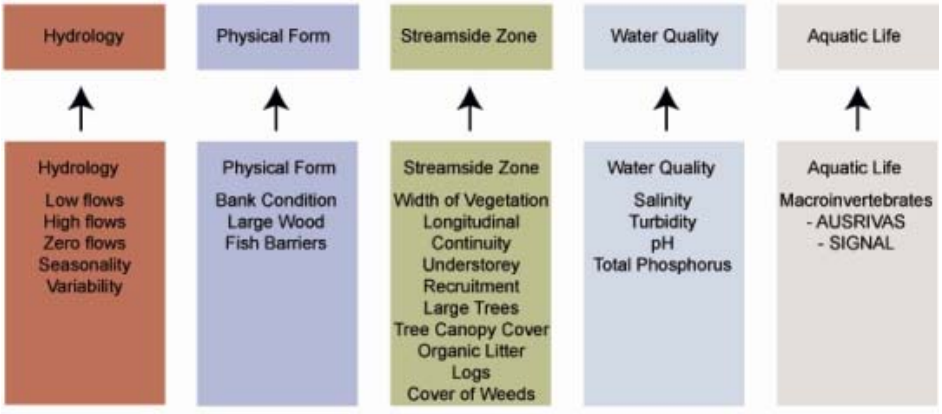

Figure 4 – Key components of stream health (DSE, 2008b)

Hydrology

Hydrology relates to the flow of water specifically the range, frequency, and timing of flows in waterways. The flow of water can be critical to many ecological processes such as the breeding of some fish species. Hydrology is closely related to hydraulics and detrimental impacts of stream hydrology and hydraulics include,

- the growth habit of Willows allows them to spread into aquatic areas which can have significant impacts on the movement and velocity of water.
- Willows in waterways can divert water and actually accelerate bank erosion in high flows and contribution to waterway course changes.
- Willows can occupy the entire cross section of a waterway and effectively reduce channel capacity which results in increased flooding and bank overtopping.
- Recent and ongoing research indicates that willows in the actual waterway channel consume large amounts of water compared to native vegetation (Doody *et al*, 2006).

Physical Form

Physical form refers to all the physical attributes of the waterway. This includes aspects such as the bed and banks of the river and even the instream timber of a waterway.

- Willows can lead to reduced bank undercut in low flows and loss of deep holes through sediment accumulation. Both these effects can have an impact on habitat values for animals such as fish and platypus.
- Willow timber is much lighter than native hardwood and can result in reduction of effective large woody debris in streams. Being light means fallen timber moves easily in high flows and does not persist long enough in a waterway to be a useful source of waterway habitat, often called woody debris.

Streamside Zone

Streamside zone refers to the health and width of the riparian vegetation that runs adjacent to waterways.

- Dense Willow cover results in denser shade in summer which in turn can shade out riparian understorey and ground cover species. This results in a monoculture of Willows along the stream bank and reduced habitat values.
- Significant Willow infestations result in reduced faunal habitat and food supply for riparian and terrestrial fauna.
- Dense Willow cover results in denser shade in summer which in turn can shade out native aquatic species resulting in reduced habitat and in some cases increased bank erosion.

Water Quality

Water quality generally refers to nutrients and physio chemical components such as pH, salinity and oxygen levels. All of these factors when exceeding natural levels can cause problems for fish, plants and other forms of aquatic life.

- Where native plants drop leaf litter more or less continually throughout the year Willows, being deciduous, tend to concentrate leaf fall in autumn. This can dramatically increase organic matter loads over a short period of time and is associated with reduced dissolved oxygen concentrations. This in turn impacts on the health of all living species susceptible to reduced dissolved oxygen levels.

Aquatic Life

Aquatic life includes all the animals, insects and plants that live in waterways.

- Generally it is considered that willows reduce aquatic biodiversity, including macro-invertebrate assemblages, and reduce habitat for native fish and platypus. However, it should be noted that some individual species may benefit from Willow populations.
- Generally Willows are less attractive to insects and as a result less insects fall into the river reducing food sources for fish and other animals.

4.2 Beneficial Values

Willows do have a number of beneficial values.

- Willows have a dense mat of shallow roots that trap silt and sediment that may impact on downstream environments if Willows were not present (Wilson, 1999; Zukowski & Gawne, 2006).
- It is generally recognised that a stream with Willow present is more beneficial to a stream with no riparian vegetation at all where they do provide shade and organic inputs.
- For many people Willow species provide an aesthetically pleasing change to the landscape, particularly around townsites and parks.
- In heavily cleared farmland they may be the only source of shade and shelter for stock.
- Some Willows have heritage values, such as marking sites of early settlers.
- Some Willows have commercial uses. Crack Willow (*Salix fragilis*) was used to provide materials for the basket-making industry in the 1800s and early 1900s, but this is now limited to a very small craft industry. A cricket bat industry using the Cricket Bat Willow (*Salix alba var. caerulea*) operated in Victoria in the 1800s until the mid 1900s, and was discontinued untill recently when it was revived with plantations in several locations in Victoria (including at Shepherd's Flat near Daylesford) and Tasmania.
- Willows can provide a source of pollen and nectar for honey bees, but the pollen is considered to be of poor nutritional quality by apiarists. The cut-flower industry also uses Grey Sallow (*Salix cinerea*) and other Willows for winter-bare branches especially Tortured Willow *S. matsudana tortuosa*.
- In some south-east Australian locations, naturalised and planted Willows are valued as elements in cultural landscapes, and some Willows are actually classified landscapes on the register of the National Estate.

5 Current status of Willow in the North Central Region

5.1 Taxa Present within the Region

A total of 21 taxa (including complex hybrids and hybrids originating at specific sites in the region) have been identified as naturalised in the North Central region (Ecology Australia, 2007). A detailed list of the species present in the North Central catchment which includes, origin, habitat, sex, reproduction, and (risk) priority for management is provided in Appendix A.

Of the 21 taxa present there are varying levels of management priority based on their ability to invade either by seed or vegetatively. The following table captures the taxa that possess a 'very high' priority for management within the North Central region.

Table 1 – Taxa with very high priority for management

Scientific name	**Common name**	**Reason for high priority**
Salix cinerea ssp. *cinerea*	Grey Sallow	Widespread, highly invasive seeding Willow
Salix x *calodendron* (hybrid between *S. caprea* x *S. cinerea sp. oleifolia* x *S. viminalis*)	Pussy Willow	Not known to be naturalised, but potentially hybridises with *S. cinerea*
Salix x reichardtii (cross of *S. caprea* x *S. cinerea sp. oleifolia* or *S. caprea* x *S. cinerea* ssp. *cinerea*)	Pussy Willow	Can hybridise with *S. cinerea* and highly invasive
Salix fragilis var. *fragilis*	Crack Willow	Widespread, highly invasive and able to form fertile hybrids with other taxa
Salix x *rubens* (cross of *S. alba* x *S. fragilis* var. *fragilis*)	Gold-crack Willow (also known as Basket Willow)	Highly invasive

5.2 Distribution within the Region

Due to the unreliability of data on Willow distribution a map of infestations has not been produced. However, a broad survey of Willows conducted by Ecology Australia in October 2006 found the following main points concerning the distribution of Willows in the North Central region (Ecology Australia, 2007).

- Willow infestations are most pronounced in the south-eastern part of the North Central region, particularly along the Loddon, Campaspe and Coliban Rivers. There are also numerous Willow infestations in or near various townships in the south-eastern part of the region away from major waterways.
- Tree Willow populations (particularly Crack Willow and Gold-crack Willow) are prevalent on permanent streams in the southern wetter parts of the region, including the Coliban River and Campbells Creek. These were introduced early on to the region as stream plantings on farms.
- Populations of Grey Sallow are abundant and expanding in the more elevated wetter parts of the region. Both sexes of this taxon were introduced and due to its ability to seed heavily it has colonised numerous stream beds, wet pastures, lake margins, farm dams and off stream

wetlands. Grey Sallow is considered to be the most invasive Willow in the North Central, the Glenelg Hopkins, Corangamite and Port Phillip and Westernport CMA regions (Carr *et al*., 2004; Ecology Australia, 2007).

- Much of the northern part of the region is relatively devoid of Willow except for plantings of certain taxa such as Golden Willow and Weeping Willow on farm dams or along waterways and irrigation channels. Generally in these areas stock grazing prevents naturalisation by vegetative reproduction.

  A recent survey in Gunbower Creek however did identify a number of naturalised willows to be abundant and expanding in the area. Grey Sallow, Crack and Gold-crack (or known as Basket) Willow were found to be prevalent throughout the creek system. In some areas planted Tortured Willow has begun to spread naturally.

- The most abundant Willow along the Murray River is Weeping Willow.

- Taxa relatively recently introduced into commercial horticulture (namely New Zealand Hybrid Willows and Chilean Pencil Willow) have led to localised recent hybridisation, as the more historic single-sex clones (e.g. Crack Willow or Gold-crack Willow) have been brought into contact with the 'new' taxa of the opposite sex. This has led to the expansion of fertile hybrids which reproduce by seed, particularly on streams, wet pasture or degraded land in or near towns such as Kyneton, Chewton, Castlemaine, Harcourt, Clunes, Creswick and Daylesford.

- Widespread taxa (such as Golden Willow, Golden Weeping Willow and Tortured Willow) were introduced fairly early to the region and were largely used for ornamental purposes. These are generally Tree Willows which occur as single-sex clones and are not, or only weakly naturalised on streams or off-stream wetlands.

Overall the North Central CMA has a large number of willow taxa and this unfortunately includes some of the most invasive species in Australia. Much of the permanent streams in the regions upper catchment have substantial infestation which does generally decline in severity within the mid and lower parts of the catchment. There are often willow populations surrounding towns and population centres.

6 Considerations for Willow Management

The current status of Willow in the North Central region suggests that action is required if the North Central CMA wishes to prevent further expansion of invasive species. It is generally not appropriate to simply react to individual requests for Willow control and a more strategic approach is required to ensure an effective, co-ordinated and value for money process is used.

Through the review of literature and discussion with the community and government stakeholders, a list of 13 key considerations for Willow management was created and is presented in Figure 4.

Through the discussion of these considerations and where appropriate, Key Management Principles have been drawn out. These Key Management Principles in some cases are unique to the North Central CMA and are used to guide actions captured in Section 7 of this document.

Figure 5 – Strategy considerations for the North Central catchment.

The following provides detail on each of these considerations and where it was relevant, Key Management Principles are proposed. It should be noted that not all considerations result in the creation of Principles and simply provide more context to a strategic approach to Willow management.

6.1 Taxa priorities

The literature review provided clear direction that this Plan should identify highly invasive seeding and brittle Willow species as they present the greatest threat to the region.

Seeding species that should be targeted include Grey Sallow *Salix cinerea* (including S.*cinerea var. cinerea* and S. *cinerea var. oleifolia*), and brittle species including Crack Willow *Salix fragilis* var. *fragilis* and Gold-crack Willow *S. x rubens.*

In addition to these established problem Willows, one of the greatest risks to the catchment is the continuing expansion of fertile hybrids. These are a result of hybridisation between invasive single-sex clone species (e.g. Crack Willow or Gold-crack Willow) with recently introduced New Zealand Hybrid Willows and Chilean Pencil Willow which have been planted on farms in the North Central catchment. The offspring of this union will be new hybrids and will reproduce by seed. This process threatens a broad range of land types including streams, wet pasture and degraded land.

Principle 1 Address all high risk invasive species first (namely Grey Sallow, Gold-crack and Crack Willow and seeding hybrid Willows).

Principle 2 To avoid the creation of new seeding hybrids, no new horticultural Willow plants or species should be introduced into the North Central region.

6.2 Catchment characteristics

The upper part of the North Central catchment has substantial populations of both brittle and seeding Willows. Tree Willow populations (particularly Crack Willow and Gold-crack Willow) are prevalent on permanent streams in the southern wetter parts of the region, including the Coliban River and Campbells Creek. Grey Sallow is also abundant and expanding in the more elevated wetter parts of the region (Ecology Australia 2007).

If the North Central CMA is going to be effective in the long term, the Willow populations at the top of the catchment need to be controlled.

Principle 3 Where invasive species are present, Willow management should start at the top of catchments and work down.

Another important consideration in management of the upper catchment of the North Central region is that Willow seed is highly mobile and can travel up to 100km airborne in the right conditions (CRC 2003). This means Willow seed can be transported from the adjacent catchments to reinfest the upper reaches of the Colliban, Loddon and Campaspe rivers.

Principle 4 Eradication of seeding willows must be complemented and coordinated with control works in adjacent catchments.

It was noted by Ecology Australia (2007) that much of the northern part of the region appears relatively devoid of Willow except for plantings of certain taxa such as Golden Willow and Weeping Willow on farm dams or along waterways where stock grazing prevents naturalisation by vegetative reproduction.

A consideration for the North Central CMA is that as it expands its program to fence riparian zones through the lower reaches of waterways and stock are excluded, it is likely that the loss of grazing will result in Willow establishment becoming more of a problem and there will be a greater need for monitoring and management actions in these regions.

6.3 Data for decision making

In order to prioritise control works a good understanding on where the high threat species are located and where they are having the greatest impact on the health of the waterway (for instance contributing to erosion issues) needs to be gained.

The data generated by other Willow investigation projects was reviewed and although it was useful to give general trends on the location of particular species, it was not sufficient to inform this Plan about which specific areas should be targeted first. In addition, the engagement with Community and other Stakeholders as part of this project also failed to provide any substantial and objective data on the locations of high threat species.

In order to focus any Willow management activity, better data is needed to ensure the highest priority areas are targeted first and to ensure funding is directed to the right places.

Principle 5 Further data needs to be collected to inform the North Central CMA on where high risk species are, where they are having the greatest impacts, and where they may threaten high value natural assets.

6.4 Protection of high value assets

The North Central region has a number of high value wetland and waterway assets. Two wetland complexes (Kerang Lakes and Gunbower Forest) and individually the Bael Bael and The Marsh wetlands in the Avoca system are in internationally recognised under the Ramsar Convention on Wetlands (1971). As a contracting party to this convention Australia is required to meet a number of obligations which include the maintenance of their ecological character (NCCMA, 2005a).

These two wetlands are linked to waterways and to protect the value of these wetland systems it is also important to maintain the health of these linked waterways. Specifically these waterways include the Avoca River (reaches 1-8), Loddon River (reaches 1-10), Pyramid Creek (reach 33) and the Murray River (not directly under the jurisdiction of the North Central region, but still important to consider in this Plan). (NCCMA, 2005a).

In addition to these internationally important wetlands there are also a number of nationally important wetlands including; Lake Buloke, Bunguluke wetlands, Lake Lalbert, Woolshed Swamp, Avoca Floodway, Tang Tang Swamp, Kow Swamp, Tragowel Swamp, Creswick Swamp and Merin Merin Swamp. All these wetlands also have linked waterways that are important to maintaining their health (NCCMA, 2005a).

The North Central region also has a number of important rivers which are key assets to the region. These waterways are either ‘near’ ecologically healthy or considered a ‘representative river’ which represents a major river type within Victoria. These waterways include sections of the Loddon River, Sailors Creek , Kangaroo Creek, Campaspe River, Coliban River, Axe Creek and the Avoca River (NCCMA, 2005a). Further detail on the location of these high value sections (termed reaches) can be found in the North Central River Health Strategy (North Central CMA 2005

It is important that Willow management activities consider these high value assets and control activity should be aimed at protecting and enhancing these areas. This generally means that the high value assets should be targeted directly for Willow control and the linked waterways or upstream environments should also be a focus of works to prevent Willows invading downstream into these high value assets.

Principle 6 High value waterway and wetland assets should be a high priority for Willow management works.

Principle 7 Waterways upstream of high value assets should be targeted for Willow control works to protect downstream values.

6.5 Physical control techniques

Most physical Willow control activity falls under two principal methods of either 'poisoning in-situ' or 'cut and removal'.

Poisoning in-situ

Where Willow is broadly disbursed amongst native vegetation then poisoning in-situ may be considered. Herbicide is applied directly into the plant's cambium layer normally through 'frilling' with a tomahawk. Trees die standing and over time will decay and fall. Further comment on control methods is provided in Appendix D.

The advantage of this method is there is very little disturbance to the surrounding environment, the soil structure remains intact, and native vegetation can easily recruit from the remnant vegetation.

The principle drawback to this method is the fallen debris is light timber, generally floats and is easily mobilised in high flows. This timber may in times of floods accumulate against downstream structures such as bridges and increase the chance of the structure failing, or increased flood impacts.

Cut and remove

Where Willow infestations are substantial and they form a closed canopy shading out all native vegetation below, then cutting and removal is normally a preferred option. This also negates the risk of dead Willow impacting on civil assets and allows for a managed revegetation program.

The drawback to this method is heavy machinery is often involved to move and stockpile the willow which can impact on surrounding vegetation and is substantially more costly than in-situ poisoning.

Applicability to the North Central catchment

Within the North Central catchment both approaches are valid. Where Willows are sparse and there are no major assets immediately downstream then poisoning in-situ should generally be undertaken. The large areas of public land such as the State Forest north of Lyonville are generally inaccessible by land and very suitable to this approach. In addition, the more sparse Willows on the lower floodplain reaches are also suited to this method.

In the upper higher rainfall reaches where Willow can totally dominate the waterway environment and there is good access to the waterway, then removal and revegetation is the most appropriate option. Irrespective of the method, follow up foliar application is required to kill regenerating or newly germinating willows.

Principle 8 Poisoning in-situ should be the first consideration due to its limited impact on the surrounding environment and it is substantially cheaper, but where there is a monoculture of Willow along the waterway then cutting and removal is required to protect downstream civil assets. Follow up revegetation is always required with the cut and removal process. In general the principles contained in National Willows Management Guide (DPI 2007) should be applied in selection of removal techniques.

6.6 Biological controls

A relatively new consideration in Willow management is the arrival of Willow Sawfly *Nematus oligospilus,* which is an exotic insect predator of Willows. The sawfly has not been deliberately

introduced into the catchment but has been recoded near Kyneton (DPI, 2007a) and across much of Victoria and South East Australia.

The first reported occurrence of the species in Australia was on Weeping Willow *S. babylonica* in Canberra in March 2004 (Bruzzese & MacFadyen, 2006). It is not known how Willow Sawfly arrived in Australia, but it is possible that it was brought into the country inadvertently via shipping containers or other contaminated material, potentially as cocoons containing larvae. It is also possible that adults were blown across from New Zealand via easterly wind systems that occur in late summer (Bruzzese & McFadyen, 2006).

Predictive models using climatic data indicate that all but the northern third of the North Central region is susceptible to Willow Sawfly infestation (DPI, 2007a).

The capacity of Willow Sawfly to provide some form of biological control is not certain, however evidence from other countries suggests it is associated with high levels of Willow defoliation but unlikely to halt the spread of Willow or eliminate them altogether.

Willow sawfly is likely to reduce the health of the plant, but is not likely to provide a substitute for active management measures such as poisoning and removal. More detail on Willow sawfly is provided in Appendix B.

It is suggested that the North Central CMA continue to monitor spread across the catchment and where possible become further involved in research into willow sawfly.

6.7 Ecological controls

It is worth considering the ability of native species to out compete Willows in a waterway environment with other native species. For some weed species a level of control can be achieved by increasing or decreasing the amount of shading of the target species.

Unfortunately in the case of Willow there are no successful examples to date of where alternative vegetation has been planted and suppressed Willow growth and spread.

6.8 National responsibility (Weeds of National Significance Program)

The Weeds of National Significance program was a coordinated response by Commonwealth, State, Territory and New Zealand government agencies in regard the major weeds that threaten our socioeconomic and environmental values.

Through an assessment of invasiveness, impacts, potential for spread and socioeconomic and environmental impacts, 20 species of flora were classified as Weeds of National Significance (WoNS). All willow species with the exception of Weeping Willows *Salix babylonica*, Pussy Willow *S. x calodendron* and Sterile Pussy Willow *S. x reichardtii* are listed under the generic title of 'Willows'.

The Weeds of National Significance status is attempting to bring particular weed species under national management for the purpose of restricting its spread and/or eradicating it from parts of Australia (DEW, 2007). The North Central CMA has an obligation to support this national framework of which this Plan is the first step in understanding the issue of Willows in the catchment and focusing on key areas for management.

Principle 9 Management activity should be aligned with the intent of Weeds of National Significance Status Program.

6.9 Complementary activities

The physical action of Willow poisoning or removal is only one part of the rehabilitation process. An issue raised during the community forums was that some landholders felt there was inadequate effort invested into post control fencing, revegetation and maintenance. It was also noted that it is a common occurrence that once Willow is removed secondary weeds such as blackberry thrive on the increased light penetration and rapidly invade the space.

The level of complementary activity is dependent on the scale of the Willow control. For instance, a program that involves in-situ poisoning of individual Willows amongst healthy native vegetation would not require any significant complementary activity. A site that is a dense stand and requires removal does require an intensive level of complementary activity.

For control of dense stands of Willows to be effective it must be associated with adequate consideration to fencing, revegetation (with locally indigenous species), control of other weeds and maintenance of the site. These activities need to be properly funded and responsibility allocated prior to any Willow control activity being initiated.

Regardless of the type of control activity, monitoring of the works sites is a necessary complementary activity for all sites that must be adequately funded and undertaken to ensure the site remains Willow free and that other weed species do not take its place.

Principle 10 Where there is major disturbance from removal activity, a holistic approach must be used which includes funding for weed control, fencing, revegetation, maintenance and monitoring.

Principle 11 Monitoring of all sites post works is necessary and must be planned and budgeted for.

6.10 Heritage values

There are numerous Willow infestations in or near various townships in the south-eastern part of the region and many are away from major waterways.

The community engagement process clearly identified that community members perceived that willows can play a significant role in heritage values and can help form part of a town's identify. It was proposed that where removal is considered in rural townships consideration must be given to adequate heritage investigation and understanding.

If the Willows are located within the vicinity of waterways and species are brittle Crack & Gold-crack Willlow) then lower limbs and branches that are likely to be broken in flood waters could be removed to reduce downstream spread. If the species are seeding, irrespective of their location, then removal should be given serious consideration with an appropriate heritage guided revegetation program.

Principle 12 Recognise Willows around towns with high heritage and amenity value and engage with the community to manage accordingly.

6.11 Community expectations

The development of this Strategic Action Plan involved community and stakeholder engagement. Community forums were held in Echuca, Kyneton and Daylesford. These forums aimed to:

- Document community attitudes toward Willow management in the region.
- Capture views and opinions.
- Tap into local information and experience.
- Raise awareness regarding Willows and the need for management.
- Obtain input into where, how and when to manage Willows in the region.

Further details of the community engagement feedback is provided in Appendix C**.** Generally the community forums evoked strong feelings for both the removal and retention of Willows which suggested that there is not one universal view towards priority locations and species for management. This feedback was extremely valuable and a number of key points were captured and directly influenced this Plan, including,

- Willows can play a significant role in heritage values and can help form part of a town's identity. Where removal is considered in rural townships consideration must be given to adequate heritage investigation and understanding.
- The North Central CMA needs to recognise that the community's perceptions of Willows may vary markedly in the region.
- The North Central CMA has a responsibility to educate and inform the community about Willow issues.
- The area around Daylesford and Hepburn Springs (northern half of Sailors Creek) is characterised by some community members having strong feelings regarding the preservation of Willows and concern regarding the perceived lack of objective science associated with removal. This Plan should recognise these views and in the interim cease removal of Willows in this area. The North Central CMA needs to undertake further consultation to help develop a full understanding of the view of the entire local community, to provide more information and identify a path forward to better understand local issues.
- Funding for any removal must be adequate to ensure appropriate revegetation and ongoing maintenance of sites.
- The process of how sites are selected for works needs to be transparent and take into account landowner and overall community views.

The interaction with the community reinforced some of the principles already provided but also led to the development of an additional three.

Principle 13 Engage with local landowners and stakeholders to understand their level of support prior to any activity being initiated.

Principle 14 Recognise that the community around Daylesford has very strong feelings about Willows and that further consultation is required with all community members to understand their issues better.

Principle 15 Establish a transparent and collaborative decision making process to focus Willow management activity into the future.

6.12 Climate change

Changes to the climate is to some degree a consideration for the future expansion of Willow in the region. The Draft Discussion Paper for the Northern Sustainable Water Strategy (DSE 2008a) communicates that under a low climate change scenario the Campaspe and Loddon systems are likely to have a reduced inflow by 9% and 10% respectively, where the high climate change scenario proposes a 54% and 58% reduction respectively.

The impact on Willow populations is a little unclear but it is reasonable to expect that on the main waterways there would be little impact on Willows, but in the more ephemeral tributaries it is likely that the reduced water will impact on their ability to survive.

It is however not recommended that these tributaries are excluded from any control program due to the time lag on climate impacts and their ability to continue to colonise downstream sites through seeding or vegetative reproduction

6.13 Irrigation reconfiguration

The irrigation region of the North Central CMA currently is undergoing reconfiguration to improve the efficiency of irrigation water supply. This activity is likely to mean that some smaller spur channels will be decommissioned and greater effort invested into the larger channels to reduce leakage.

Willows that exist on these small channels that are also ephemeral in nature will no longer receive water and it is likely the Willows will not persist.

7 Strategy

Through this investigation it was determined that the perceived value and threat posed by Willows varies throughout the catchment. Engagement with the community suggested that there is not one universal view towards priority locations and species for management. In addition the mapping data reviewed was not sufficient to drive an action oriented Plan that is underpinned by solid survey information that overlays high value assets and high risk Willows.

Therefore, this Plan does not attempt to provide a prescriptive list of priority sites for the management of Willows. Instead, through considering the Key Principles provided in Section 7 of this document and establishing a transparent decision making process to guide site specific works sites, it allows progression of Willow management activities in the region. In this way Willow control works can be integrated and programmed with a range of waterway works planned by the North Central CMA .

This Plan intends to move away from a reactive Willow removal approach to a strategic approach. Through a strategic approach it aims to ensure the North Central CMA has a holistic management approach, resulting in multiple and sustainable benefits to the environment.

7.1 Principles

The following principles have been carried over from Section 6 of this document. Basing actions on these principles will result in an approach that is strategic in nature and not simply responding to any given opportunity.

Principle 1 Address all high risk invasive species first (namely Grey Sallow, Gold-crack and Crack Willow and seeding hybrid Willows).

Principle 2 To avoid the creation of new seeding hybrids, no new horticultural Willow plants or species should be introduced into the North Central catchment.

Principle 3 Where invasive species are present, Willow management should start at the top of catchments and work down.

Principle 4 Eradication of seeding willows must be complemented and coordinated with control works in the adjacent catchment.

Principle 5 Further data needs to be collected to inform the North Central CMA on where high risk species are, where they are having the greatest impacts and where they may threaten high value natural assets.

Principle 6 Protect the best first (high value wetlands and high value waterways).

Principle 7 Prevent Willows invading downstream high value assets from upstream.

Principle 8 Poisoning in-situ should be the first consideration due to its limited impact on the surrounding environment and it is substantially cheaper, but where there is a monoculture of Willow along the waterway then cutting and removal is required to protect downstream civil assets. Follow up revegetation is always required with the cut and removal process. In general the principles contained in National Willows Management Guide (DPI 2007) should be applied in selection of removal techniques.

Principle 9 Management activity should be aligned with the intent of Weeds of National Significance status program.

Principle 10 Where there is major disturbance from removal activity, a holistic approach must be used and include funding for weed control, fencing, revegetation, maintenance and monitoring.

Principle 11 Monitoring of all sites post works is necessary and must be planned and budgeted for.

Principle 12 Recognise Willows around towns with high heritage and amenity value and engage with the community to manage accordingly.

Principle 13 Engage with local landowners and stakeholders to understand their level of support prior to any activity being initiated.

Principle 14 Recognise that some parts of the community have very strong feelings about Willows and that further consultation is required with all community members to understand their issues better.

Principle 15 Establish a transparent and collaborative decision making process to focus Willow control activity into the future.

7.2 Types of actions

Figure 5 provides an overview of five broad categories of actions that this Plan has addressed. These actions are generally cyclic in nature where the logical progression begins with gathering more information to inform more detailed planning. Where there are perceived gaps in the knowledge then further research and education are important to ensure the community and all stakeholders are aware of key issues and priorities. Implementation (actual works) is then undertaken followed by monitoring and maintenance at a site level. The overall success of the program should be periodically undertaken to ensure it is achieving its intended targets.

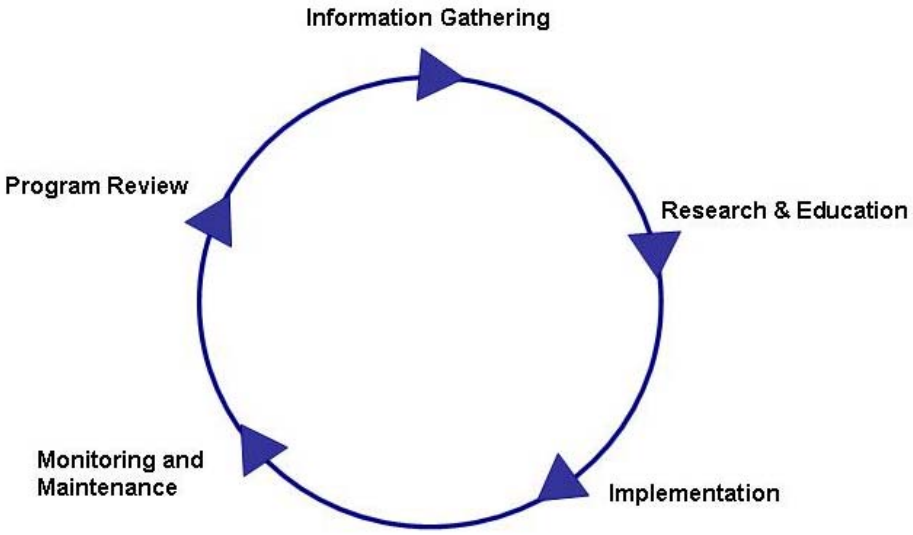

Figure 6 – Action program

7.3 Information Gathering

Accurate information is critical in prioritising and planning on-ground action so that funds are spent in the most effective way, and in areas where maximum long term improvement/protection can occur. While reactive works will always need to be done in response to critical situations, it is important that planned and steady progress is made toward the longer term objectives.

To effectively prioritise and plan for management of Willows the quality and extent of data on willow infestations needs to be extended. Taking into account the principles above, data collection priorities need to focus in the south eastern parts of the North Central region (top of the catchment), areas upstream of and within high value natural assets (both waterways and wetlands), areas of heritage values and specifically on high risk seeding and brittle Willows (and their hybrids).

It does need to be considered that a key objective of this Plan is to focus effort to the highest priority areas and achieve the most cost effective outcome. Given the budget for Willow management is dependant on State and Federal government funding it is possible that the program may need to ramp up or down, depending on the level of funding.

Within the following mapping and implementation actions a first and second priority action has been proposed. If funding is limited then it is recommended that effort is only directed to the first priority to avoid diluting effort and success.

ACTION 1: WILLOW MAPPING

A1.1 As a first priority, survey the upper Campaspe, upper Loddon and Coliban catchments, high value assets (waterways) and their upstream minor tributaries to determine the full extent and population status of Grey Sallow *Salix cinerea* (including *S. cinerea var. cinerea* and *S. cinerea var. oleifolia*), Crack Willow *Salix fragilis* var. *fragilis* and Gold-crack Willow *S.* x *rubens*.

A1.2 As a second priority, survey the high value wetland assets and their upstream waterway to determine the full extent and population status of Grey Sallow *Salix cinerea* (including *S. cinerea var. cinerea* and *S. cinerea var. oleifolia*), Crack Willow *Salix fragilis* var. *fragilis* and Gold-crack Willow *S.* x *rubens*.

A1.3 Accurately map Willows with heritage values, particularly around existing town sites in consultation with community groups and Heritage Victoria.

Responsibility and costs

Responsibility for Willow mapping actions would largely rest with the North Central CMA with possible assistance from the Victorian Department of Sustainability and Environments (DSE) and Department of Primary Industries (DPI) in providing mapping data.

The mapping activity is labour intensive and most likely requires a suitably qualified contractor to walk the waterways with a GPS to capture the data. It is likely that to map the regions proposed in action A1.1 would cost in the order of $25,000, and A1.2 around $30,000 (please note all costs estimates are GST exclusive).

A quicker and hence cheaper option is to divide the priority mapping areas up into small reaches and visually classify each reach regarding the level of infestation of high risk species and their impacts on the waterway environment. This approach does not result in all Willow populations being geospatially referenced, but still allows sufficient information to plan where resources should be directed. This approach should be based on the agreed WoNS classification level of infestation. It is likely that to undertake survey of this nature will cost in the order of $15,000 for A1.1 2, and for A1.2 around $20,000.

7.4 Research and Education

There is a need to build capacity and increase 'human capital' (the knowledge, skills and abilities of people) amongst all stakeholders, including the North Central CMA . There is also a need to communicate, raise the awareness of and educate the community regarding the threat posed by high risk Willows and the need to manage them.

It is accepted that there is a large amount of local knowledge of impacts of Willows (both positive and negative) and it is recommended that the North Central CMA engage with the community further to listen to their perspectives and views. The Daylesford community in particular has a view on a number of research opportunities to help understand the positive or negative impacts of Willow in the local area.

An important consideration in any research and education activity is that there is already a large amount of literature on Willow research being generated and it is important not to duplicate other research programs and their extension material. It is suggested that the most effective learning for the Region is to pursue joint community projects to test local issues, perceptions and implications of Willow removal or retention.

National Management Guidelines for the management and control of Willows has recently been prepared (Holland Clift and Davies, 2007) and is suggested as a key document for further reading and is a key document to use when planning to undertake works.

ACTION 2: FURTHER RESEARCH

A2.1 Pursue collaborative research projects with local communities and other groups/agencies that display a strong interest in Willow management. Projects should be focused on one specific issue and not try to encompass many issues. Key research opportunities that may be considered based on both North Central CMA and community input include;

- Do significant nutrient slugs occur after willow removal (0 – 6 months)?
- What is the water consumption of Willows compared to native vegetation?
- Do Willows have a greater level of phosphorous uptake than native plants?
- Do Willows have more effective fire retardant attributes than native riparian vegetation?
- What is the level of sediment storage and release after removal?
- What is the rehabilitation success of sites post large scale Willow removal?
- Is there significant difference in invertebrate numbers and communities between sites in close proximity that have substantial willow overstorey and those with native overstorey?

It should be noted that the output of these activities may inturn influence the further education actions documented below.

ACTION 3: FURTHER EDUCATION

A3.1 Undertake training to ensure North Central CMA field staff, landholders and community are competent in identifying high risk Willow species which are known to occur in the catchment. Training should also include identification of Black Willow (*Salix nigra*) which is a highly invasive species and has not been recorded in the North Central Catchment Management Region.

A3.2 Identify and utilise simple resource material produced by other agencies which aims to educate and raise awareness regarding the need to manage high risk Willows.

A3.3 Distribute and promote resource material and this Strategic Action Plan widely and ensure all major stakeholders are sent a hard copy and have access to an electronic copy.

A3.4 Work within existing networks to discourage further import, propagation and promotion of Willow by the nursery industry (in particular, New Zealand Hybrid Willows and Chilean Pencil Willow).

Responsibility & costs

Given the focus on research is a partnership with the community, it is proposed that there is a shared responsibility between the North Central CMA and community groups or individuals to initiate discussion and propose viable topics to be considered.

The costs associated with this activity are likely to be relatively small and largely comprised of in kind North Central CMA and community labour, and possibly some ongoing water quality and ecosystem monitoring costs. It is difficult to estimate given the actual research topics are not agreed upon, but it is estimated that for around $10,000 per annum a substantial effort can be made towards working with local communities to investigate concerns. The topics of research could be a number of small projects rolled out over a number of years.

It is also possible that these issues could be incorporated into larger research projects being undertaken by universities or government agencies.

The responsibility for disseminating information resides with the North Central CMA, but the community and individuals are strongly encouraged to source more information on Willow management and the reference pages associated with this report can provide a substantial amount of further reading.

7.5 Further Consultation

It is recognised that further consultation is required to progress Willow management in the region. There needs to be further engagement with landholders/community and it is also suggested that further consultation with other government land managers is undertaken to ensure all activities and programs are aligned.

ACTION 4: FURTHER CONSULTATION

A4.1 Prior to undertaking any Willow control works landholders on both sides of the waterway should be consulted and involved in the process.

A4.2 Prior to undertaking further control of Willows in areas of community concern (including poisoning in-situ), undertake additional engagement with landholders, land managers and wider community to develop a local approach which includes the research activities captured in A2.1.

A4.3 Undertake a proactive consultation process with Parks Vic, local government, industry and other agencies to ensure a common understanding of priority species, areas and to develop a collaborative willow management program.

Responsibility & costs

The responsibility for further consultation resides with the North Central CMA. The costs of good consultation are often higher then expected and the North Central CMA should ensure adequate time is allocated to talk to all targeted landholders and other key agencies.

The consultation with the community around Daylesford does require a degree of planning to ensure all community members are aware of the consultation process and involved. An additional cost that may be considered is the engagement of an independent chair in the community meetings to ensure they are as productive as possible and to allow all community members to communicate their views.

7.6 Implementation

Based on the Principles developed it is proposed that strategic effort should be directed to the areas in the catchment that have more intact native vegetation (higher value), have an environment that is most conducive to Willow expansion (generally higher rainfall areas and upper catchment geology), and areas that involve or are connected to high value natural assets.

It is likely, however, that unforseen priority management areas for Willows will appear in the short-term and planning needs to make some allowance. Such issues may include:

- Quick removal of newly discovered seeding Willows or crop of seedlings.
- Removal of seeding parent trees even if they are well away from the river.
- Risk of asset damage from Willow growth such as flooding or avulsion, or loss of access.
- Small scale work in response to requests/proposals by landholders or community groups, provided they fit into the overall Plan, and will have long term benefits through capacity building.

To ensure alignment of the implementation with the Principles and Objectives it is suggested that a Standard Work Procedure is developed. This will ensure a consistent approach and that all key issues are adequately considered.

The Standard Work Procedure should be consistent with current North Central CMA procedures and provide a process to;

- Determine land ownership and tenure of works site and neighbouring properties and identify the level of consultation with adjacent landholders and other stakeholders.
- Confirm the Willow species involved.
- Flag the need to obtain all appropriate clearances/approvals/permits (e.g. Indigenous and European Heritage; Planning Permits).
- Ensure a site plan is developed which considers the potential impact of the work (physical, biological, and social) and incorporate appropriate management/mitigation measures.
- Ensure that appropriate management techniques are employed which are consistent with National Willows Management Guide (DPI 2007)
- Ensure signage is installed to inform the community on the reason for works, extent of works and proposed rehabilitation process and timing.
- Ensure site is fenced (where appropriate) and revegetation activities are aligned with EVC species and densities.
- Ensure ongoing management responsibilities are clearly documented including maintenance of fences, revegetation, ongoing weed control, control of any regenerating Willow, and maintenance of revegetation to ensure survival (eg watering if necessary).
- Ensure all work is recorded on a GIS database.

ACTION 5: IMPLEMENTATION

A5.1 As a first priority, undertake Willow control in the localised asset areas (INFER), high value waterway reaches and their tributaries (RHS). These include the Loddon River (reach 10), Sailors Creek (reach 28), Kangaroo Creek (reach 21), Campaspe River (reach 6) and Coliban River (reach 22), Axe Creek (reach 12) and the Avoca River (reaches 1-8).

Within these areas Grey Sallow *Salix cinerea* (including S.*cinerea var. cinerea* and S. *cinerea var. olefolia*), and brittle taxa including Crack Willow *Salix fragilis* var. *fragilis* and Gold-crack Willow *S. x rubens* and seeding hybrid Willows should be specifically targeted.

A5.2 As a second priority, undertake Willow control in the high value wetlands (Kerang Lakes and Gunbower Forest) and their connecting waterways which include the Avoca River (reaches 1-8), Loddon River (reaches 1-10), Pyramid Creek (reach 33).

Nationally important wetlands should also be targeted along with their connected waterways including Lake Buloke, Bunguluke wetlands, Lake Lalbert, Woolshed Swamp, Avoca Floodway, Tang Tang Swamp, Kow Swamp, Tragowel Swamp, Creswick Swamp and Merin Merin Swamp.

Within these areas Grey Sallow *Salix cinerea* (including S.*cinerea var. cinerea* and S. *cinerea var. olefolia*), and brittle species including Crack Willow *Salix fragilis* var. *fragilis* and Gold-crack Willow *S. x rubens* and seeding hybrid Willows should be specifically targeted.

A5.3 Engage with management authorities (eg: Melbourne Water and neighbouring CMA's) in the adjacent catchments to coordinate Willow removal activities, with particular emphasis

on seeding Willow species, primarily Grey Sallow (*Salix cinerea*) and other seeding hybrids.

A5.4 No implementation should be undertaken in the Daylesford and Hepburn Springs area (northern half of Sailors Creek) until additional engagement with landholders, land managers and wider community is completed.

A5.5 Produce a Standard Work Procedure or Checklist to ensure all future activities comply with an agreed standard of works and consultation.

Responsibility and costs

The primary responsibility for implementation actions resides with the North Central CMA. The removal of large trees can be a dangerous task and only qualified contractors should be used. Where there are juvenile Willows recruiting then landholders or Landcare groups have the ability to spray or stem inject these whilst they are at a manageable size.

The physical works of poisoning, removal, fencing, revegetation or other associated management activities and maintenance are to be funded by both the State and Federal governments via North Central CMA regional funding processes. This is an annual budget and the extent of works is influenced by the amount of funding the North Central CMA receives.

It is likely that first priority area for Willow management (high value waterway reaches) will be substantially more expensive than the second priority (high value wetlands and connecting waterways) given the known level of infestation.

7.7 Monitoring and Maintenance

Monitoring and maintenance is a critical activity in any natural resource management activity. As part of the Standard Work Procedure (A5.1), a monitoring and maintenance plan should be produced for every works site or waterway reach (which ever is more appropriate) to communicate the key issues on site and frequency of maintenance activities.

This monitoring should focus on short term measurable waterway health outcomes which include the effectiveness of control, succession of other weed problems and success of revegetation.

It is also suggested that at representative sites a more extensive monitoring program could be undertaken over a number of years to show the impacts of willow removal on the five key areas of waterway health as discussed in Section 4 of this document. An ongoing program such as this does need further thought but it is likely that opportunities may be associated with,

- aquatic invertebrate species diversity and numbers.
- presence of fish and platypus.
- physical water quality parameters.

ACTION 6: MONITORING AND MAINTENANCE SCHEDULE

A6.1 Every works site should have a documented works agreement and schedule for the ongoing management of the site which is consistent with current North Central CMA procedures. This does not need to be a large task but does need to communicate;

- Timing for follow up control of Willow regrowth and other weeds.
- Timing for revegetation maintenance activities (weed control and possibly watering)
- Nomination of who is responsible for monitoring and maintenance.

A6.2 A monitoring program that focuses on longer term, measurable waterway health outcomes should be considered and as a start monitoring of aquatic invertebrate species diversity and numbers, and physical water quality parameters is recommended.

A6.3 It is also recommended that a monitoring program annually inspects waterways at the top of the catchment to detect any reestablishment from seeding Willows in the adjacent catchment.

Responsibility and costs

The primary responsibility for monitoring resides with the North Central CMA, but it does provide an opportunity for community groups, such as Waterwatch to become involved. Experience from other Willow control programs around the State suggests that the cost of monitoring is likely to be between 5 -10% of the entire Willow Management budget.

Maintenance activities are the responsibility of the North Central CMA in the short term unless otherwise negotiated in the site specific monitoring and maintenance plan. A general observation of natural resource management (NRM) activity around Victoria indicates that maintenance is often under funded. It is suggested that the North Central CMA should allocate a sizable portion of the works funding (~20%) and take a lead role in maintenance for the first three years post works.

7.8 Review

It is suggested that review of the implementation of this Plan is useful to create a continuous improvement approach and allow the North Central CMA to promote outcomes and improvements to waterway health to all stakeholders.

ACTION 7 – AUDIT AND REVIEW

A7.1 Annually hold a half day workshop with staff and interested stakeholders to review the effectiveness of management work and outcomes.

A7.2 Every three years conduct a comprehensive audit and review of all Willow control work undertaken and this Strategic Acton Plan. Assess the value of waterway health outcomes in light of monitoring results and the resources invested. Provide recommendations to improve the planning, implementation, monitoring and maintenance of Willow control work and update Plan as required.

Responsibility and costs

The primary responsibility for audit and review of the program falls with the North Central CMA, although it is recommended that a third party is engaged to independently review the progress and alignment with this Plan. Likely costs of a program review would be around $15,000 every three years.

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Appendix A - Summary of Willow Taxa in Victoria & North Central CMA Region.

Willow Taxa Known to Occur in Victoria.

Those shown in **bold** have been recorded in the North Central region. Sources: Carr (1996); Ladson (1997); Ecology Australia (2007).

SCIENTIFIC NAME	COMMON NAME	ORIGIN	HABIT	SEX	REPRODUCTION	PRIORITY FOR MANAGEMENT	STATUS IN VICTORIA	STATUS IN NORTH CENTRAL REGION
***Salix* x *calodendron* (*S. caprea* x *S. cinerea sp. oleifolia*x *S. viminalis*)**	**Wild Pussy Willow**	**Europe**	**Narrow, erect tree o 10 m high; multi-stemmed.**	**F**	**V, S?**	**Very High**	**This hybrid has been planted rarely e.g. in the Ovens River catchment; branches are tough and spread by trunks falling down and branches rooting where they touch the ground.**	**Rarely planted, not naturalised, but hybridises with *S. cinerea.***
Salix cinerea* ssp. *cinerea	**Grey Sallow**	**Europe Siberia, N Africa**	**Large spreading shrub or small tree to 10 m high; branches erect to slightly pendulous.**	**M, F**	**V, S**	**Very High**	**One of the most abundant and destructive *Salix* sp. in Vic; capable of invading swamps as well as streams; seed is produced prolifically; vegetative reproduction is small-scale and localized.**	**Abundantly naturalised in the more elevated, higher-rainfall part of the region.**
Salix cinerea* ssp. *cinerea* x *S.* x *reichardtii	**Wild Pussy Willow**	**Europe**			**V, S?**	**Very High**	**A hybrid of European origin; widespread and often cultivated.**	**Commonly planted, not naturalised, but hybridises with *S. cinerea.***
Salix fragilis* var. *fragilis	**Crack Willow**	**Europe**	**Large spreading tree to 20 m high; trunk single or several.**	**M, F**	**V, S?**	**Very High**	**The most widespread and abundant Willow in Victoria; often difficult to distinguish from *S.* x *rubens.* This taxon has had the most serious impact on Victorian streams. Branches and twigs are extremely fragile and have given rise to most if not all populations.**	**Abundantly naturalised on steams in the wetter south of the study area; male parent of a suite of hybrids.**
Salix* x *rubens* (*S. alba* var. *vitellina* x *S.	**Gold – crack (Basket**	**Europe**	**Large spreading tree to 16 m or more high; trunks one to**	**F, M?**	**V, S?**	**Very High**	**This is one the commonest Victorian Willows. It is often very difficult to distinguish between**	**Abundant on streams (vegetative reproduction) and**

SCIENTIFIC NAME	COMMON NAME	ORIGIN	HABIT	SEX	REPRODUCTION	PRIORITY FOR MANAGEMENT	STATUS IN VICTORIA	STATUS IN NORTH CENTRAL REGION
***fragilis*)**	**Willow)**		**several.**				**this and *S. fragilis* var. *fragilis* and complex hybrid suites are evident. Branches very brittle – almost all reproduction and spread has been by vegetative means.**	**occasionally cultivated. Parent of increasingly common hybrids.**
Salix alba* var. *vitellina	**Golden Willow**	**Europe**	**Erect or spreading tree to 20 m; one or several trunks.**	**F?**	**V, S**	**High**	**If seed is set the pollen donor is another taxon e.g. *S.* x *sepulcralis, S.fragilis*.**	**Commonly planted for ornament and on farms, increasingly common as parent of hybrids.**
***Salix alba* var. *vitellina* x *S. matsudana* 'Tortuosa'**	**Golden Tortured Willow**	**Vic.? hybrid also known in Europe**	**Small weeping tree; stems several.**	**M**	**?**	**High**	**One recent collection on the Yarra River at Kangaroo Ground South; the parents nearby. Rarely naturalised vegetatively but increasingly common as parent of multiple hybrids.**	**Commonly planted as ornamental, rarely naturalised vegetatively but increasingly common as parent of multiple hybrids.**
Salix alba* var. *alba* x *S. matsudana	**New Zealand Hybrid Willow**	**New Zealand**	**Pyramidal, spreading, or Moderately weeping, single stemmed tree to 25 m high.**	**M, F**	**V, S?**	**High**	**Hybrids released and now widely planted. Potential for naturalisation and hybridisation with other taxa is high.**	**Occasional but increasingly common and the parent at a suite of hybrids (e.g. at Creswick). Needs careful monitoring.**
***Salix* x *pendulina* (*S. babylonica* x *S. fragilis* var. *fragilis*)**	**Weeping Willow**	**Europe**	**Large spreading, very weeping tree to 18 high; trunk short.**	**F, M**	**V**	**High**	**Relatively uncommon or rare; has formerly been misidentified as *S. babylonica.* Very abundant in the ACT and NSW southern tablelands.**	**Presence in Catchment needs to be confirmed.**
Salix* x *sepulcralis* var. *chrysocoma* (*S.	**Golden Weeping**	**Europe**	**Large spreading tree to 18 m high with long**	**M, F**	**V, S**	**High**	**Previously identified as *S. babylonica* with which it often occurs; it is sometimes locally or**	**Occasionally cultivated possibly naturalised**

SCIENTIFIC NAME	COMMON NAME	ORIGIN	HABIT	SEX	REPRODUCTION	PRIORITY FOR MANAGEMENT	STATUS IN VICTORIA	STATUS IN NORTH CENTRAL REGION
***babylonica* x *S. alba* var. *vitellina*)**	**Willow**		**pendulous branches.**				**regionally more common than *S. babylonica*. Isolated trees are capable of setting viable seed because of flowers of both sexes in catkins. Also forms hermaphrodites and likely to form hybrids with other taxa.**	**(vegetatively) and likely to form hybrids with various taxa.**
***Salix* x *sepulcralis* var. *sepulcralis* (*S. babylonica* x *S. alba* var. *alba*)**	**Weeping Willow**	**Europe**	**Large spreading tree to 18 m high with long pendulous branches.**	**M, F**	**V, S**	**High**	**Previously identified as *S. babylonica* with which it often occurs; it is sometimes locally or regionally more common than *S. babylonica*. Isolated trees are capable of setting viable seed because of flowers of both sexes in catkins. Also forms hermaphrodites and likely to form hybrids with other taxa.**	**Commonest Weeping Willow frequently planted and widely naturalised vegetatively. Likely to form hybrids with various taxa.**
Salix alba* var. *caerulea	**Cricket Bat Willow**	**Europe**	**Spreading tree to 30 m.**	**F**	**V, S**	**Low**	**Rarely cultivated - not naturalised.**	**Cultivated at Shepherds Flat near Daylesford. Not naturalised. Potential source of hybrid seed.**
***Salix* x *reichardtii* (*S. caprea* x *S. cinerea*)**	**True Pussy Willow**	**Europe**	**Large multi stemmed shrub or small tree to 12 m high; canopy is higher than wide.**	**M**	**V**	**Low**	**A hybrid of European origin; widespread and often cultivated.**	**Commonly planted, not naturalised, but hybridises (rarely) with *S. cinerea.***
Salix babylonica	**Weeping Willow**	**China**	**Large, spreading tree to 30 m high; trunk single, branched low down.**	**F**	**V**	**Low**	**Naturalising by vegetative means to a moderate extent; may receive pollen from another species.**	**In North Central region probably the least common species of Weeping**

SCIENTIFIC NAME	COMMON NAME	ORIGIN	HABIT	SEX	REPRODUCTION	PRIORITY FOR MANAGEMENT	STATUS IN VICTORIA	STATUS IN NORTH CENTRAL REGION
								Willow.
***Salix matsudana* 'Tortuosa'**	**Tortured Willow**	**Europe**	**Ultimately a large spreading, weeping tree to 14 m high; branches and twigs moderately fragile.**	**F**	**V**	**Low**	**Rarely naturalised with small populations, but it has the potential to spread further. Most abundant (though only occasional) on floodplain of Murray River at Albury.**	**Commonly planted as ornamental, rarely naturalised vegetatively but increasingly common as parent of multiple hybrids.**
Salix alba var. *alba*	White Willow	Europe, Asia, N Africa.	Erect or spreading tree to 20 m; one or several trunks.	M, F	V		Rare in Victoria but could become more common.	Not known to occur
***Salix alba* var. *vitellina x (S. alba x S. matsudana*; or F1 hybrid)**	**Hybrid Willow**	**Vic.?**	**Small weeping tree; stems several.**	**?**	**?**		**Rare hybrid in North Central region.**	**Rare hybrids noted at Creswick and Clunes.**
(*Salix alba* x *S. matsudana*) x *S. matsudana* ('Tortuosa')	**Hybrid Willow**	**Vic.?**	**Probably as above.**	**?**	**?**		**Rare hybrid in North Central region.**	**Rare hybrid noted at Creswick**
(*Salix alba* x *S. matsudana*) x *S. fragilis* var. *fragilis*	**Hybrid Willow**	**Vic.?**		**?**	**?**		**Rare hybrid in North Central region.**	**Rare hybrid noted at Creswick and Clunes.**
(*Salix alba* x *S. matsudana*) x *S. chilensis* 'Fastigiata'	**Hybrid Willow**	**Vic.?**		**?**	**?**		**Rare hybrid in North Central region.**	**Rare hybrid noted at Creswick and Clunes.**
Salix chilensis	Pencil	South		M	V, S?		Occasional, planted as an ornamental and the parent of rare	Not known to occur

SCIENTIFIC NAME	COMMON NAME	ORIGIN	HABIT	SEX	REPRODUCTION	PRIORITY FOR MANAGEMENT	STATUS IN VICTORIA	STATUS IN NORTH CENTRAL REGION
'Fastigiata'	Willow	America					(but increasingly common) hybrids.	
***Salix chilensis* 'Fastigiata' x (*S. alba* x *matsudana*)**	**Hybrid Willow**	**Vic.?**		**?**	**V, S?**		**Rare hybrid in North Central region.**	**Rare hybrid noted at Creswick.**
Salix chilensis* 'Fastigiata' x *S. fragilis* var. *fragilis	**Hybrid Willow**	**Vic.?**		**?**	**V, S?**		**Rare hybrid in North Central region.**	**Rare hybrid noted at Creswick.**
Salix cinerea ssp. *oleifolia*	Rusty Willow	Europe Siberia, N Africa	Large spreading shrub or small tree to 10 m high; branches erect to slightly pendulous.	M,F	V,S		One of the most abundant and destructive *Salix* sp. in Vic; capable of invading swamps as well as streams; seed is produced prolifically; vegetative reproduction is small-scale and localised.	Not known to occur
Salix fragilis var. *fragilis* x *S. nigra*	Willow	*In situ* Australian hybrid	Spreading tree to 10 m high.	M,F	V,S		A rare hybrid which has the potential to occur wherever the parents occur. Potentially seriously weedy because both sexes are present.	Not known to occur
Salix fragilis var. *fragilis* x *S. matsudana* 'Tortuosa'	Hybrid Willow	*In situ* Australian hybrid	Tree, but all plants so far seen are immature.	?M ?F	?		Rare hybrid naturalised where parents have been planted or are naturalised; branches quite fragile, thus it has a high potential to spread vegetatively.	Not known to occur
Salix fragilis var. *furcata*	Forked-catkin Crack Willow	Europe	Large spreading tree to 15 m.	F	V		Similar to *S. fragilis* var. *fragilis* in most respects; restricted but locally abundant in the Tarwin River catchment.	Not known to occur
Salix x *mollissima* (*S.*	Willow	Europe	Multi-stemmed shrub	F	?		A very rare plant known from a single	Not known to occur

SCIENTIFIC NAME	COMMON NAME	ORIGIN	HABIT	SEX	REPRODUCTION	PRIORITY FOR MANAGEMENT	STATUS IN VICTORIA	STATUS IN NORTH CENTRAL REGION
triandra x *S. viminalis*)			to 3 m high.				specimen.	
Salix nigra	Black Willow	North America	Large spreading tree to 20 m high; trunk often single.	M,F	V,S		Currently restricted but it is very rapidly recruiting by seed and hybridising with at least one other species (*S. fragilis*). This is one of the top three weedy Willows.	Presence not recorded in North Central. Monitor carefully for presence.
Salix purpurea	Purple Osier	Europe, Japan, North Africa	Large multi-stemmed shrub or small tree, ultimately spreading; to 5 m or more high.	M,F	V,S		Widely used in the Snowy Mountains (NSW) for batter and stream stabilisation and to a limited extent in Victoria. Plants seed prolifically and likely to become naturalised. It is likely to hybridise with other shrub Willows. A sterile clone of New Zealand origin –'Booth Willow' is also present in Victoria.	Monitor carefully in case sterility is not reliable.
(*Salix alba* x *S. matsudana*) x *S.* x *rubens*	**Hybrid Willow**	**Vic?**			**?**		**Rare hybrid in North Central region.**	**Rare hybrid noted at Creswick and Harcourt.**
Salix chilensis* 'Fastigiata' x *S.* x *rubens	**Hybrid Willow**	**Vic?**			**?**		**Rare hybrid in North Central region.**	**Rare, noted as part of a hybrid swarm at Creswick.**
Salix x *rubra* (*S. purpurea* x *S. viminalis*)	Osier	Europe or *in* *Situ* (Australia)	Large multi stemmed shrub or small tree to 8 m high.	M,F	S, V?		This hybrid may have been imported and have arisen in Australia where both parents occur.	Not known to occur

Appendix B - Willow Sawfly distribution and impact

Overview of Willow Sawfly

This summary of information draws largely on the work of Ede (2006) and references therein.

A relatively new consideration in Willow management is the Willow Sawfly *Nematus oligospilus,* which is an exotic insect predator of Willows. It is native to the northern hemisphere and found across Europe from Ireland to the Himalayas, and in North America from Alaska to Mexico (Bruzzese & McFadyen, 2006). The first reported occurrence of the species in Australia was from Weeping Willow *S. babylonica* in Canberra in March 2004 (Bruzzese & MacFadyen, 2006). It is not known how Willow Sawfly arrived in Australia, but it is possible that it was brought into the country inadvertently via shipping containers or other contaminated material, potentially as cocoons containing larvae. It is also possible that adults were blown across from New Zealand via easterly wind systems that occur in late summer (Bruzzese & McFadyen, 2006).

The life cycle of the Willow Sawfly involves four stages: egg; larva; pupa; and adult. During winter Willow Sawfly undergoes diapause, a physiological resting stage in which the final stage larva spins a cocoon and remains in a pre-pupal stage for about five months. Cocoons are placed in various places, including on leaves, branches, tree trunks and in other vegetation or on man-made structures (DPI, 2007a). Pupation occurs at the end of this period, and the adults emerge in spring, after Willow leaves have been produced so they can lay their eggs on fully expanded, mature leaves (Ede, 2006). The larva then emerges from the egg and chews a hole through the leaf, the hatched egg remaining on the leaf for several weeks.

There are no known natural parasites of Willow Sawfly in Australia, however, Ichneumonid Wasps *Gelis tenellus* are known to parasitise the species in New Zealand (Berry, 1997) and numerous other insect parasites are known from elsewhere in the world (Ede, 2006). Spiders and bugs (Order Hemiptera) are known to predate Willow Sawfly larvae and it is possible that ants and birds are also predators (DPI, 2007a).

Effects of Willow Sawfly on Willows

The larva eats a hole in the leaf close to where it emerges from the egg, and the hole becomes progressively larger as the larva grows. Larvae eat all of the green material and the mid-rib remains. Typically, several leaves along a shoot are eaten and new leaves emerging from epicormic buds are eaten when Willow sawfly larval density is high (DPI, 2007a).

Urban & Eardley (1995, 1997; cited in Ede [2006]) report that small Willow trees may be totally defoliated by Willow sawfly, with larger Willow trees defoliated more heavily in the lower canopy. Repeat defoliation events have been observed, and tree deaths have been recorded.

Observations of the Crack Willow in the north-eastern Victoria indicate that after the initial defoliation event there is some recovery made by Willows, however once this new growth has been removed there is little or no further growth, other than minor shoots from the bases of trees (Ede, 2006). Evidence from New Zealand indicates that after initially causing severe defoliation of Willow trees, the impact of Willow Sawfly diminishes over time. High populations of Willow Sawfly significantly affect the canopy density of Willows during the Sawfly season, and canopy density has been shown to decline from 70% to less than 10% at one site in north-eastern Victoria (DPI, 2007a).

There is no direct evidence that defoliation by Willow Sawfly causes tree death in Australia, but tree death has been recorded in New Zealand (Ede, 2006). Associated with a decline in Willow canopy cover is an increase in ambient light under the canopy, but it is not yet known if this has an impact on the understorey vegetation below the Willow canopy.

Distribution of Willow Sawfly

Victoria

The Willow Sawfly has now spread through south-eastern South Australia, Victoria and Tasmania and the entire Australian population is believed to comprise females only and as such the population reproduces by parthenogenesis.

In a survey of Victoria in 2005/2006 Willow Sawfly were recorded on 76 of 336 individual Willows reflecting an increase from the previous season (Ede, 2006). They were found mainly on Crack Willow or its hybrids, various Weeping Willow taxa as well as Golden Willow, Chilean pencil Willow and Tortured Willow. The only shrub Willows on which Willow Sawfly were found were two Grey Sallow plants, which is the first field sighting of Willow Sawfly on Grey Sallow in the southern hemisphere (Findley and Adair, 2006).

In 2006/2007, intensive monitoring of eight sites in Victoria was conducted for Willow Sawfly population levels and their impacts on Willows (DPI, 2007a). Tree defoliation by Willow Sawfly was noted at the following locations in the 2006/2007 season:

- Kiewa Valley (north-east Victoria)
- Murray Valley (north-east Victoria)
- Broken River and tributaries (central Victoria)
- Goulburn River (central Victoria)
- Campaspe River (central Victoria)
- Tarago River (southern Victoria)
- Pheasant Creek (southern Victoria)
- Fosters Creek (southern Victoria)
- Boneo, Mornington Peninsula (southern Victoria)

In the Kiewa Valley, north-eastern Victoria, the level of defoliation varied over the course of the Willow Sawfly season, with trees showing little or no defoliation in September and severe defoliation by May. Some trees were able to recover substantially around January as new foliage regenerated, but these trees once again become severely defoliated by late summer and autumn. At the other seven sites monitored in 2006/2007 (see above), the levels of Willow Sawfly and therefore tree defoliation were very low. However, Willow Sawfly had not previously been recorded at these seven sites prior to spring 2006, indicating that Sawfly populations had not yet had time to build up to large levels in 2006/2007.

The extent of defoliation by Willow sawfly varied between Willow taxa. At eight of ten sites with Crack Willow, Willow Sawfly populations were low in 2006/2007. The Crack Willows at Kiewa, where Willow Sawfly populations were high, showed high levels of defoliation. Willow Sawfly defoliation was also low on Golden Willow, Black Willow, nil to very low on Grey Sallow and Purple Osier, moderate on Chilean Pencil Willow and variable (low to high) on Weeping Willow and Golden Weeping Willow (DPI, 2007a). Given that Grey Sallow is considered the most invasive Willow in the region, the importance of Willow Sawfly in its control and management cannot be understated. Observations made in 2006/2007 at several sites and in New Zealand indicate that Willow Sawfly can defoliate this taxon, but as a least preferred host it would seem populations of sawflies must be at high levels for there to be appreciable effects (DPI, 2007a).

North Central Region

The first record of the species in the North Central region was in January 2007 on the Campaspe River near Kyneton (DPI, 2007a). However, it is believed that Willow Sawfly was present on the Campaspe River prior to this time based on the extent of damage to Willows there in March 2007. Adult Willow Sawflies were observed laying eggs as well as many larvae and pupae. It was estimated that about 2 km of the Campaspe River was affected by Willow Sawfly in January 2007, and by March 2007 at least 4 km of the Campaspe River west of the Calder Highway had severe defoliation to Willows (as low as 1% canopy cover). Two other sites, the Little Coliban River (south of Kyneton) and at Carlsruhe (7–8 km south-east of the major infestation) had Willow Sawfly in 2007 (DPI, 2007a).

It is predicted that Willow Sawfly will spread across the entire North Central region over the next two or three years (NCCMA, 2007). Predictive models using climatic data indicate that all but the northern third of the North Central region will eventually have populations of Willow Sawfly and associated high levels of Willow defoliation (DPI, 2007a). There is, however, little known about the relationship (if any) between drought and Willow Sawfly populations and the effects of climatic change on this insect are not understood.

The spread and impact of Willow Sawfly is being closely monitored by DPI and NCCMA on a number of field trial sites. The capacity of Willow Sawfly to provide some form of biological control is not certain, however evidence from other countries suggests it is unlikely to halt the spread of Willow or eliminate it from certain areas.

Appendix C - Community Engagement Outcomes

Community engagement outcomes

The development of this Strategic Action Plan involved community and stakeholder engagement. Community forums were held in Echuca, Kyneton and Daylesford. These forums aimed to:

- Document community attitudes toward Willow management in the region.
- Capture views and opinions.
- Tap into local information and experience.
- Raise awareness regarding Willows and the need for management.
- Obtain input into where, how and when to manage Willows in the region.

Generally the forums evoked strong feelings for both the removal and retention of Willows and the issues were captured and are presented in Table 2 below. It should be noted that in the interests of transparency the information in this table reflects all the actual points made during these forums and no judgements are provided on the validity or accuracy of the comment.

Table 2- Community Feedback

ISSUE	COMMUNITY FEEDBACK
Amenity	• Willows are attractive especially along the Murray
Community	• Sites for removal must have community support. • Past Willow removal practices have disappointed members of the community within the Daylesford area. • The CMA needs to engage and include people in Willow debate to help develop informed views within the community. • There should be a moratorium in the Daylesford area to stop any. removal/poisoning and work with people to provide unbiased science on the perceived environmental impacts/benefits. • The lack of comparative information between Willows, native vegetation and combination makes it difficult for the community to make an informed decision.
Ecological impact	• Willows reduce invertebrate populations. • Willow removal improves recreational and biodiversity values. • Willow debris can significantly impact on river health. • Willow removal increases light penetration and increases the density and health of aquatics. • Staged removal can preserve habitat value. • Systems can recover very quickly after Willow removal. • Willow removal increases habitat value (especially fish and platypus).
Fire	• Fire risk increases with increased native vegetation. • Willows do not provide any meaningful firebreak given their place in the landscape. • Willows can provide a fire break.
Fodder systems	• Fodder systems may spread Willow.

ISSUE	COMMUNITY FEEDBACK
	• Harvesting and pollarding can spread Willow downstream. • Funding should be provided to help landholders develop systems to harvest Willow. • Willow has fodder value and in agricultural areas management intervention can create useful stock feed systems.
Geomorphic impact	• Willow can cause geomorphic change to streams and facilitate erosion. • Willow accrete the bed of a waterway that has been incised by gold mining activities.
Heritage	• Revegetation after Willow removal should consider heritage values (i.e screening of heritage assets, such as a bridge). • State legislation covers the protection of heritage values and needs to be consulted especially for Willow removal work in and around townships. • Willows can form part of the town's heritage values and help form the town identity.
Other	• Need to consider carbon generation from burning Willow stockpiles. • We are really only producing an interim landscape outcome and in reality we are 200 years away from creating a natural landscape. • More invasive hybrids from NZ are replacing the weeping Willows on farms. • Olives are a key issue that needs to be addressed along side Willows. • Stop poisoning Willows in the Daylesford area. • Stop talking about visions and just get on with it (Willow removal). • Can the CMA provide information on how a Weed of National Significance is declared? • Can the CMA provide information on how many Willows have been removed from the CMA and what level of funding has been invested to achieve these outcomes?
Process	• Follow up funding must be ongoing to be successful. • A flexible sensible approach is important. • The consultation process is influenced and compromised by government agenda. • There is a public expectation that the government manages weeds in waterways and heritage issues. • Willow research should be locally important. • The approvals process for Willow removal should be available to the community.
Stream flow	• Willows can totally block streams. • Willows impact on stream choking. • Willow removal can improve the impact from flooding. • The native trees that replace Willows can contribute to instream debris.
Water Quality	• Willows have greater Phosphorus uptake than natives. • An evaluation of water quality impact needs to be undertaken as it is proposed.

ISSUE	COMMUNITY FEEDBACK
	• There is a nutrient release (0-6 months after removal).

This feedback was extremely valuable and a number of the points presented in Table 2 have been incorporated into the formulation of this Strategic Action Plan. Specifically these items are:

- Willows can play a significant role in heritage values and can help form part of a town's identify. Where removal is considered in rural townships consideration must be given to adequate heritage investigation and understanding.
- The NCCMA recognises that the community's perceptions of Willows may vary markedly in the region.
- Given the historic promotion of Willows the NCCMA also recognises is has a responsibility to educate and inform the community.
- The area around Daylesford is characterised by some community members having strong feelings regarding the preservation of Willows and concern regarding the perceived lack of objective science associated with removal.
- The strategy will recognise these views and cease removal of Willows in this area. The CMA will undertake further consultation to help develop a full understanding of the view of entire local community, to provide more information and identify a path forward to better understand local issues.
- Funding for any removal must be adequate to ensure appropriate revegetation and ongoing maintenance of sites.
- The process of how sites are selected for works needs to be transparent and take into account landowner and overall community views.

Appendix D - Control Methods

Willow Control Best Practice

It is prudent to provide some detail on control methods to communicate what is currently considered best practice and that there are different approaches for different situations. A National Willows Management Guide for the management and control of Willows has recently been prepared (Holland Clift and Davies, 2007). This section also helps reinforce that control activities also include remediation and rehabilitation actions. The following provides a short overview of current best practice:

Poisoning. Appropriately registered herbicide is delivered as a "stem injection" to cuts, drill holes or injected using special devices in spring-autumn. Trees are then left standing until completely killed. This method is relatively inexpensive, minimises toxic effects on non-target species and mitigates broken (live) branches and twigs spreading downstream.

In- situ poisoning is often undertaken in more remote areas of a catchment or where the willow infestation is only single or small groups of trees disbursed along a longer waterway reach. This practice is normally used at sites with a healthy indigenous riparian vegetation cover that will easily recruit when the Willow dies.

Removal. Where the Willow infestation is heavy the poisoned dead trees are lopped or removed (using chainsaws and excavator) depending on the type, condition and location of the waterway that they are established on. Where the environment has existing remnants and machinery access is likely to have a detrimental impact on indigenous vegetation then hand removal can be used.

The removal is necessary to allow revegetation activities and importantly to ensure that downstream assets such as bridges are not damaged during flood events by Willow debris. Willows that are removed are normally stockpiled and burnt.

In some cases, where waterways are not flowing (in summer) Willows can be removed without poisoning. While less preferred this method relies on there being no rainfall, but it can be cost effective because crews only need to be mobilised once. Once removed stumps are painted or injected with herbicide and it is critical that all branches are removed, and if necessary an in-stream boom installed to prevent the Willows debris being carried downstream.

Weed and Fauna Control. In all Willow control programs there is a strong need for follow-up control of Willow regrowth (from stumps, fragmented stems or seeds) and other weeds (eg. blackberry). This is an ongoing need and may be required for a period of 3-5 years after the initial control measures.

Revegetation. Where there has been removal with machinery, revegetation is an extremely important aspect of control. Revegetation best practice normally includes the restoration of some or all of the original ecological vegetation class (EVC) over, mid and understorey species and at suitable densities. Direct seeding or planting of tubestock can be used.

Fencing. If stock is not excluded from areas subject to Willow removal they have the potential to introduce weeds, cause erosion and instability and graze/damage revegetation. If the waterway is fenced establishment of off-stream watering needs to be considered and installed where required.

Successful willow control in high density areas includes poisoning, removal, fencing, revegetation and ongoing weed control.

It should be noted that other methods (eg. biocontrol, preventative measures such as declaring Willows regionally prohibited) may play an increasingly important role for control and management of Willows in the North Central region, but are not discussed further here.

Appendix E – WoNS resource sheet (No 2)

Willow Identification

An essential skill for successful willow management

Willow Resource Sheet : 2

Supported by the State Government of Victoria

State Government Victoria Department of Primary Industries

National Willows Taskforce

Australian Government

The art of identification

Willows are an extremely diverse and complex plant group, consisting of more than 300 willow taxa (which includes species, sub-species, varieties, cultivars and hybrids[1]) worldwide. Of these, approximately 100 have been introduced into Australia and it is estimated that over 30 taxa have become naturalised (that is, growing and spreading naturally in the environment) in Australia.

Plant features (such as form, bark, stems, leaves, flowers and roots) can vary dramatically among willow species. For example, willows can be either trees or shrubs, weeping or upright and single-stemmed or multi-stemmed. They can have rough or smooth bark, long or short leaves, early or late flowering, fragile or strong branches, and the list goes on.

Willows also have a remarkable ability to form hybrids, making accurate identification difficult. Almost all willows are able to hybridise with one or more other willows (mostly within the same subgenus) if they flower at the same time and fertile male and female plants grow near enough for pollination to occur.

Fortunately, precise identification is not necessarily required when planning willow management. However, a basic level of identification is essential. To most effectively manage willows, it is most important to be able to:

1. determine the sex of a willow (p.4),
2. confirm if it is producing viable seed (p.6),
3. distinguish between 'tree' and 'shrub' willows (p.7), and
4. determine how brittle (or 'fragile') the branches are (p.9).

In addition, it is useful to

5. learn to identify some key willow taxa already naturalised in Australia (p.9 to 16) and
6. collect plant samples, where possible, and send them to a herbarium (p10).

Learning these skills will further enhance our ability to manage willows.

Although willow identification can be difficult, a basic level of identification is essential for effective management.

What's in a name?

All willows belong to the **genus** *Salix.* Within this genus, there are 3 recognised **subgenera** (or major groupings):

- Subgenus *Salix* - '**tree willows'**,
- Subgenus *Vetrix* - '**shrub willows**',
- Subgenus *Chamaetia* - dwarf, arctic or alpine willows.

Within each of these 3 subgenera, there are many species, sub-species, varieties, hybrids and cultivars. Willows that are growing and spreading naturally in Australia belong to either the *Salix* ('tree willow') subgenus or *Vetrix* ('shrub willow') subgenus. To date, no plants within the subgenus *Chamaetia* have been recorded as naturalised in Australia, but they have often been sold in nurseries.

A botanical name consists of the name of the **genus**, followed by the name of the **species** – e.g. if the genus is *Salix* and the species is *alba*, the name of the plant is *Salix alba* (or *S. alba* where it is clear that ***S.*** refers to the genus *Salix*).

A species may be subdivided into **varieties** (e.g. *S. alba* **var.** *vitellina* and *S. alba* **var.** *alba*) and **cultivars** (e.g. *S. matsudana* '**Tortuosa**').

Hybrids may be formed as a result of a male of one species pollinating a female of another – e.g. *S. alba* can cross-breed with *S. fragilis*. The hybrid that results may be identified by its parents (e.g. *S. alba* **x** *fragilis*) or its own name (e.g. *S.* **x** *rubens*), where **x** indicates that it is a hybrid.

Willows are often called by their **common names** (such as **pussy willow** and **crack willow**), as they are easier to remember. However, common names should only be used if the correct botanical name is implied. For example, the common name 'pussy willow' is often used for a number of different willows, including *Salix cinerea*, *S.* x *reichardtii*, *S.* x *calodendron* and *S. caprea*. This can become extremely problematic for management, since *Salix cinerea* is considered one of the most invasive willows in Australia, while *S.* x *calodendron* is excluded from the Weeds of National Significance list.

[1] All willow species, sub-species, varieties, cultivars and hybrids will be referred to generically as 'taxa' in this guide.

Why identify willows? Implications for management

Willow invasion dynamics

Different willows vary in their ability to spread into and thrive in new environments. It is important to understand how different willows spread and to adapt management programs accordingly. Willows can either spread sexually (via seed) or vegetatively (via twigs and branches) or by both of these means. The seeds germinate on bare, wet sediments, while branches, attached or detached, root mainly on wet ground or in shallow water.

♦ Spread by seed

The ability of willows to spread by seed depends mainly on the availability of favourable seedbeds (bare, wet ground) and the overlap in flowering times of compatible female and male plants. A female willow can produce thousands of seeds each spring. However, often these seeds do not germinate or grow, possibly due to the lack of suitable seedbed, rising or rapidly falling water levels and floods that uproot or bury the seedlings.

Suitable conditions for seedling establishment likely occur in most temperate Australian streams every 5 to 20 years[2]. Major disturbances, such as wildfire or the collapse of a swamp can also promote massive seed germination. Thus, while spreading by seed may appear restricted for many years, a catastrophic explosion of seedlings may occur at any time, given the right conditions.

Some willows can spread by seed up to 50-100km. These willows may spread rapidly across regions and states, so even the most remote environments are at risk of invasion.

The ability of willows to spread large distances by seed highlights the need for coordinated action across regions and states to prevent further spread.

♦ Control of seeding willows

Early identification and control of seeding willows is critical and should be made a high priority for management. In some cases, such willows will need to be immediately controlled in areas where they do not currently cause significant impacts, to prevent them from spreading to other, more important environments.

Hybridisation between willows generally only occurs between plants within the same subgenus[3]. Almost all willows are able to hybridise with at least one or more other willows, so long as they flower at the same time and fertile male and female plants grow near enough for pollination to occur.

We are not sure exactly how far willow pollen can travel (by insects or wind) and successfully pollinate a female plant. Although bees may fly up to 3 or 5 km to collect pollen and nectar, it is thought that cross-pollination is generally restricted to much smaller distances (e.g. 50 m). However, female plants growing 1km from the nearest male have been observed producing viable seeds[4]. It is therefore recommended that male plants be separated from females by at least 2 km and preferably more if possible.

If you find female and male willows from the same subgenus ('tree' or 'shrub') within a few kilometres of each other, remove all female plants immediately.

To stop willows spreading by seed, it is essential to at least identify the gender (male, female or both) and subgenus (shrub or tree) of each willow and whether it is producing viable seed.

[2] Kurt Cremer, personal observation

[3] One exception is *S. x mollissima* – a cross between *S. viminalis* (subgenus *Vetrix*) and *S. triandra* (subgenus *Salix*). *S. triandra* is not yet naturalised in Australia however.

[4] Kurt Cremer, personal observation

- **Spread by branches/twigs**

Some willows can readily reproduce by twigs breaking off at the base of the stem and taking root downstream. In addition, dense layering of willows can occur where trunks collapse or branches hang down and form new roots where they touch the soil.

The brittleness (or 'fragility') of a branch/twig is the most important feature determining a willow's ability to spread aggressively by vegetative means. Brittleness is determined by the ease with which the branch can break at its base – the rest of the branch may be quite flexible. Many of the tree willows in Australia are easily broken at the base. The shrub willows are generally less fragile and are therefore less likely to spread by this method.

Crack willows (*Salix fragilis*) have extremely 'fragile' branches that snap easily at the base, with an audible 'crack'. *S. fragilis* and related hybrids have spread aggressively and are currently the most widespread and abundant willows, occupying thousands of kilometres of streams across south-eastern Australia.

The brittleness (or 'fragility') of a branch/twig is the most important feature determining a willow's ability to spread aggressively by vegetative means.

- **Controlling spread by branches**

As with seeding willows, careful planning, management, revegetation and follow up weed control are crucial to ensure that these willows are managed effectively. It is important to remember that:

- if willows or other weeds are removed from an area, twigs and branches from upstram may easily spread downstream and reinvade the area where the willows (or other weeds) were just removed;
- when controlling these willows, it is critical to ensure that all branches and other live material are removed - otherwise a multitude of new willows may sprout from the remaining material;
- removing these willows may expose an ideal seedbed for seeding willows to colonise, unless revegetation occurs quickly.

To stop the spread of willows by branches and twigs, it is important to identify willows with brittle branches that are growing along waterways.

Impacts of willows

Willows infest thousands of kilometres of waterways across southeast Australia and cause substantial social, economic and environmental impacts such as:

- reducing the quality and flow of water,
- increasing erosion and flooding and causing damage to nearby infrastructure,
- reducing available habitat for fish, birds, insects and spiders and
- obstructing access to streams for fishing and aquatic sports.

Willows clearly need to be managed to reduce the current impacts they are causing, as well as to prevent future spread. Many regional Catchment Management Authorities (CMA) or Natural Resource Management (NRM) bodies address the impacts of willows on river health through the implementation of their Regional River Health Strategies.

Current/potential distribution

Willows impact upon thousands of kilometres of waterways, wetlands, drainage lines and other moist areas across Victoria, New South Wales, the ACT and Tasmania. They are also known to occur to a much lesser extent in South Australia, southern Queensland and Western Australia. Information on the current distribution of willows, including the gender, subgenus and, in some cases, species is essential for planning an effective willow management strategy. Such information is seriously lacking in all states/territories.

The extent of willow infestation in Australia has not been well documented and records that do exist often lack key information necessary for effective management.

Willow management priorities

Eradication of willows across Australia is not feasible or desirable. Instead, we need to prioritise the selective removal of undesirable willows. In general, willows should be prioritised for control if they are:

- female willows growing near male plants (within about 2km) and/or producing viable seed;
- 'fragile' willows (that is, with branches that easily break off) growing along waterways;
- causing impacts to river health or other social, environmental or economic values.

To do this, we require information on the gender, subgenus and brittleness of all willows.

1. Is the plant male, female or both?

Most willow plants are either male or female, with a few rare exceptions where both male and female flowers occur on the one plant. If plants of both sexes are present in a locality, pollination can result. It is therefore important to know the sex of willows, as an indication of their ability to spread by seed.

The sex of the plant can be determined in spring when flowering occurs

Willows flower for approximately 3 weeks each year between the months of August and November. Flowering times vary among species and according to climate. In general, if a male and female plant from the same subgenus (i.e. 'tree', 'shrub' or 'alpine') flower at the same time, they can hybridise and form new plants.

Willow catkins

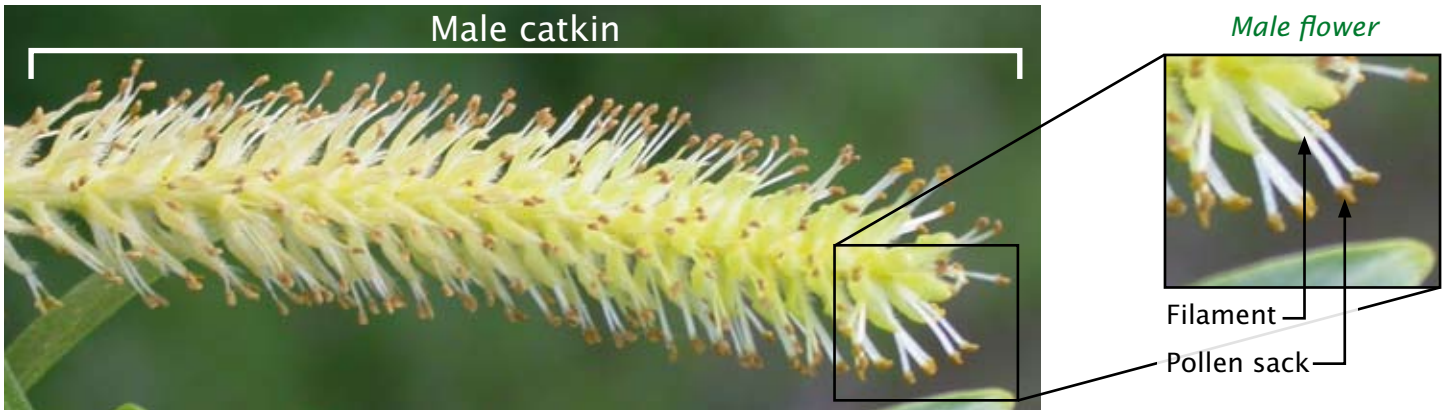
Catkins are influorescences comprising of 100 or more male or female **flowers**. Female flowers produce **nectar** only, whereas male flowers produce nectar and **pollen**. It is believed that insects mostly pollinate the flowers (attracted by the nectar), but it is possible that some wind pollination may occur.

A simple way of determining if the catkin is male or female is to remember that only males produce pollen.

Male flowers have **stamens** that consist of a fine **filament** tipped by two yellow **pollen sacks**, which release yellow pollen when mature. **Female** flowers, on the other hand, each have a single bulbous green **ovary** topped by a **stigma**. This ovary later matures into a capsule that splits open and releases fluffy seed.

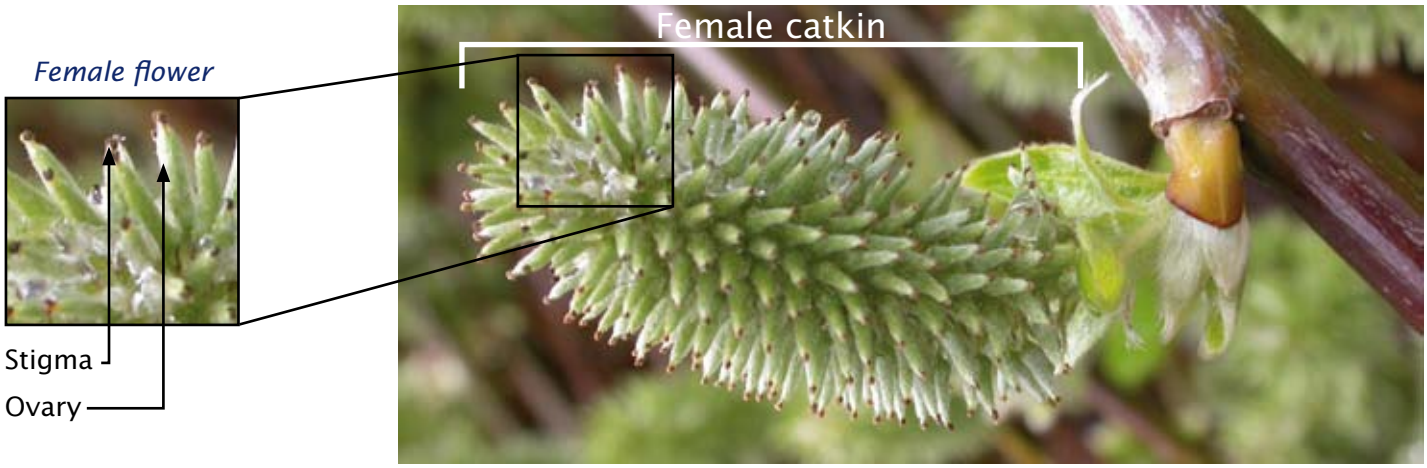
Willow seedlings growing along the King River, North East Victoria. The seed of some willows can spread long distances by wind, so even the most remote environments are at risk of invasion.

Male: Each flower on a male catkin has several stamens, which consist of fine filaments with bright yellow pollen sacs at the tips



Above: Male catkin from a crack willow (*Salix fragilis* var. *fragilis*). Each flower has 2 or more stamens, each consisting of a fine filament and bright yellow pollen sack (Photo: Matthew Baker)

***Female*: Each flower on a female catkin has a single *bulbous green ovary* topped by a single stigma.**



Above: Female catkin from a grey sallow (*Salix cinerea*). Each flower has a bulbous green ovary and is topped by a single stigma (Photo: Matthew Baker).

Above: If pollinated, female catkins produce lots of fluffy seeds that can be dispersed long distances by wind.

Catkins can vary in size and shape between willow species. For example, Salix cinerea has egg-shaped catkins, while Salix alba has long, slender catkins.

Above: (left) Male *Salix cinerea* catkins and (right) female *Salix alba* catkins. Note: (right) the 'tree' willow's leaves have emerged with the catkins and (left) there are no leaves on the stem as the 'shrub' willow's catkins have emerged before the leaves.

Male and female flowers on the same catkin!

In some rare instances, male and female flowers can form on the same plant and sometimes even on the same catkin. The golden weeping willow (*Salix* x *sepulcralis* var. *chrysocoma*) and the New Zealand hybrids (*Salix matsudana* x *S. alba*) can both develop male and female flowers on the one plant. This allows the plant to fertilise its own flowers, enabling a single, isolated tree to set viable seed.

Above: Catkins with both male and female flowers from (left) a golden weeping willow (*Salix* x *sepulcralis* var. *chrysocoma*) and (right) a New Zealand hybrid willow (*S. matsudana* x *S. alba*).

When do willows flower?

Flowering occurs between August and November, but the precise timing varies among willow taxa. Some willows commence flowering in August, while others do not flower until late September and October. The following table illustrates the approximate flowering times of different willows, based on data collected in the ACT from 1995-19991. Actual flowering times may vary considerably, however, depending on variations in temperatures between years and across regions and states.

	August	September	October	November
Tree willows				
S. babylonica ♀	ooooooooooooooooooooooooooooooooooooooooo			
S. × *chrysocoma* ♂	ooooooooooooooooooooo			
S. matsudana × *alba* ♂ ♀	ooooooooooooooooooooooooooooooooooooooooo			
S. alba ♂ ♀	ooooooooooooooooooooooooooooooooooooooooo			
S. fragilis ♂	ooooooooooooooooo			
S. matsudana 'Tortuosa' ♀	ooooooooooooooooooooooooooooooooooooooooo			
S. × *rubens* ♂ ♀	ooooooooooooooooooooooooooooooooooooooooo			
S. alba var. *vitellina* ♀	ooooooooooooooooooooooooooooooooooooooooo			
S. nigra ♂ ♀	ooooooooooooooooooooooooooooooooooooooooo			
Shrub willows				
S. × *reichardtii* ♂	ooooooooooooooooooooooooo			
S. viminalis ♂ ♀	ooooooooooooooooooooooooooooooooooooo			
S. purpurea ♂ ♀	ooooooooooooooooooooooooooooo			
S. cinerea ♂ ♀	ooooooooooooooooooooooooooooooooooooo			

[1] Data obtained by Cremer (1995 and 1999) in the ACT between 1994 and 1998.

♀ - forms female catkins ♂ - forms male catkins

ooooo = Catkins enlarging ooooo = Flowering ooooo = Seed development ooooo = Seed shed

2. Is the seed viable?

If both female and male plants from the same subgenus (e.g. *Salix* or *Vetrix*) are present in an area and their flowering times overlap, pollination is likely to occur and viable seed produced.

To confirm if viable seed is being produced:

1. Collect branches with catkins that have started to release white, cottony fluff but also have unopened capsules.
2. Place cut ends in a vase of water as you would do with a bunch of flowers.
3. Keep in a sheltered room and wait until the new capsules open and release fresh seed (usually only a day or two).
4. Select 10–20 seeds, with or without attached cottony fluff.
5. Press firmly into very wet tissue paper on a dish so that seed makes close contact with the wet paper.
6. Cover dish with glass or plastic wrap so that the seed keeps moist, but not dark.
7. Keep at room temperature (20–25°C) in a well-lit position, but not in direct sunlight.
8. Germination is usually obvious after 1 or 2 days – a pair of 1mm long green leaves will appear.

Some willows can spread by seed up to 100km, emphasising the need for early identification and management of seeding willows.

3. Is the willow a 'tree' or 'shrub'?

If both female and male plants from the same subgenus (either 'shrub' or 'tree') are present in an area and their flowering times overlap, pollination is likely to occur and viable seed produced. Identifying which of these major groupings (or subgenera) the willow belongs to will help prioritise where resources should be allocated for management. The following table outlines some features that can generally be used to distinguish between tree and shrub willows. It is important to note, however, that there are some exceptions to the rules.

Shrub willows - osiers vs pussy willows

Both osiers (e.g. common and purple osiers) and pussy willows (e.g. grey sallow and pussy willow) belong to the subgenus *Vetrix* (shrub willows). Osiers are similar to pussy willows in having many stems, flexible branches, generally rather smooth bark and dark flower scales (you will only be able to see flower scales with an eye glass or microscope). However, osiers have several features that resemble tree willows (subgenus *Salix*). Like tree willows, osiers generally have long, narrow leaves and catkins and, in some cases, the catkins of the common osier (*Salix viminalis*) emerge with the leaves, a feature otherwise only seen in 'tree willows'.

	Tree willows (*subgenus Salix*)	**Shrub willows** (osiers and pussy willows) **(*subgenus Vetrix*)**
	Includes *Salix fragilis, Salix nigra, Salix babylonica* and *Salix alba* var. *vitellina*	The pussy willows include *Salix cinerea, Salix x reichardtii*. The osiers include *Salix purpurea* and *Salix viminalis*
Form	Single to multi-stemmed tree or shrub 10–20 metres tall at full size; weeping or upright	Multi-stemmed low shrub to small tree 4–9 metres tall at full size
	  	  
Stems	♦ Generally break easily at the base – some may crack more easily than others	♦ Do not break easily – branches flexible at the base
Bark	♦ Generally rough or fissured	♦ Generally rather smooth, but can become somewhat fissured with age





Leaves

- Long and narrow, shaped like a canoe when seen from above
- Toothed margins
- Length usually more than 3x the width
- Silky or hairless



Osiers:

- Thin, long and narrow, usually 5-10 times longer than wide
- Margins usually smooth, sometimes irregularly toothed


Osier

Pussy willows:

- Thick, generally oval to elliptic in shape
- Irregularly toothed margins, hairy with conspicuous veins beneath
- Usually less than 3 times longer than wide


Pussy willow

Catkins

- Emerge with the leaves, hence leaves and catkins both present on the stems
- Slender and cylindrical, upright or sometimes drooping
- Flower scales pale green or yellow


Yellow flower scale


Female


Male

Osiers:

- Long, cylindrical, 1.5-5cm long, closely spaced along one-year-old shoots, may emerge before or with the leaves

Pussy willows:

- Short and oval-shaped and produce lots of fluffy seed
- Emerge well before the leaves, hence no leaves are seen on the stems; flower scales dark



Pussy willow

4. How brittle are the branches?

Determining how brittle (or fragile) the branches are will indicate how easily a willow can spread by branches breaking off and rooting downstream.

Do the crack test! Break a twig off at its base. If it cracks or breaks easily, then it has brittle branches and will spread easily by vegetative means.

Try to break the twig off here at the base

5. What is the willow species, subspecies, variety or hybrid?

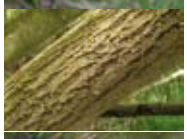
The following is a guide to identifying key willows that are recognised as being invasive in Australia. This is by no means a comprehensive list and other species not listed may also be extremely invasive. This list will need to be updated as we gain further information on the invasiveness, risk and current and potential distribution of different willows in Australia.

What features do I look for, at what time of year?

The following plant features will help you identify the willow or group of willows you are looking at. Some of these features can only be seen at a certain time of year, whereas others can be seen all year round. Also, certain characteristics (such as leaf hairiness, bark colour/texture and leaf shape) can vary depending on the time of year, growing conditions and tree or shrub age.

Even if you are unsure which willow you are dealing with, record information on the following features, so that someone else may be able to later identify it.

(Left) Some characteristics of a willow can vary depending on tree or shrub age. E.g. black willow (*Salix nigra*) has a conical shaped crown when young but forms a broader crown when old.

	Feature of the plant	Time of year
	Form – tree or shrub; narrow or wide crown; single-stemmed or multi-stemmed; weeping, contorted or upright branches	Any time of year
	Stems/branches – colour; degree of brittleness or flexability (do they snap when broken); straight or curvy; are there ridges under the bark	Any time of year
	Bark – colour and texture (rough or smooth) along the trunk	Any time of year
	Roots – colour of exposed roots (pink or white)	Any time of year
	Leaves – size, shape, colour on both sides, degree of hairyness, edge shape (smooth or jagged) and number of veins.	Summer to Autumn
	Flowers/catkins – shape, size, sex, number of flowering parts and flowering time	Spring

6. How to collect a willow specimen?

If you are uncertain about the willow species (or variety or hybrid) you are dealing with, collect a specimen and send it to your local herbarium or expert for advice (see Further Information for contact details). Sending a plant sample to the herbarium has the added benefit of establishing a permanent record of that plant at a particular location and time. This assists our understanding of the distribution and ecological preferences of that species.

Remember, it takes almost as much effort to prepare a poor specimen as it does to prepare an excellent specimen.

For accurate identification of willows, complete specimens should be collected at two periods of the year - in the spring for catkins (or flowers) and in the summer or early autumn for mature foliage. If a site can only be visited once, collect material in the summer or early autumn, as leaves provide more valuable information for identification than catkins do.

If you discover willow seedlings in an area, collect specimens of likely parents growing in the neighbourhood also, to aid identification and management.

1. Complete a label that includes the information outlined on the right;
2. Collect a healthy specimen (approx. 30cm long), with leaves and twigs. If possible, return in spring to collect catkins and/or seed bearing capsules;
3. Take a photo of the tree form and bark;
4. If specimen is dirty, gently clean it with water and dry;

   (Note: if you do not have paper with you when collecting, place specimen in a dry plastic bag and press within 24 hours)
5. Place specimen between several sheets of newspaper;
6. Arrange the specimen so that all parts can be clearly seen (stems and both sides of leaves);
7. Place weights on specimen to apply pressure and flatten the specimen;

   (Note: this can be done with objects such as books or boards with bricks on top);
8. Change newspaper daily for the first few days, then weekly until dry;
9. When dry, put specimen between 2 sheets of newspaper, then 2 sheets of firm cardboard;
10. Place catkins and/or seed in a labelled envelope with specimen;
11. Check that the specimen is correctly labelled;
12. Securely wrap package;
13. Attach a letter with your contact details and request for identification.

Label

The information recorded on the label is as important as the specimen you collect.

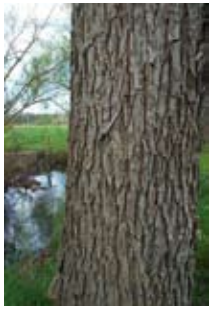
For each specimen collected, attach a label with the following information.

Example only: Four Specimen Information lables are avaliable on the back of this booklet for photocopying.

Specimen information

Number (year/month/day/sequential number): _____
Name: _____
Date: _____
Precise location (on a map or latitude/longitude or easting/northing): _____
_____
Town: _____ State: _____
Growth form (e.g. tree, shrub; weeper, non-weeper):
_____
Number of trunks (emerging from base): _____
Height (m): _____
Bark texture (rough or smooth) & colour: _____
_____
Colour:
fresh stems _____
leaves – upper _____
leaves – under _____
catkins (flowers) _____
roots (if visible) _____
Habitat (e.g. riverbank, wetland, grazed paddock, drainage line, riparian forest etc.): _____
_____
Abundance of mature plants (no./ freq. of plants) and presence of seedlings: _____
_____
Other info (e.g. damage to tree, growing in stream or along bank etc.): _____
_____
_____
_____

Tree Willows - Upright

	Salix nigra **Black willow**	***Salix fragilis*** **Crack willow**	***Salix x rubens*** **Gold-crack willow**	***Salix alba var. vitellina*** **Golden willow**
Distinguishing features	Deeply fissured grey bark on stems over 10cm diameter and leaves almost equal bright green on both sides. Spreads aggressively by seed and branches in NSW and Vic.	Distinctive glossy, greenish brown, hairless twigs snap off at base very easily with a loud crack. Bright red/ pink rootlets in water. *S.* x *rubens* can look very similar.	A hybrid of *S. fragilis* and *S. alba*, with appearance intermediate between. One of the most abundant and widespread willows. Both sexes often present, rootlets pink or partly pink in water.	Yellow or orange-yellow twigs, wide spreading crown, slightly hairy on underside of mature leaf and distinctive white rootlets in water. Older twigs not brittle at point of attachment.
Habit/form ● Height ● Shape of crown ● Number of stems	♦ Up to 20m tall ♦ Crown conical when young, broad when old in isolation ♦ Usually with a single prominent stem	♦ Up to 20m high ♦ Broad rounded crown, wide spreading branches ♦ Trunk divides into major branches at ground level	♦ Up to 20-25m high ♦ Broad rounded crown, spreading branches ♦ 10-20+ apparently independent stems, which are actually low branches emerging from the accumulating sediment	♦ Up to 15-20m high ♦ Open crown and spreading branches; may weep in lower crown ♦ Usually with a single stem
				
Bark ● Roughness ● Colour	♦ Usually deeply fissured on stems >10cm in diameter	♦ Rough and fissured with age ♦ Greyish-brown	♦ Rough and fissured with age ♦ Greyish-brown	♦ Rough and fissured with age ♦ Greyish-brown
				

Shoots/twigs ● Colour ● Brittleness/flexibility ● Hairiness ● Other	♦ Shiny red-brown ♦ Brittle at base ♦ Predominantly hairless ♦ Rough on stems down to 10cm diameter; scaly when older; slender but not drooping	♦ Shiny; grey-green in summer, yellow-brown in winter ♦ Very brittle at point of attachment to branch (twigs snap off easily at base, without stripping any bark) ♦ sparse short hairs when young, becoming hairless ♦ Never weeping	♦ Colour variable, red, yellow-orange, olive-green or brownish-green ♦ Slight to very brittle at base ♦ Thinly hairy at first, becoming hairless	♦ Very orange-yellow to more than 1m from tips, later yellowish brown ♦ Not very fragile – when twig is broken off, it will peel bark away with it ♦ Fine, short hairs at first, soon becoming hairless
				
Leaves ● Size and shape ● Colour on both sides and degree of hairiness ● Time it emerges	♦ Thin, linear ♦ Equally bright green on both sides, hairless	♦ 7-13cm long (mostly over 8cm) and slender ♦ Shiny, dark green, hairless above. Paler, bluish-whitish, soon hairless below ♦ Emerge 1 month later than *S. alba*.	♦ 7-12cm long, 1.5-3cm wide; narrow and long or elliptical; serrated edges ♦ Usually shiny green above. Bluish grey below, soon becoming hairless	♦ 8-12cm long; 1.5-2cm wide; fine serrations on edges ♦ Lustrous green and slightly hairy above, bluish grey and thinly hairy below ♦ Emerge August-September
Catkins/flowers ● Male/Female/both ● Size and shape of catkins ● Time it emerges	♦ Male and female trees equally common ♦ 6-12cm long with widely spaced 6mm long flowers, with 4-7 stamens per flower; ovary on 2mm long stalk	♦ Mostly male, females rare ♦ 4-9cm long, slender and cylindrical, dropping on hairy stalks ♦ appears with or after leaves; flowers September-October	♦ Male or female ♦ 3.5-6cm long; narrowly cylindrical; usually spreading ♦ Appears with or after leaves; flowers September-October ♦ Similar to *S. fragilis* (left) or *S. alba* (right)	♦ Female or male ♦ 4-6cm long; narrow, cylindrical and curved ♦ Late flowering September-October
				

Tree Willows - Upright and Weeping

	Salix matsudana* x *alba **New Zealand hybrid**	***Salix matsudana 'Tortuosa'*** **Tortured willow**	***Salix* x *sepulcralis var. chrysocoma*** **Golden weeping willow**	***Salix babylonica*** **Weeping willow**
Distinguishing features	Single-stemmed, erect, steeply branched, narrow crown, culminating in a tip. Twigs flexible and not readily detaching. Not yet common. Spreads easily by seed	Strongly twisted outer branches, twigs and leaves. Bright green foliage and very short cylindrical catkins. A cultivar of *S. matsudana*.	Golden or greyish yellow twigs and sometimes both sexes on same catkins. Catkins on stalks 1-5mm long. Long weeping branches and river narrowing habit.	Dense foliage and long, slender, weeping twigs that often touch the ground in mature plants. Earliest flowering tree willow. Can form hybrids with *S. alba* and *S. fragilis*.
Habit / form ● Height ● Shape of crown ● Number of stems	♦ Tall tree to 25m high ♦ Narrow or moderately spreading apical-shaped crown; erect branches ♦ Single prominent stem to top of tree	♦ Tree to 15-20m high ♦ Narrow rounded crown, erect but outer most branches sometimes slightly weeping.	♦ Tree to 15-20m high; equal height to width ♦ Wide-spreading rounded crown; long weeping branches	♦ Tree to 15-20m high; taller than it is wide ♦ Wide-spreading, rounded crown, very weeping branches
				
Bark ● Roughness ● Colour	♦ Fissured ♦ Grey-brown to dark brown	♦ Moderately fissured with age ♦ Grey-brown to dark brown	♦ Fissured with age ♦ Grey-brown to dark brown	♦ Moderately fissured with age ♦ Grey
				

Shoots/twigs ● Colour ● Brittleness/ flexibility ● Hairiness	♦ Reddish green, becoming grey-green or reddish-brown ♦ Slender; spreading or erect; slightly to moderately brittle ♦ Becoming hairless	♦ Lustrous green to dark reddish, finally brown ♦ Moderately brittle, slender, spreading or erect ♦ Hairy at first, becoming hairless	♦ Golden yellow to greenish yellow for more than 1m from tips ♦ Slender, moderately brittle ♦ Silky when young then hairless	♦ Greenish or brownish green ♦ Long, slender, weeping ♦ Hairs when young, becoming hairless
Leaves ● Size and shape ● Colour on both sides and degree of hairiness ● Time it emerges	♦ 9-14cm long, 1-1.7cm wide; lanceolate; serrated edges ♦ Light green to bluish green; silky hairy when young, becoming sparsely hairy above	♦ 8-13cm long, 1-2.5cm wide, narrow and long, tapering to a thread; margins finely serrated, blades markedly twisted and buckled ♦ Bright green above, often blue-green below; silky hairy at first, soon becoming hairless	♦ 7-18.5cm long, 0.8-2.9cm wide; narrow-long to narrow-elliptical; pointed but not drawn out; fine serrations on edges ♦ Bright green above; bluish-grey below; silky on both sides at first, becoming hairless	♦ 7-18cm long, 0.5-2.5cm wide; fine serrations (or bumps) on margins; leaf tips drawn out and wavy ♦ Slightly shiny, medium green above; bluish grey below; hairs at first, becoming hairless
Catkins/flowers ● Male/Female/both ● Size and shape of catkins ● Time it emerges	♦ Male, female or both sexes on the same catkin ♦ Narrow, cylindrical, 2-3.5cm long and 6-12mm wide ♦ Appears with or after leaves in September-October, similar to *S. babylonica* and *S. alba*	♦ Female only ♦ Short, cylindrical, 2cm long ♦ Very dark bud scales ♦ Flowers late Sept-Oct with or after leaves. Hybridises with *S. fragilis* and *S. matsudana* x *alba* ♦ Seed produced has low viability	♦ Male, female or both sexes on same catkin ♦ 2-5cm long, narrow, cylindrical and slightly curved; distinctly stalked (1-5mm); ovary not much longer than pale yellow catkin scale ♦ Flowers September-October	♦ Female only ♦ Narrow, cylindrical and often curved; 0.6-2.8cm long, almost stalkless ♦ Usually appears with but sometimes after leaves; flowers early in August-September

Shrub Willows - Pussy Willows and Osiers

	Salix cinerea **Grey sallow**	***Salix* x *reichardtii*** **Pussy willow**	***Salix viminalis*** **Common osier**	***Salix purpurea*** **Purple osier**
Distinguishing features	Longitudinal ridges on the wood beneath the bark (sometimes visible on the outside of smooth branches also). Wide rounded crown (wider than it is high). Oval shaped leaves. Branches flexible. Can spread by seed 10's of kilometres from the initial source.	Hybrid between *S. caprea* and *S. cinerea*. Variable in its characteristics but generally differs from *S. cinerea* in having longer leaves with more pointed tips, very showy, silver catkins and being taller than it is wide when mature.	Long, narrow leaves, dark green above, pale silky below, with toothless inrolled margins. No ridges beneath bark. Stigma cut in two for about half its length. Leaves not bitter to taste.	Many leaves opposite or semi-opposite, especially near shoot tips; leaves wider above the middle (kite shaped) and bitter to taste. Clumped, multi-stemmed habit, young twigs sometimes purplish. Mainly occurs in the Snowy Mountains region.
Habit / form ● Height ● Shape of crown ● Number of stems	♦ 6-12m high ♦ Wide, rounded crown (much wider than high in mature trees) ♦ Several sturdy branches arising near ground level	♦ 6-12m high, significantly higher than it is wide ♦ Several upright stems arising from a short trunk	♦ To about 8m high, but usually 3-6m high ♦ Erect form ♦ Several upright stems	♦ To about 8m high ♦ Variable in habit, from erect to spreading, often with slender, graceful branches
Bark ● Roughness ● Colour	♦ Rather smooth at first, becoming fissured with age	♦ Rather smooth, shallowly fissured near base ♦ Greyish-brown	♦ Rather smooth ♦ Greyish-brown	♦ Rather smooth ♦ Grey, inner bark yellow

Shoots/twigs
- Colour
- Brittleness/ flexibility
- Hairiness

- Greenish, greyish, redish or purple
- Not brittle, long striations/ridges visible on wood beneath bark (may need to peel the bark to see the ridges)
- Usually hairy at first, becoming hairless

- Olive to reddish-brown
- Not brittle; smooth with a few short striations/ridges beneath bark
- Very hairy when young

- Green to yellowish green; sometimes yellowish brown to reddish brown, especially when exposed to the sun
- Slender and very tough and flexible; no striations beneath bark
- Densely hairy at first, becoming hairless

- Grey-green to yellowish green; sometimes yellowish brown, reddish brown or purple when young
- Long, straight, very tough and flexible
- Densely hairy at first, becoming hairless

Leaves
- Size and shape
- Colour on both sides and degree of hairiness
- Time it emerges

- 2-7cm long, 1.5-3.5cm wide, generally oval, broadest in middle, sometimes elliptic; tip short, pointed; margins sparsely and irregularly toothed.
- Hairy both sides; dense grey hairs below or sometimes sparsely covered in reddish brown hairs
- Emerge late September after catkins

- 4-10cm long, 2.5-5.5cm wide; oval to elliptic; margins rippled and sparsely toothed, leathery, broadest above middle
- Mid-green above, becoming hairless except for midribs

- Rather erect, long and narrow, 6-18cm long, 0.5-2cm wide; margins not toothed and often recurved
- Dark shining green above; usually covered with whitish or greyish silky down below
- Juvenile leaves often longer and narrower than older leaves

- Long and narrow, 2.5-11cm long, 0.5-2cm wide; often opposite towards the tips of the shoot; mostly broadening above the middle and minutely toothed towards the tip
- Dark glossy green above; bluish green or glaucous below; sometimes hairy when young, becoming hairless

Catkins/flowers
- Male/Female/both
- Size and shape of catkins
- Time it emerges

- Male or female or both
- Male flowers ovate in shape and white with yellow tips; female flowers green and cylindric-ovate in shape
- Begin to emerge in late August before the leave (earlier than most other willows) and shed lots of seed 4 weeks after flowering

- Male only, but may hybridise with female *S. cinerea*
- Broad, oblong catkins, 2-3.5cm long with red buds
- Emerge before leaves

- Male or female
- Cylindric, 1.5-6cm long and 0.5-1cm wide, stigma cut in two for about half its length (bifid)
- Appear before or as leaves emerge in August to October, depending on altitude

- Male or female
- Narrowly cylindric, often curved; male catkins 1.5-3cm long; female catkins 2-4cm long; often in semi-opposite pairs
- Emerge before leaves in August to September

Female

Male

Further information

Relevant weblinks:

For further information on willows and links to other willow-related websites go to:

www.weeds.org.au/WoNS/willows

Australia's Virtual Herbarium provides links to State and Territory herbarium websites:

www.anbg.gov.au/avh

Further reading/references:

Cremer, K.W. (1995). *Willow identification for River Management in Australia*. Technical Paper No. 3., CSIRO Division of Forestry, Canberra, Australia.

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Geoff Carr for his invaluable scientific key to willows in Australia.

Willow identification contacts by state/territory:

Note: *Some herbaria charge a fee to identify specimens. Please refer to the relevant website or contact the person directly to determine costs.*

Australian Capital Territory
Plant Enquiry Service
Australian National Botanic Gardens
GPO Box 1777
Canberra ACT 2601
Ph: (02) 6250 9540

New South Wales
Botanical Information Service
National Herbarium of NSW
Botanic Gardens Trust
Mrs Macquaries Road
Sydney NSW 2000
Fax: (02) 9251 1952

Queensland
Botanical Information and Advisory Service
Queensland Herbarium
Brisbane Botanic Gardens, Mt Coot-tha
Mt Coot-tha Rd
Toowong QLD 4066
Ph.: (07) 3896 9326 Fax: (07) 3896 9624
Queensland.Herbarium@epa.qld.gov.au

South Australia
Plant Biodiversity Centre
PO Box 2732
Kent Town SA 5071
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Compiled by Sarah Holland Clift from:
Cremer, K. W. (1995). Willow identification for River Management in Australia. Technical paper No. 3. CSIRO Division of Forestry, Canberra, Australia.

Van Kraayenoord, C. W. S., Slui, B. and F. B. Knowles (1995). Introduced Forest Trees in New Zealand: Recognition, role and seed source, 15. The Willows *Salix* spp. New Zealand Forest Research Institute Limited.

Meikle, R. D. (1984). Willows and Poplars of Great Britain and Ireland. Botanical Society of the British Isles, London.

Specimen information

Number (year/month/day/sequential number): _____

Name: _____

Date: _____

Precise location (on a map or latitude/longitude or easting/ northing): _____

_____

Town: _____ State: _____

Growth form (e.g. tree, shrub; weeper, non-weeper):

_____

Number of trunks (emerging from base): _____

Height (m): _____

Bark texture (rough or smooth) & colour: _____

_____

Colour:

- fresh stems _____
- leaves – upper _____
- leaves – under _____
- catkins (flowers) _____
- roots (if visible) _____

Habitat (e.g. riverbank, wetland, grazed paddock, drainage line, riparian forest etc.): _____

_____

Abundance of mature plants (no./ freq. of plants) and presence of seedlings: _____

_____

Other info (e.g. damage to tree, growing in stream or along bank etc.): _____

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