Approved **Recovery Plan**

Salt Pipewort (*Eriocaulon carsonii*) Recovery Plan

December 2002

NSW NATIONAL PARKS AND WILDLIFE SERVICE

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Cover Photograph: *Eriocaulon carsonii* at Paroo-Darling NP, NSW.

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NSW National Parks and Wildlife Service Recovery Planning Program

Salt Pipewort (*Eriocaulon carsonii*) Recovery Plan

Prepared in accordance with the New South Wales *Threatened Species Conservation Act 1995*

December 2002

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This plan was prepared by Matthew Chambers, Matt Cameron and Geoff Robertson, NSW National Parks and Wildlife Service, Threatened Species Unit, Western Directorate. A good deal of the background information included in the Plan was sourced from earlier management documents prepared by Dr John Pickard, whose assistance in preparing this document is greatly appreciated.

Foreword

The conservation of threatened species, populations and ecological communities is crucial for the maintenance of this State's unique biodiversity. In NSW, the *Threatened Species Conservation Act* 1995 (TSC Act) provides the framework to conserve and recover threatened species, populations and ecological communities through the preparation and implementation of recovery plans.

The preparation and implementation of recovery plans are identified by both the National Strategy for the Conservation of Australia's Biological Diversity and the approved NSW Biodiversity Strategy as a key strategy for the conservation of threatened flora, fauna and invertebrates. The object of a recovery plan is to document the research and management actions required to promote the recovery of a threatened species, population or ecological community and to ensure its ongoing viability in nature.

This plan describes our current understanding of the Salt Pipewort, documents research and management actions undertaken to date and identifies actions required and parties responsible to ensure ongoing viability of the species in the wild.

NSW National Parks and Wildlife Service has prepared the Salt Pipewort Recovery Plan with the assistance of a number of people. I thank these people for their efforts to date and look forward to their continued contribution to the recovery of the species.

BOB DEBUS MP
Minister for the Environment

Executive Summary

Legislative context

The *Threatened Species Conservation Act* 1995 (TSC Act) is NSW's most comprehensive attempt at establishing a legislative framework to protect and encourage the recovery of threatened species, populations and communities. Under the TSC Act, the Director-General of the NSW National Parks and Wildlife Service has certain responsibilities including the preparation of Recovery Plans for threatened species, populations and ecological communities. This Recovery Plan has been prepared in accordance with the provisions of the TSC Act.

Preparation of Plan

This Recovery Plan has been prepared with the assistance of interested parties with relevant expertise. Components within the plan do not necessarily represent the views nor the official positions of all the individuals or agencies consulted. The information in this Recovery Plan was accurate to the best of the NPWS' knowledge on the date it was approved.

Current Species Status

Eriocaulon carsonii has been listed under a variety of legislation and conservation mechanisms as Endangered. These include Schedule 1 of the New South Wales *Threatened Species Conservation Act* (1995), the Commonwealth *Environment Protection and Biodiversity Conservation Act* (1999), the IUCN Red List of Threatened Plants **(**1997**)** and *Rare and Threatened Australian Plants* by Briggs & Leigh (1996). The 'Artesian Springs Ecological Community', of which *Eriocaulon carsonii* is a key component, is listed as Endangered under the New South Wales *Threatened Species Conservation Act* (1995) and the Commonwealth *Environment Protection and Biodiversity Conservation Act* (1999).

Recovery Objectives

The primary objective of this Recovery Plan is to conserve a wild population of the species in New South Wales.

The specific objectives are to:

1. Monitor the status of the species at Peery Lake within Paroo-Darling National Park;
2. Gain an understanding of environmental factors impacting upon the species at Peery Lake;
3. Control known threats to the species at Peery Lake;
4. Establish an *ex situ* population to ensure future conservation; and
5. Ensure that Great Artesian Basin management programs, such as piping and capping of artesian bores, deliver benefits for *Eriocaulon carsonii*.

Recovery Criteria

Recovery criteria are that:

1. Any changes in population abundance or distribution at Peery Lake are measured;
2. Known on-park threats are controlled;
3. Managers of the Great Artesian Basin are properly informed as to the status of *Eriocaulon carsonii* and the artesian springs in NSW, and any usage reduction measures are properly implemented to achieve environmental benefits;
4. *Ex situ* conservation is conducted to guarantee the conservation of the species; and
5. The general public, in particular visitors to Paroo-Darling National Park, will have access to information on the species, its management and conservation.

Biodiversity Benefits

The perennial flow of water from the Great Artesian Basin into arid and semi-arid areas creates an unusual and diverse ecosystem that is often in direct contrast to the surrounding dry environment. Artesian springs are a very specialised environment, sparsely distributed and extremely limited in their geographical extent across the continent. As a specialised environment they are renowned for supporting a variety of wildlife including plants, fish and invertebrates that are found only on artesian springs (Ponder 1986, Wilson 1996). This unique assemblage of species has led to the 'Artesian Springs Ecological Community' being listed as Endangered in State and Commonwealth legislation (TSC Act 1995; EPBC Act 1999). Although there have been no detailed studies at Peery Lake, a similar suite of unique biota could be expected. Thus, any conservation of *Eriocaulon carsonii* that aims to maintain the existing environment of the springs will benefit other rare endemics and the artesian spring community at Peery Lake.

BRIAN GILLIGAN
Director-General

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1 Current Conservation Status

The Salt Pipewort *Eriocaulon carsonii*, is a forb endemic to a small number of mound springs on the edge of the Great Artesian Basin. It has a restricted distribution in New South Wales, being found only at Peery Lake in the west of the state. A survey undertaken in 1987 suggests the NSW population numbered approximately 3000 rosettes, covering only a small area and was under severe threat from trampling by animals drinking at the springs and rooting by feral pigs. More recently, the numbers of individuals have fluctuated markedly for no apparent reason, and in 2001 were considerably reduced to perhaps a few hundred. Localised extinction has already occurred in NSW with the loss of the first known population at Wee Wattah Springs, the 1888 type locality of the species.

Eriocaulon carsonii has been listed under a variety of legislation and conservation mechanisms as Endangered. These include Schedule 1 of the New South Wales *Threatened Species Conservation Act* (1995), the Commonwealth *Environment Protection and Biodiversity Conservation Act* (1999), the *IUCN Red List of Threatened Plants* **(**1997**)** and *Rare and Threatened Australian Plants* by Briggs & Leigh (1996). All have reached a similar conclusion on the conservation status of *Eriocaulon carsonii* determining the species to be:

- in a demonstrable state of decline which is likely to result in extinction;
- significantly prone to future threats which are likely to result in extinction; and
- very rare in terms of abundance and distribution.

2 Description

2.1 Taxonomy

Scientific Nomenclature:	*Eriocaulon carsonii* von Mueller
Family:	Eriocaulaceae
Common Name:	Salt Pipewort
Recent Synonyms:	*E. tatei* Ruhland, *E. submersum* Tate
Other Common Names:	Pipewort

2.2 General

The plant is quite distinctive and can not be mistaken for any other species growing on artesian mound springs, its only known habitat.

Eriocaulon carsonii is described as a small hairless herb. Leaves are broad, lanceolate and striate, 1.5-6cm long, 2-10mm wide, gradually narrowing to a rounded often incurved tip, with enlarged and sheathing bases that join to form a basal tuft or rosette. Inflorescences glabose, 3-4mm in diameter, with female flowers forming first, followed by the male flowers, which may be a means of avoiding self-

pollination. Bracts glaborous; outer bracts obovate, concave; inner bracts obovate. Male flowers stipitate; outer tepals 3, one spathulate, others oblong spathulate, scarious; inner tepals fused into an obconical tube, 3-lobed, tube much longer than lobes, lobes minute with a few white hairs towards apex, each appressed to stamens; stamens mostly 6. Female flowers with 2 outer, broad, +/- boat shaped perianth lobes; inner perianth 3-lobed, lobes narrow-ovate, almost flat, white with dark brown markings towards apex, inserted slightly more apically on floral axis with a few white hairs towards apex; ovary sessile. Fruit a membranous, swollen, 3-celled capsule; seeds ellipsoid, shining brown, almost smooth, about 0.6 mm long, solitary in each cell. Flowers from summer to late autumn (Cunningham *et al.* 1981; Conn 1993).

Further descriptions can be found in von Mueller (1890), Black (1960), Evans (1966), Jessop (1981), Symons (1985) and Davies (2000).

Pickard (1992b) has described the plants at Peery Lake as fitting the descriptions provided by Conn (1993) and Cunningham *et al*. (1981). Likewise, Bruce Wilson (Qld Dept of Environment and Heritage, Toowoomba, pers. comm.) has indicated that plants at Edgbaston Station fit the descriptions in Cunningham *et al.* (1981) and Conn (1993). However, he has noted that the Edgbaston population also contains considerably larger plants, up to 250 mm high, which may be a yet undescribed species of *Eriocaulon*.

The mound springs of Peery Lake have been a focal point for the traditional owners, the Paakantji for many thousands of years. The water from the springs represents a life source in an arid environment and the springs themselves are a significant feature in their dreaming.

3 Distribution

3.1 Geographical distribution

Eriocaulon carsonii is an endemic of active or flowing artesian mound springs on the margins of the Great Artesian Basin (Fatchen & Associates 1983; Fatchen 1984; Fatchen & Fatchen 1993; Symon 1984, 1985; Pickard 1992b, c; Wilson 1995; Fensham 1998). Until 1992 it was believed that it was restricted to a few springs in the Lake Eyre region in South Australia (Fatchen 1984; Symon 1985), Peery Lake in New South Wales, and the Springvale region in Queensland (Ponder 1985). More recent surveys (Wilson 1995; Fensham 1998) have extended the range into Queensland.

Only two sites are known in NSW, the type locality of Wee Wattah Springs (also known as Wee Wata) where the plant was collected in 1888, and Peery Lake. Until its discovery by Peter Goodson at Peery Lake near White Cliffs in 1986, this species was believed to be extinct in New South Wales (Evans 1966). The extinction of the population at Wee Wattah Springs was believed to be a result of trampling by stock and the loss of spring flow caused by the localised lowering of the water table resulting from an artesian bore being sunk in the vicinity. Wee Wattah Springs has

been examined several times in the last few decades but stock have destroyed the mound spring such that its exact location is uncertain. A survey of about 40 mound springs in the NSW section of the Great Artesian Basin was undertaken in February 1992, at which time *Eriocaulon carsonii* was found on only one mound on the western side of Peery Lake (Pickard 1992a). There was no apparent reason for its absence from other mounds on the western side, all within 1 km, or from springs on the eastern side of the lake.

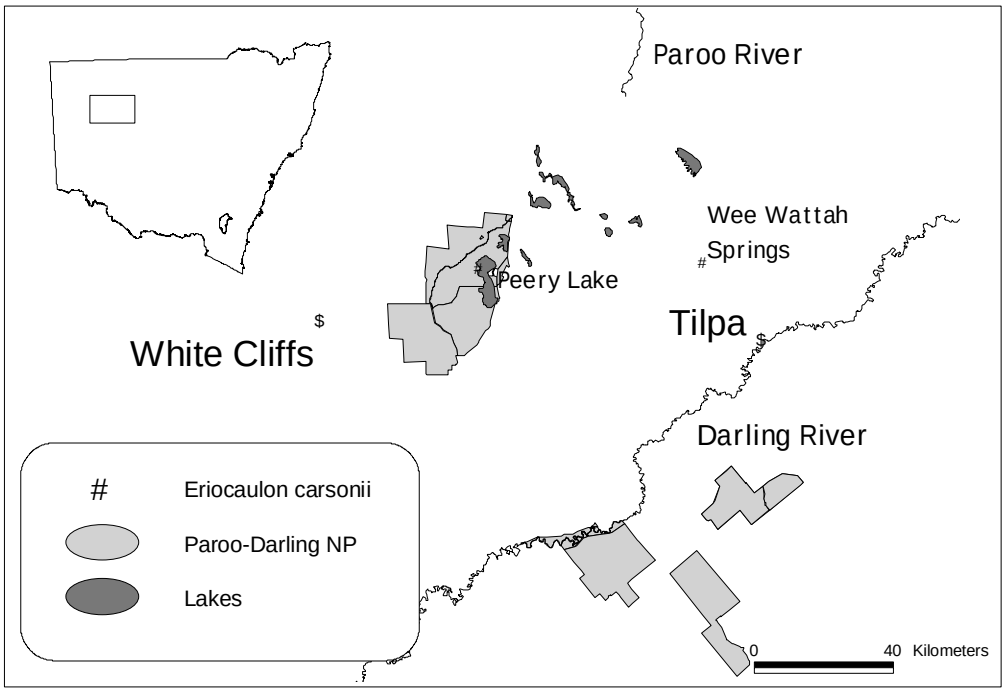

Figure 1: Location of *Eriocaulon carsonii* in New South Wales.

3.2 Tenure

The northern section of Peery Lake, which includes the eastern and western springs, was gazetted as National Park under the *National Parks & Wildlife Act* 1974 (NP&W Act) on the 31 August, 2000. Paroo-Darling National Park (formerly Peery National Park) covers an area of approximately 209 700ha and includes all the known extant populations of *Eriocaulon carsonii* in NSW.

3.3 Movements

The potential current habitat in New South Wales appears to be mound springs at Peery Lake, and perhaps some others. For mound springs to provide suitable habitat there must be some seepage and minimal trampling by domestic and feral herbivores. Some mound springs further east appear suitable for *Eriocaulon carsonii*. In spite of this, with the exception of Wee Wattah Springs, there is currently no evidence that

the plant ever occurred naturally on these springs and given the distance of these sites from Peery Lake any natural colonisation of these springs would appear to be unlikely.

One of the notable features of the plant at Peery Lake was that it was restricted to a single mound in a complex of many tens of mounds. There was no apparent reason for this as conditions such as water composition and disturbance at all mounds was similar (Pickard 1992d). More recently the plant spread to adjacent mounds, but has now (2001) contracted to a single mound again. The causes and mechanisms of the spread and subsequent contraction are unknown.

Incidents of recent colonisation of other springs have been reported at Elizabeth Springs in Queensland and Hermit Hill Springs in South Australia (Fatchen & Associates 1983). Fatchen & Fatchen (1993, 1999) suggest that seed or vegetative material transported by grazing animals or birds may be responsible for the spread of the species between mounds at Hermit Hill Springs. The recent spread of the species at Peery Lake does not appear to have been associated with any single environmental condition or combination of conditions (rain, floods, grazing by domestic, native and feral herbivores), all of which appear to have occurred previously. The duration of study (1992 – present) and the intensity of survey (Pickard 1992d) limit examination of the spread of *Eriocaulon carsonii* at Peery Lake. Currently there is insufficient data to determine whether the species has just spread opportunistically or whether the current expansion is part of a long-term cycle of an increase in numbers and populations following a decline that may be associated with the periodic flooding of Peery Lake.

Fatchen & Fatchen (1993) suggest movement between springs within a complex is related to spring numbers and the compactness of the complex. Through studies of the many spring complexes around Hermit Hill, it was found that movement between springs occurred mostly where there were numerous springs within a short distance of one another within a complex. During these studies there was only one record of a long distance movement of the species, which occurred between two separate spring complexes. This movement over a long distance was attributed to plant or seed material being transported between the complexes by feral horses.

The plant has not been translocated to any sites in New South Wales except to horticultural collections in Sydney where it has been grown with little difficulty at the Royal Botanic Gardens. The plant has been translocated with considerable success to springs in South Australia (Fatchen & Fatchen 1993).

4 Ecology

4.1 Life Cycle

Until recently, very little was known about the life cycle of *Eriocaulon carsonii*. Of the information available, most was based on anecdotal observations that were often in conflict. Recent studies of the Hermit Hill Springs reported in Fatchen & Fatchen (1993, 1999) and Davies (2000) have shed considerable light on the life cycle of the species. Davies (2000) has confirmed that the species reproduces sexually by producing seed and asexually by producing new plants from underground rhizomes. Inflorescences consisted of an average of 12 female flowers and 17 male flowers with the male reproductive development generally delayed, which may be an evolutionary adaptation to promote cross pollination. Flowers appear to be present throughout the year with peak production in and around October (Richard Davies, Flinders University, pers. comm.). Seed production was abundant with an average of 23 viable seeds per inflorescence. Dispersal of the seed between springs may be assisted by its small size (800 x 500μm), hard nature, ability to withstand desiccation, and the release of the seed enclosed within two boat-shaped scarious sepals which would enable transport by flood waters and possibly by the wind. Examination of the soil seed bank at Hermit Hill Springs has shown that seeds persist up to 6cm below the surface and are unlikely to remain viable for more than a decade (Davies 2000). The life span of individual plants has not yet been determined.

4.2 Habitat

Eriocaulon carsonii is entirely restricted to flowing mound springs. Such springs occur on all margins of the Great Artesian Basin (Habermehl 1980, Ponder 1986). These landforms occupy an extremely small percentage of semi-arid Australia, and are probably the rarest landform on the continent.

The springs lie on faults, which provide direct access for the artesian water to reach the surface. Accumulated evaporite and mud deposits at the springs form mounds from 1 to 10 m high and 2 to > 100 m diameter. *Eriocaulon carsonii* is generally associated with vegetated mounds that, over considerable time, have formed organic fen soils. Fen soils are the alkaline equivalent to the acidic peat bog. The species appears to prefer areas of shallow standing water with slow flow (Fatchen & Fatchen 1993). Populations are generally found at the tail of the spring or above the vent of slow flowing springs. Fatchen & Fatchen (1993) provide some insight into the water chemistry and conditions of springs in South Australia where *Eriocaulon carsonii* occur. Spring water was alkaline with a 7-9.5 pH, conductivity ranged from 2000 – 8000 μS/cm, and water temperature varied from 20-25 ^{0}C in slow flowing springs to up to 30 ^{0}C in fast flowing springs. There is very little information available on the water chemistry of the springs at Peery Lake. Limited sampling of artesian bores around Peery Lake indicates conductivity ranges from 3330 – 9800 μS/cm (n=3) (Pickard 1992d). Recent studies at Hermit Hill Springs in South Australia suggest *Eriocaulon carsonii* prefers lower conductivities, with the species being most

abundant where the average conductivity is less than 2000 μS/cm (Davies 2000). Further studies are required to establish the conductivity of springs in New South Wales and the potential influence of this variable on the long-term conservation of the species.

The mound spring habitat of *Eriocaulon carsonii* at Peery Lake is located in the bed of an ephemeral lake prone to periodic flooding and inundation. Records of inundation suggest Peery Lake floods in 25% of years (Pickard 1992d). Although the mounds are elevated above the lakebed they can become submerged in years of particularly heavy rain. Peery Lake flooded extensively in the early nineties with the mounds being submerged from early 1990 to late 1991 (J. Pickard pers. comm.). Examination of the population in 1992 showed a possible reduction in numbers that may suggest a response to being submerged for long periods (Pickard 1992d). Heavy rains in early 2000 have again resulted in the mounds being submerged (Bill Tick pers. comm.).

4.2.1 Critical Habitat Components

Flowing or active mound springs are critical to the survival of this endangered species. Mound springs have not been listed as a critical habitat under the New South Wales *Threatened Species Conservation Act* 1995 nor the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999. The Artesian Springs Ecological Community is listed as an Endangered Ecological Community on Part 3 of Schedule 1 of the TSC Act.

4.3 Ecology

There is no formal information available on the ecology of the species. In order to obtain the necessary ecological understanding required to guide proper management, the Western Mining Corporation (Roxby Downs, South Australia), Flinders University and other granting bodies have funded research into the species through a PhD scholarship at Flinders University. At this stage only preliminary results are available for this study and are detailed in Davies (2000, 2001).

Grazing, either by stock or native herbivores, appears to have a function in allowing the persistence of *Eriocaulon carsonii* through controlling competition from other mound plants such as *Phragmites*, *Baumea* and *Fimbristylis* spp. The effects of competition from more dominant species upon *Eriocaulon carsonii* and *Cyperus laevigatus* appear similar. Harris (1992) suggested that native herbivores alone would not control these dominant species so an alternative mechanism must have been responsible for the control of competitors prior to the introduction of domestic stock. Furthermore it was suggested that the alternative control might have been fire, introduced to the environment periodically by indigenous Australians. Aboriginal people frequently burnt the mound at Hermit Hill Springs in order to increase flow from the vent (Fatchen & Fatchen 1993). Trial burns to determine its effectiveness to control competitive species was undertaken at Emerald Springs in SA as part of the Hermit Hill Springs study. At this spring *Eriocaulon carsonii* was not present. However, it was shown that fire successfully

reduced *Phragmites* growth to levels below that which it is competitive with another species, *Cyperus laevigatus,* for several years. Trial burns of mounds containing *Eriocaulon carsonii* have been undertaken in South Australia at Hermit Hill Springs. Preliminary results indicate that the species can survive the burning of mounds (Davies 2001). Further monitoring is required to determine the long-term response to fire by *Eriocaulon carsonii* and its competitors.

5 Relevant Legislation

5.1 Threatened Species Conservation Act 1995

The *Threatened Species Conservation Act* 1995 (TSC Act) provides for the protection and recovery of threatened species, endangered populations and endangered ecological communities. The Act defines the proper assessment of impacts associated with any action and allows for the licensing of those that may cause harm to an endangered population, endangered ecological community, threatened species or its habitat. *Eriocaulon carsonii* is listed on Schedule 1 of the TSC Act as an Endangered species. The 'Artesian Springs Ecological Community', which includes the springs at Peery Lake, is listed as an Endangered Ecological Community on Schedule 1 of the TSC Act.

5.2 National Parks and Wildlife Act 1974

In NSW, *Eriocaulon carsonii* is known only from springs on the west side of Peery Lake. This population is now included in Paroo-Darling National Park, gazetted under the *National Parks and Wildlife Act* 1974 and in the care and management of the NSW National Parks and Wildlife Service.

5.3 Environmental Planning and Assessment Act 1979

Land use and development on leasehold land in NSW is subject to assessment in accordance with the *Environmental Planning and Assessment Act* 1979 (EP&A Act). Threatened species are to be taken into account by consent authorities when they are considering development applications under Part 4, and by determining authorities undertaking or approving activities under Part 5 of the Act. Under the *Western Lands Act* 1901 the Department of Land and Water Conservation may be the determining authority under the EP&A Act.

The TSC Act amendments to the environmental assessment provisions of the EP&A Act require that consent and determining authorities in NSW consider relevant recovery plans when exercising a decision making function under Parts 4 and 5 of the EP&A Act. When considering any activity which may affect *Eriocaulon carsonii* these authorities must consider the conservation strategy outlined in this plan.

5.4 Native Vegetation Conservation Act 1998

The clearing of vegetation in NSW is subject to consent from the Department of Land and Water Conservation in accordance with the *Native Vegetation Conservation Act* 1998. The Act is integrated with the *Environmental Planning and Assessment Act* 1979, and requires that threatened species are taken into account by the consent authority when considering clearing applications under Part 4 of the EP&A Act. As the species only occurs in a gazetted National Park the NVC Act does not apply but would be invoked if populations were found on any other tenure.

5.5 Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth)

Eriocaulon carsonii is listed as Endangered on the Commonwealth *Environment Protection and Biodiversity Conservation Act (EPBC Act)* 1999. The 'community of native species dependent on natural discharge of groundwater from the Great Artesian Basin' has been listed as an Endangered Ecological Community under the EPBC Act. The EPBC Act protects threatened species and ecological communities in Commonwealth areas and regulates the activities of Commonwealth agencies. The EPBC Act regulates actions that may result in a significant impact on nationally listed threatened species and ecological communities. It is an offence to undertake any such actions in areas under State or Territory jurisdiction, as well as on Commonwealth-owned areas, without obtaining prior approval from the Commonwealth Environment Minister. As *Eriocaulon carsonii* and the artesian spring dependant community is listed nationally under the EPBC Act, any person proposing to undertake actions likely to have a significant impact on this species or community should refer the action to the Commonwealth Minister for the Environment for consideration. The Minister will then decide whether the action requires EPBC Act approval.

6 Management Issues

6.1 Threats and Reasons for Decline

The threats to *Eriocaulon carsonii* are associated with feral herbivores, trampling by ducks and other water birds, flooding, competition from other wetland plants, the operation of bores causing drawn down and a loss of basin pressure and its small geographic distribution.

Field observations over many years at Peery Lake indicate that rooting by pigs could potentially be the major threat to the species. Managers of other interstate populations of *Eriocaulon carsonii* suggest pigs are also a significant threat to conservation. Feral pigs cause significant disturbance to mounds in their search for rhizomes and tubers. There has been no formal study into impacts associated with pig rooting at any population in NSW or interstate. Consequently, there is little

information to determine pressures associated with pigs and effective mitigation measures to reduce the impacts. Regardless of the limited information on the impacts of pigs, there is sufficient anecdotal evidence to warrant an active pig control program to ensure conservation of the species.

Grazing is reputed to be a major threat to *Eriocaulon carsonii*. However, the plant has survived over 100 years of grazing at Peery Lake and other known localities (Fatchen & Fatchen 1993). Previous interstate management actions of removing stock or fencing populations that were believed to be under threat from grazing have resulted in obvious changes to individuals and the populations. These changes include a shift from numerous small individuals to fewer large individuals in a population (Fatchen & Fatchen 1993). The long-term impact of such actions has not been determined so it is impossible to suggest unequivocally that destocking or fencing is a benefit and that grazing is a serious threat.

Studies undertaken by Fatchen & Fatchen (1993) provide considerable insight into the relationship between grazing and *Eriocaulon carsonii*. Grazing of mound springs gave *Eriocaulon carsonii* a competitive advantage over *Phragmites*, *Fimbristylis* and *Baumea* species through the prevention of an increase in biomass of the latter species. In turn this reduced competition for light and water and limited the formation of rhizomal mats. This allowed *Eriocaulon carsonii* to inhabit the wetter area at the centre of the vent, which stock can not reach without becoming mired. Furthermore, vegetation can, if uncontrolled, form a 'cap' stopping flow to the surface or consume sufficient moisture to effectively dry out a spring. Observations of kangaroo scat densities at Peery Lake suggest that kangaroos heavily graze the mounds with populations of *Eriocaulon carsonii*. Kangaroo grazing apparently limits the growth of sedges (e.g. *Baumea* and *Fimbristylis*) on the mounds. Thus, when grazing was excluded at Hermit Hill Springs in SA, the populations of *Eriocaulon carsonii* declined abruptly. Fatchen & Fatchen (1993) stated where stock was excluded, loss of *Eriocaulon carsonii* was primarily associated with *Phragmites* competition. Limited grazing or grazing by certain species such as kangaroos may in fact be beneficial or even necessary for the species' conservation.

A greater threat caused by herbivores is that of trampling the plants. The fragile *Eriocaulon carsonii* suffers in two ways. *Eriocaulon carsonii* and the surrounding sedge species are highly palatable and its habitat can be the primary water source for stock and other undomesticated herbivores. The extinction of the Wee Wattah Springs population is thought to have been caused by stock trampling the species whilst drinking at the spring. Domestic stock was removed from Peery Station when purchased by NSW NPWS and the population of *Eriocaulon carsonii* has increased in size. This suggests that feral and native herbivore densities at Paroo-Darling National Park do not appear high enough to cause grazing or trampling problems. However, this does not appear to be the case with Queensland or South Australian springs in the past.

When Peery Lake is full, most of the mounds on which *Eriocaulon carsonii* has been recorded are covered by water. As the lake dries, the mounds are progressively

exposed. The mounds are favoured roosting and feeding sites for numerous ducks and other water birds that flock to Peery Lake when it is full. The vegetation on the mounds is reduced by cropping and trampling by the extremely heavy use by the birds. As this behaviour has been a regular feature of this habitat, it is not a threat in and of itself.

Peery Lake is located in the terminal basin at the end of the Paroo River. The populations at Peery Lake are flooded at irregular intervals and for varying periods. Heavy rains in 1990 and 2000 resulted in the mound springs being completely submerged for long periods. A post-flood assessment of impacts was inconclusive but indicated a possible decline in numbers (Pickard 1992d). The impact of flooding and complete inundation of the mounds is not yet fully known and should be further studied to determine the species response and its possible role in the movement of the species between mounds.

Drawdown and vegetation caps are known to cause spring extinctions (Fatchen & Fatchen 1993). Reduced pressure results in reduced flows and possible extinction of springs. The problem of reduced pressure, and hence water flow from the Great Artesian Basin, is widely recognised. The cause of reduced pressure is the excessive use of water from the aquifer. Of the estimated 1500 ML drawn from the aquifer per day, 80% is wasted through evaporation or seepage, mostly from bore drains (GABCC 1998; Endersbee 1999). Reduced pressure results in the reduction of flow causing the waning of a spring, which in turn promotes vegetation capping and may result in the gradual clogging of vent fissures. One of these factors or several in combination may eventually cause the extinction of a spring. The fear of damage to the aquifer that results from reduced pressure is warranted. The fissures in the aquifer that allows the water to travel may be slowly closing as basin volume and pressure is reduced (Endersbee 1999). Closure of the fissures is almost certainly irreversible and as reduced pressure is reputed to be the cause of numerous spring extinctions in NSW, our ability to conserve the remaining artesian springs in NSW is questionable. Drawndown of artesian water at bore sites has been correlated with several spring extinctions in SA (Fatchen & Fatchen 1993). It is a common belief that previous drawdown of artesian water leading to extinction of springs had caused a decline in the distribution and abundance of *Eriocaulon* (e.g. Pickard 1992d, Ponder 1986). There is no evidence that current drawdown rates are affecting the species in South Australia (Fatchen & Fatchen 1993).

6.2 Social and Economic Considerations

The only known extant population of *Eriocaulon carsonii* in NSW is located at Peery Lake, wholly within Paroo-Darling National Park. Paroo-Darling National Park is managed according to the NP&W Act for the purpose of natural and cultural heritage conservation. Therefore, there is likely to be only a minimal cost associated with conservation of the species, above that which is already spent on park management.

In the event that further populations are discovered outside Paroo-Darling National Park, there is not expected to be significant social or economic costs. Where a new population is located on leasehold or freehold land, which has existing uses such as grazing, the plan does not propose regulating such activities. As management actions from this plan as a whole have beneficial outcomes for most land uses, including conservation, the plan promotes co-operative management. Forms of co-operative management could include integrated pest management or strategic stock control via the provision of fencing and artificial watering points.

Paroo-Darling National Park has several significant features of cultural and natural heritage that ensure moderate visitation by individual tourists and commercial tour operators. Tourism associated with national parks provides increased expenditure in businesses in neighbouring towns and may represent a valuable source of revenue.

6.2.1 Role and interests of indigenous people

Individuals associated with indigenous communities represented within the region have been consulted with regard to the cultural value of *Eriocaulon carsonii*. Whilst the species is know to the indigenous communities, no obvious specific cultural value was apparent. *Eriocaulon carsonii* does, however, reside within an environment which is of importance to the local indigenous communities. Implementation of recovery actions under this plan will include consideration of the role and interests of the local indigenous communities.

6.2.2 Intrinsic Ecological Value

Eriocaulon carsonii is a relict of a past environment far more tropical than the arid Australia of present (Fatchen & Fatchen 1993). The genus *Eriocaulon* is a largely tropical to subtropical genus with some 400 species worldwide, 20 of which are found in Australia, mostly located in the more tropical environments (Conn 1993). *Eriocaulon casronii* now occurs as small isolated and disjunct populations. Examination of the type specimen from Wee Wattah Springs in NSW shows there are subtle morphological differences with interstate populations suggesting further isolated evolutionary differentiation between the populations.

6.2.3 Scientific and Taxonomic Value

Springs that form mounds and have a significant vegetation mat across the surface are recognised as developing fen soils. Fens represent the alkaline form of the acidic peat bog. Fen soils have the potential for recording past climatic and vegetation history, which can be revealed through pollen analysis (Symon 1985). This accumulation of a past history of climatic information represents a significant asset to climatic studies, in particular those associated with the arid zone.

6.3 Biodiversity Benefits

The perennial flow of water from the Great Artesian Basin into arid and semi-arid areas creates an unusual and diverse ecosystem that is often in direct contrast to the surrounding dry environment. Artesian springs are a very specialised environment, sparsely distributed and extremely limited in their geographical extent across the continent. As a specialised environment, they are renowned for supporting a variety of wildlife including plants, fish and invertebrates that are found only on artesian springs (Ponder 1986, Wilson 1996). This unique assemblage of species has led to the 'Artesian Springs Ecological Community' being listed as Endangered in State and Commonwealth legislation (TSC Act 1995; EPBC Act 1999). Although, there have been no detailed studies at Peery Lake, a similar suite of unique biota could be expected. Thus any conservation of *Eriocaulon carsonii* that aims to maintain the existing environment of the springs will benefit these other rare endemics and the artesian spring community as a whole.

Other threatened flora species may occur on or near the mound springs. *Dentella minutissima* is listed as Endangered (TSC Act) and can occur on mud flats around drying waterholes. It is only known in NSW from the Paroo River in Nocoleche Nature Reserve, approximately 100km to the north of Paroo-Darling National Park. Although not recorded from NSW, another rare and threatened plant, *Frimbristylis sieberiana*, which is known to occur on mound springs in SA and Queensland in association with *Eriocaulon carsonii* (Briggs & Leigh 1989) may occur at Paroo-Darling National Park. Further studies of *Eriocualon carsonii* at Paroo-Darling National Park may result in the discovery of these or other threatened plants. Conservation efforts that are directed at *Eriocaulon carsonii* should be beneficial to other threatened plant species.

Fen mounds are very limited within the extensive landscape of the arid zone and as such they are of major conservation significance if we are to ensure that each unique ecosystem is adequately conserved.

Feral pigs have a significant impact on the environment. Any effort to control feral pigs that is undertaken to help conserve *Eriocaulon carsonii* will produce a positive benefit for other species and ecosystems.

7 Previous Actions Undertaken

New South Wales

All of the artesian springs in the Western Division have been located and examined and no further populations of *Eriocaulon carsonii* have been identified (Pickard 1992a). The area encompassing the springs at Peery Lake was gazetted as a National Park under the New South Wales NP&W Act providing a degree of protection not present under its previous leasehold status. Since the gazettal, NSW NPWS has undertaken measures to control both feral goats and pigs, which will benefit

Eriocaulon carsonii. No action has been undertaken to implement any of the proposals in an earlier management document for this species (Pickard 1992d).

Queensland

Several springs have been fenced and despite results showing that the exclusion of grazing can cause population decline, there is a continuing program to fence additional populations of *Eriocaulon carsonii* (Wilson 1995). However, in Queensland *Phragmites* is not as prevalent and *Eriocaulon carsonii* is not as effected by thick grass as it is in South Australia (Richard Davies pers. comm.).

South Australia

Long-term monitoring of *Eriocaulon carsonii* commenced in 1983 and is partially reported by Fatchen & Fatchen (1993). Stock were excluded from Hermit Hill Springs in 1986 and within a few years *Phragmites australis* had expanded and grown to 5m high, resulting in a substantial decline in *Eriocaulon carsonii* (Fatchen & Fatchen 1993). Western Mining Corporation, Flinders University and other granting bodies have provided funding for a detailed study of the species ecology. Preliminary results have been reported in Davies (2000, 2001).

8 Species Ability to Recover

The species has survived the past century of grazing by domestic, feral and native herbivores. It has recently spread naturally at Peery Lake and is easily propagated and transplanted successfully (Fatchen & Fatchen 1993) indicating that there is high potential for recovery. The major limitation to the species recovery remains the inherently limited number of potential sites (artesian springs) and the operation of threatening processes. Regardless of the recent establishment of new populations both at Peery Lake and interstate, there is too little information currently available to suggest that, in the long term, the species in NSW and nationally is recovering naturally and no longer in decline. Active management and monitoring is still necessary to guarantee the long-term conservation of the species in NSW.

9 Recovery Objectives and Performance Criteria

9.1 Objectives of the Recovery Plan

The primary objective of this Recovery Plan is to conserve the remaining wild population of the species in New South Wales.

Specific objectives are to:

1. Monitor the status of the species at Peery Lake within Paroo-Darling National Park;
2. Gain an understanding of environmental factors impacting upon the species at Peery Lake;
3. Control known threats to the species at Peery Lake;
4. Establish an *ex situ* population to ensure future conservation; and
5. Ensure that Great Artesian Basin management programs, such as piping and capping of artesian bores, deliver benefits for *Eriocaulon carsonii*.

9.2 Recovery Performance Criteria

Recovery criteria are that:

1. Any change in the population abundance or distribution at Peery Lake is measured;
2. Known on-park threats are controlled;
3. Managers of the Great Artesian Basin are properly informed as to the status of *Eriocaulon carsonii* and the artesian springs in NSW and any usage reduction measures are properly implemented to achieve environmental benefits;
4. *Ex situ* conservation is conducted to guarantee the conservation of the species; and
5. The general public, in particular visitors to Paroo-Darling National Park, will have access to information on the species, its management and conservation.

10 Recovery Actions

10.1 Action 1 - Monitoring of *Eriocaulon carsonii* at Peery Lake

The monitoring program at Peery Lake will assess both species status and environmental variables. Monitoring of species status will be in terms of abundance and distribution with the aim of identifying any trends over the long-term. Monitoring of environmental variables will include the impact of floods, lake water levels, human visitation, changes to the function of the Great Artesian Basin and feral herbivores, with the aim of identifying any influences these may have on species status. This program will be periodically reviewed to ensure its effectiveness and efficiency.

Outcome
Information is gathered on the overall health of the population and our understanding of threatening processes will be enhanced. Effective monitoring will enable the development of management strategies that ensure conservation of the population.

Action 1	**2002/2003**	**2003/2004**	**2004/2005**	**2005/2006**	**2006/2007**
Population	$11 000	$8 800	$4 400	$4 400	$4 400
TOTAL					**$33 000**

Agency responsible for implementation
NSW National Parks and Wildlife Service

Funding Source
NSW National Parks and Wildlife Service

10.2 Action 2 – Feral Herbivore Control at Paroo-Darling National Park

Whilst light grazing may be beneficial in controlling competitive species the trampling and disturbance to the soil particularly from feral pigs searching for rhizomal tubers is considered a significant threat. The density of feral pigs in the arid zone is typically highest in and around the wetter habitats such as rivers, lakes and wetlands. Peery Lake, which is located in the terminal basin of the Paroo River, maintains a high density of feral pigs and they are considered one of the greatest threats to *Eriocaulon carsonii* in Paroo-Darling National Park. At Peery Lake, where *Eriocaulon carsonii* may be confined to an area of just a few square metres, a small number of pigs can potentially destroy or disturb a large proportion of the population in NSW in a single event. Goats are present in Paroo-Darling National Park, but are not considered a significant threat to the survival of *Eriocaulon carsonii*. Goats browse on a wider range of plants than pigs, do not concentrate in the wetter habitats and generally occur at lower densities. For these reasons, goats are not likely to impose as great a threat to *Eriocaulon carsonii* as feral pigs.

Current management of Paroo-Darling National Park includes the suppression of pigs and goats. However, in August 2002 a number of mound springs were observed to have sustained significant feral pig damage indicating the feral pig threat to *Eriocaulon carsonii* remains despite the current suppression program (P. Christie & G. Robertson pers. comm.). The suppression program should, therefore, be expanded to ensure that the threat posed by feral herbivores is eliminated or minimised to a point where it is not significant. A monitoring program will be developed and implemented to regularly assess the extent of disturbance, and to assist in evaluating the success of the suppression program.

In addition to feral animal suppression, the effectiveness of pig proof fencing should be trialed. If found effective, a program of protecting populations of

Eriocaulon carsonii in this manner should be implemented. Monitoring of protected populations will be conducted to measure the effectiveness of this action and to ensure no deleterious effects to the population occur as a result of excluding mammalian grazing.

Outcome
A reduction or elimination of the threats posed by feral herbivores at Paroo-Darling National Park, which may result in an improvement in species status and distribution.

Action 2	**2002/2003**	**2003/2004**	**2004/2005**	**2005/2006**	**2006/2007**
Supplementary feral animal management	$10 000	$10 000	$10 000	$10 000	$10 000
Fencing	$4 000	$8 000	$1 000	$1 000	$1 000
Monitoring	Nil*	Nil	Nil	Nil	Nil
TOTAL					**$65 000**

* Monitoring of feral herbivores will be undertaken by NPWS as part of routine on-park management. Therefore, no additional costs for monitoring will arise as a result of this Recovery Plan.

Agency responsible for implementation
NSW National Parks and Wildlife Service

Funding Source
NSW National Parks and Wildlife Service

10.3 Action 3 – Support the Sustainable Usage of the Great Artesian Basin

Current usage of the Great Artesian Basin exceeds 1500ML per day and an estimated 80% of this is wasted through evaporation and seepage. This level of usage has resulted in drawdown or a lowering of the water table, and a reduction in flow rates from springs and bores. Furthermore, the net loss of water from the system results in the downward shift of rock above the aquifer and the gradual closing of the fissures that allows for the movement of water. The narrowing or closure of the fissures in the aquifer is thought to be irreparable. These impacts on the Great Artesian Basin clearly indicate that current usage levels are unsustainable and if continued will have dire consequences on the aquifer, and industries and environments that depend on artesian water.

The need for sustainable usage of the Great Artesian Basin has been identified as essential by State and Commonwealth governments. State and Commonwealth committees have been formed to evaluate the situation and determine future management options. The key to sustainable use of the Great Artesian Basin is reduction of usage, which can be readily achieved by minimising wastage.

Capping of bores and replacement of bore drains with piping are two means that have been identified as capable of eliminating a significant proportion of wastage. The Commonwealth government has recently developed an incentive package, including limited financial support, which will assist in the capping and piping. Further financial support will be required to sufficiently reduce usage to achieve sustainability.

Protection of the Great Artesian Basin to a level that ensures proper function and flow of artesian springs is essential to the conservation of *Eriocaulon carsonii* and the artesian spring community in New South Wales. Furthermore, the additional protection measure of translocation of *Eriocaulon carsonii* to other suitable artesian springs would only be feasible if the recovery and proper function of the Basin were assured.

NPWS will actively liase with key State and Commonwealth agencies and committees responsible for the management of the Great Artesian Basin and the implementation of the capping scheme. NPWS will advise on the status of *Eriocaulon carsonii* and the Artesian Springs community in New South Wales in order to ensure that direct environmental benefits for *Eriocaulon carsonii* are being deliver from the capping and piping scheme.

Outcome
NPWS liaison will ensure environmental concerns are adequately considered and every effort is made to ensure sufficient artesian spring flow for the survival of *Eriocaulon carsonii* at Paroo-Darling National Park.

Action 3	**2002/2003**	**2003/2004**	**2004/2005**	**2005/2006**	**2006/2007**
Liaison	Nil	Nil	Nil	Nil	Nil
TOTAL					**Nil**

Agency responsible for implementation
NSW National Parks and Wildlife Service

Funding Source
NSW National Parks and Wildlife Service

10.4 *Ex situ* conservation

In New South Wales, *Eriocaulon carsonii* is known from only a single location, where it is found on mound springs covering only a small area. These factors mean the species is vulnerable to extinction in New South Wales as a result of a single catastrophic event. Events that could conceivably occur at Peery Lake would include massive flooding that caused the destruction of the plants, inundation for periods longer than the plant is able to survive, or extinction of the springs that are fundamental to the species.

With the exception of the extinction of the springs, most events no matter how damaging, are relatively temporary in their nature and the habitat can be rehabilitated to the point that it is once again suitable for the species.

Ex situ conservation should be employed to provide further guarantee that the population will survive should any event result in the demise of the wild population in New South Wales. *Ex situ* conservation would involve the collection and storage of a representative sample of seed from the wild population. The storage will include a component of testing seed viability. If seed viability is not considered sufficient, ex situ conservation should investigate and utilise other alternatives such as live plants or cryogenics and culturing. *Ex situ* conservation could also provide the stock required should any translocation program be deemed appropriate.

Outcome
Ex situ conservation would alleviate any risk of losing the wild population therefore providing some guarantee of conservation.

Action 4	**2002/2003**	**2003/2004**	**2004/2005**	**2005/2006**	**2006/2007**
Seed storage	$6 000	$3 000	$3 000	$1 500	$1 500
TOTAL					**$15 000**

Agency responsible for implementation
NSW National Parks and Wildlife Service

Funding Source
NSW National Parks and Wildlife Service

10.5 Action 5 – Community Awareness

A threatened species conservation profile should be prepared for *Eriocaulon carsonii*. The aim of the profile is to provide relevant information to all interested parties. The profile should contain information on the biological and ecological requirements of the species, its uniqueness as an endemic to mound springs of the Great Artesian Basin and efforts undertaken to conserve the species in New South Wales.

Outcome
All parties will have access to information on the species, its management and conservation. The profile will also increase awareness of threatened species in western New South Wales.

Action 5	2002/2003	2003/2004	2004/2005	2005/2006	2006/2007
Eduction	Nil	$1 650	Nil	Nil	Nil
TOTAL					**$1 650**

Agency responsible for implementation
NSW National Parks and Wildlife Service

Funding Source
NSW National Parks and Wildlife Service

10.6 Action 6 – Recovery Plan Coordination

Effective coordination of this Plan is essential to ensure its implementation is conducted in a timely, cost-effective and efficient manner. This action also seeks to ensure that relevant Government Agencies, Organisations, Stakeholders and individuals are sufficiently informed about the process. Furthermore, the responsibility of Recovery Plan coordination will extend to liaison with other recovery programs to ensure the implementation of this Plan does not unnecessarily impact other threatened species.

Outcomes
Efficient and coordinated implementation of Recovery Plan actions.

Responsibilities for Implementation
NSW National Parks and Wildlife

Action 6	2002/2003	2003/2004	2004/2005	2005/2006	2006/2007
Recovery Coordination	$4 000	$4 000	$4 000	$4 000	$4 000
TOTAL					**$20 000**

11 Alternative Management Strategies

11.1 Translocation to other suitable artesian springs

In New South Wales, *Ericoaulon carsonii* has been recorded from two mound springs complexes. The species was formerly known from Wee Wattah Springs where it has not been recorded for several decades. The species remains extant at Peery Lake.

The species existence at a single location in New South Wales poses a significant risk. If existing threats are not adequately controlled or a single catastrophic event was to occur, *Eriocaulon carsonii* could become extinct in the wild in New South

Wales. The translocation and establishment of additional populations in suitable habitat elsewhere in the State would reduce this risk.

The unsustainable use of the Great Artesian Basin, which results in reduced flow or extinction of springs, will remain a significant threat where ever a population of *Eriocaulon carsonii* is established on an artesian spring. This threat is not easily controlled and will take considerable time and financial support before sufficient change is achieved so as to ensure sustainable use and the restoration of proper function to the Great Artesian Basin. Until such time as this is achieved, it would not be appropriate to undertake translocation of *Eriocaulon carsonii* to other artesian springs in New South Wales. Should translocation become a feasible option in the future, a comprehensive review should be undertaken to provide an understanding of the translocation options available and the issues associated with this action.

11.2 No management action taken

Eriocaulon carsonii is known from a single mound spring complex in Paroo-Darling National Park. As the species occurs only in a conservation reserve, an alternative strategy is not to undertake any management for the species beyond which occurs as part of normal Park management.

The approach is not considered appropriate for several reasons. The cause of the sporadic change to abundance and distribution at Peery Lake is unknown and may not represent a trend that will ensure the species recovery. *Eriocaulon carsonii* and the artesian springs ecological community are listed on the TSC Act and EPBC Act whose objectives are the conservation of biodiversity and recovery of threatened species and communities. Active management in some form is likely to be required in order to ensure the species continued existence in New South Wales.

12 Implementation

The following table allocates responsibility for the implementation of recovery actions specified in this plan to relevant government agencies for the period 2002 till 2007.

12.1 Date of Last Amendment

This document is the first Recovery Plan for *Eriocaulon carsonii*. No amendments to the plan have been made.

Table 1: Implementation schedule

Section	Description	Responsibility for implementation	Cost	Timeframe	Priority
10.1	Monitoring	NPWS	$33 000	Ongoing	High
10.2	Feral Management	NPWS	$65 000	Ongoing	High
10.3	Liaison with key groups	NPWS	Nil	Ongoing	High
10.4	Ex situ Conservation	NPWS	$15 000	Ongoing	High
10.5	Community Awareness	NPWS	$1 650	Ongoing	Medium
10.6	Recovery Co-ordination	NPWS	$20 000	Ongoing	High
TOTAL			$134 650		

12.2 Review Date

This Recovery Plan, and the conservation status of *Eriocaulon carsonii*, will be reviewed by NPWS within five years of the date of publication.

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