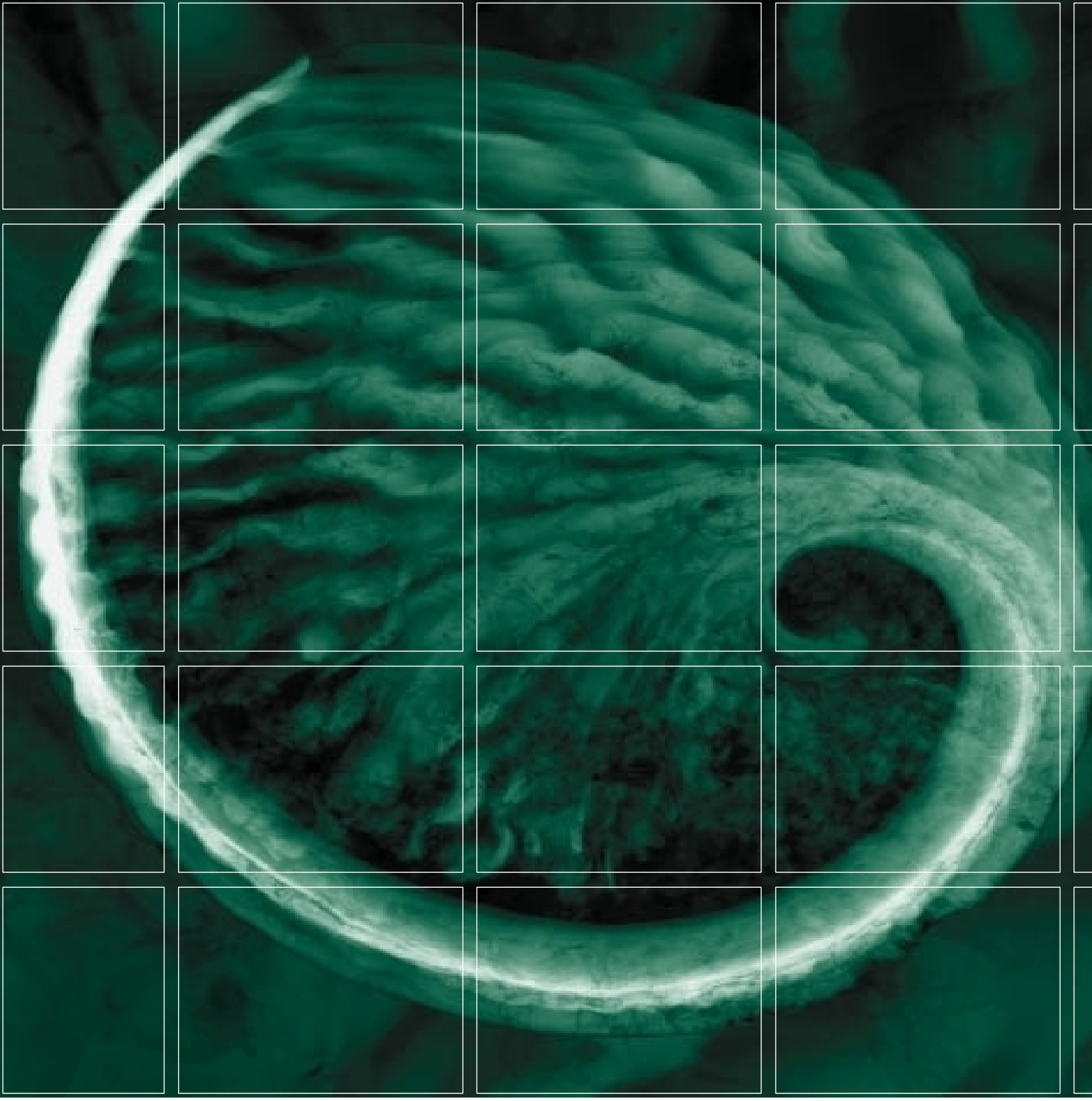
ANNEX V

Community Lands Environmental Management Plan



Fern Bay Seaside Village
Community Lands Environmental Management Plan

Aspen Group
0063154 CLEMP Final
February 2009
www.erm.com

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Approved by:	*Amanda Antcliff*
Position:	Project Manager
Signed:	
Date:	*11 February, 2009*
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Environmental Resources Management Australia Pty Ltd Quality System

Fern Bay Seaside Village
Community Lands Environmental Management Plan

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1 INTRODUCTION

1.1 PURPOSE

This Community Lands Environmental Management Plan (EMP) has been prepared for Fern Bay Seaside Village at Lot 16, DP 258848 Nelson Bay Road, Fern Bay (refer to *Figure 1.1* for the locality plan) and applies to land within the site to be dedicated as community conservation areas. This land will be hereafter referred to in this report as community lands. The community lands cover approximately 117 hectares (ha) or 57 percent of the site. A plan identifying the zoning of the Fern Bay Seaside Village site is provided in *Figure 1.2*.

This EMP aims to enhance and protect native vegetation and fauna habitat through rejuvenation and regeneration landscaping and maintenance of natural areas. It has been prepared to support the Community Association (established via Community Title) in managing and sustaining the ecological values of the conservation areas and reserves throughout the site.

1.2 REPORT STRUCTURE

The structure of this report is as follows:

- *Chapter 1* outlines the purpose and overall objective of the EMP;
- *Chapter 2* includes a description of relevant legislation, policies and strategies;
- *Chapter 3* details the methodology used in the development of the EMP;
- Chapter 4 describes the existing environment including the climate, geology, topography, slopes, soils, vegetation communities, weeds, fauna habitat, threatened species and Aboriginal heritage;
- *Chapter 5* addresses the potential impacts at the site from the development of Fern Bay Seaside Village;
- *Chapter 6* outlines the proposed management of these impacts pre construction, during construction and post construction;
- *Chapter 7* provides specific management requirements for threatened species and habitat areas, weeds, fire, pests, access and stormwater;
- Chapter 8 details the proposed restoration and weed management works and the implementation of the works over stages;
- *Chapter 9* outlines the monitoring program to be implemented; and
- *Chapter 10* details the responsibilities for implementing management strategies and the process of reviewing the EMP.

Legend

Fern Bay Seaside Village

Figure 1.1

Locality Plan

Client:	Aspen Group Pty Ltd		
Project:	Fern Bay Seaside Village		
Drawing No:	0063154hv_CL-EMP_05		
Date:	10/02/09	Drawing size:	A3
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Legend

- Fern Bay Seaside Village
- 1(a) 1(a) Rural Agriculture Zone
- 2(a) 2(a) Residential Zone
- 7(a) 2(a) Environment Protection Zone

Figure 1.2

Fern Bay Seaside Village Community Lands Zoning.

Client:	Aspen Group Pty Ltd		
Project:	Fern Bay Seaside Village		
Drawing No:	0063154hv_CLEMP_11		
Date:	10/02/09	Drawing size:	A3
Drawn by:	SP	Reviewed by:	PD
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1.3 OBJECTIVE

The main objective of this CLEMP is the prescription of management strategies and methods to mitigate impacts on natural and modified vegetation communities, threatened flora and fauna species, and habitats that may occur within conservation areas, reserves and other areas throughout the site as a result of the development. This will be achieved by:

- management of threatened species, including their habitat and endangered ecological communities (ECC);
- management of retained habitat features within the development footprint, including during the construction phase;
- management of specific habitat enhancement measures, (eg hollow / habitat trees, koala fencing, artificial hollows and nest boxes);
- regeneration and landscaping works;
- weed management;
- pest animal control;
- fencing;
- bush fire management;
- public access management; and
- stormwater management.

2 POLICY FRAMEWORK

This EMP has been prepared to ensure that the management of conservation areas and reserves, specifically the management of threatened species and their habitat, is undertaken in a way that is consistent with Commonwealth, State and local government legislation, policies, strategies and guidelines. Relevant legislation, policies, strategies and guidelines are presented below.

2.1 COMMONWEALTH

2.1.1 Revised National Weeds Strategy 1999

The National Weeds Strategy was produced by the Commonwealth Government in 1999 to reduce the impact of weeds on the sustainability of Australia's productive capacity and natural ecosystems by adopting a more coordinated and integrated approach to weed management. The National Weeds Strategy also defines the roles and responsibilities of various stakeholders in weed management.

Two of the principles upon which this Strategy is based relate to the roles and responsibilities of those involved in weed management. These principles are reproduced below.

- '*Successful weed management requires a coordinated national approach which involves all levels of government in establishing appropriate legislative, educational and coordination frameworks in partnership with industry, landholders and the community.*'; and

- '*The primary responsibility for weed management rests with landholders/land managers but collective action is necessary where the problem transcends the capacity of the individual landholder/land manager to address it adequately.*'

A central component of the National Weeds Strategy 1999 is the identification of Weeds of National Significance (WONS). WONS are listed in *Annex A*. WONS are prioritised using a series of questions that measure each weeds invasiveness, impact, potential for spread and socioeconomic and environmental values. WONS identified on site are Alligator Weed (*Alternanthera ohiloxeroides*), Bitou Bush (*Chrysanthemoides monilifera* subsp *rotundata*), Blackberry (*Rubus fruiticosus*) and Lantana (*Lantana camara*).

The Strategy has also identifies 28 weeds as National Environmental Alert Weeds, including Chinese Violet (*Asystasia gangetica* subsp *micrantha*) which has been recorded as occurring on the site. National Environmental Alert Weeds are non native plant species that are in the early stages of establishment and have the potential to become a significant threat if they are not managed.

The Strategy specifies that individual landowners have a role to:

- understand that weeds are an important factor in land degradation;
- detect and report new weed occurrences;
- understand land use systems and the cause/effect relationships which apply to weed problems;
- apply their knowledge and skills to improve weed management;
- integrate economic and environmental values in the management of weed problems on their land;
- cooperate with and, where relevant, plan weed management activities jointly with neighbours; and
- support and promote sustainable production practices to minimise the development of weed problems.

The Strategy specifies that communities have a role to:

- coordinate local group development and action on weed problems;
- encourage local involvement in the management of public land;
- participate in local and regional weed management programs; and
- raise awareness and improve education on weed issues.

2.1.2 Agricultural and Veterinary Chemicals Code Act 1994

All pesticides (herbicides, insecticides and fungicides) used, supplied or distributed in Australia must be registered under the *Agricultural and Veterinary Chemicals Code Act 1994* by the Australian Pesticides and Veterinary Medicines Authority (APVMA: formerly the National Registration Authority for agricultural and veterinary chemicals (NRA). All APVMA approved chemicals (or products) have affixed product labels, which contain specific usage requirements and application rates. Label breaches can result in prosecutions under this Act.

All herbicides to be used on site in weed management should adhere to relevant requirements under this Act.

2.1.3 Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act) regulates significant environmental impacts on species and communities listed as threatened under this Act. The *EPBC Act* can be triggered if activities are

considered likely to have a significant impact on matters of national environmental significance.

Matters of national environmental significance under the Act include the following:

- World Heritage properties;
- National Heritage places;
- Ramsar wetlands of international importance;
- threatened species or ecological communities listed in the *EPBC Act*;
- migratory species listed in the *EPBC Act*;
- commonwealth marine environment; and
- nuclear actions.

There are no World Heritage properties, National Heritage places, Commonwealth marine areas, Commonwealth listed ecological communities or nuclear actions on or near the proposed development area.

The Fullerton Cove covers part of the Hunter Estuary National Park and is a Ramsar listed wetland. It is located approximately 400 metres to the west of Nelson Bay Road.

Care must be taken on site to minimise the impacts associated with weeds and vegetation management activities particularly on the nationally listed threatened Newcastle Doubletail Orchid (*Diuris praecox*) that has been recorded on site.

2.2 NEW SOUTH WALES

2.2.1 *Threatened Species Conservation Act 1995*

The *Threatened Species Conservation Act 1995* (*TSC Act*) lists a number of species and ecological communities, which are protected under this Act, which should not be disturbed without a permit. This Act regulates significant environmental impacts on listed species. Ten threatened species listed under the TSC Act have been recorded on site (refer to *Section 4.7* for a list of these species).

The NSW Scientific Committee established by the *TSC Act*, has listed 'the invasion of native plant communities by exotic perennial grasses', 'invasion of native plant communities by Bitou Bush and Boneseed', 'invasion and establishment of exotic vines' and 'invasion, establishment and spread of

Lantana' as key threatening processes under the *TSC Act*. These threatening processes are operating in Fern Bay Seaside Village and are considered in the EMP.

In addition DECC has approved a threat abatement plan for Bitou Bush. This plan seeks to control the invasion of native plant communities by Bitou Bush/Boneseed (*Chrysanthemoides monilifera*). The site is not identified in the threat abatement plan.

2.2.2 Noxious Weeds Act 1993

The *Noxious Weeds Act 1993* identifies, classifies and guides the control of noxious weeds in NSW. The Act defines the roles of government, councils, private landholders and public authorities in the management of noxious weeds. It also determines control actions for the various noxious weeds, according to their potential to cause harm to our local environment. There are five different "control classes" listed under the Act. Landowners are obliged to control all noxious weeds on their land according to specified "control classes".

The current list of noxious weeds within the Port Stephens local government area (LGA) is reproduced in *Annex B*.

2.2.3 National Parks and Wildlife Act 1974

The objectives of the *National Parks and Wildlife Act 1974* (*NP&W Act*) include:

(a) 'the conservation of nature, including, but not limited to, the conservation of:

(i) habitat, ecosystems and ecosystem processes, and

(ii) biological diversity at the community, species and genetic levels, and

(b) the conservation of objects, places or features (including biological diversity) of cultural value within the landscape, including, but not limited to:

(i) places, objects and features of significance to Aboriginal people.'

Under this Act a person must not intentionally cause damage to any habitat of or pick a threatened or protected species unless authorised under the Act.

Care must be taken to minimise the impacts associated with weed and vegetation management activities on threatened species (refer to *Section 4.7)*, protected flora (listed in Schedule 13 of the Act), protected fauna (those not listed in Schedule 13 of the Act) and aboriginal objects, places or features known to occur on the site.

2.2.4 *Protection of the Environment Operations Act 1997*

The *Protection of the Environment Operations Act 1997* (*POEO Act*) provides a framework for environment protection in New South Wales. Under the *POEO Act* it is an offence to pollute water. Waste is also required to be transported and disposed of in accordance with the Act and its associated regulations. The selection and use of herbicides should be undertaken in such a manner that prevents the pollution of water.

2.2.5 *Pesticides Act 1995*

The *Pesticides Act 1995* and the Pesticides Regulation 1995 regulate the use of all pesticides in NSW after the point of sale, and provides specific provision of record keeping, training, and notification of use. The Act requires that pesticides are used according to instructions on the label or permit, and that for each use actions are taken to ensure appropriate application.

All pest animal control works which require the use of pesticides (for example the use of 1080 for the control of foxes and wild dogs), must be undertaken in accordance with the *Pesticides Act 1995*.

2.2.6 *Rural Lands Protection Act 1998*

The pest animal provisions of the *Rural Lands Protection Act 1998* (*RLP Act*) outline the conditions under which animals, birds and insects are "declared" pests and provides for the control of such pest species. Gazettal of pest species occurs through Pest Control Orders that allow the Minister for Primary Industries to specify pest species on a state wide or local basis and the conditions or factors that apply to the control of each pest. Rabbits, wild dogs and feral pigs have been declared pest animals throughout NSW.

2.2.7 *Humane Pest Animal Control Code of Practice and Standard Operating Procedures, 2005*

The Code of Practice identifies pest animal control methods that are considered the most humane, target specific, cost effective and safe for use in the control of pest animal species. The recommended methods should be used for the control of pest animal species. The Code of Practice is supported by a number of Standard Operating Procedures and provides guidance on the control of foxes, wild dogs, feral pigs, feral cats and rabbits.

All pest animal control works undertaken should be consistent with the Code of Practice and Standard Operating Procedures to ensure the control of pest animal species is undertaken in a humane and safe manner.

2.2.8 Natural Resource Commission Statewide Targets

The NSW Natural Resource Commission has established statetwide targets for natural resource management. One of the targets is specifically aimed at addressing the impact of invasive pest and weed species. The target is:

"By 2015 there is a reduction in the number of invasive species".

In order to measure progress towards meeting the targets, the following indicators have been developed:

- *'number of new invasive species established;*
- *distribution and abundance of key invasive species;*
- *success of control programs foe widespread invasive species as measured by:*
    - *i. a reduction in biodiversity impacts; and*
    - *ii. a reduction in other impacts;'* (DECC, 2008)

Statewide and regional priorities are currently being established. In addition, a statewide dataset for invasive species together with a three-tiered monitoring program are currently being established and are expected to be released during 2009. The monitoring program will build upon that which has already been development for the Bitou Bush Threat Abatement Plan and will provide standardised protocols for monitoring.

This CLEMP has been prepared prior to the release of the monitoring program. This CLEMP, including the identification of targets and a monitoring program consistent with DECC requirements (once released) will be updated in subsequent reviews.

2.3 PLANS AND STRATEGIES

Other legislation, plans, strategies and documents that relate to weed and pest animal management, waste removal and environmental restoration on site include:

- the *Bitou Bush Management Strategy* (Port Stephens Council, 2004) which provides for the control of bitou bush and includes up-to-date maps of the infestation in the region;
- the *NSW Weeds Strategy* (NSW Agriculture, 1998) which aims to reduce the negative impacts of weeds on the economy, community, industries and environment. One outcome of the Strategy is the development and implementation of programs to reduce environmental degradation and the loss of biodiversity through weed invasion;

- the *NSW Threat Abatement Plan* (Department of Environment and Conservation, 2006) which seeks to control the invasion of native plant communities by bitou bush/boneseed (*Chrysanthemoides monilifera*);

- The *NSW Threat Abatement Plan* for predation by the Red Fox, which aims to reduce the impact of red foxes on threatened species;

- the *NSW Bitou Bush Strategy* (NSW National Parks and Wildlife Service, 2000) which is designed to assist in reducing the impacts of bitou bush on NSW coastal ecosystems;

- the *NSW Occupational Health and Safety Regulation (2001)* under which there is a requirement for the Controller of Premises to provide information on hazards associated with site activities to ensure safety of the workers, environment and general public through appropriate disposal of hazardous materials;

- the *Fern Bay Estate Master Plan* (ERM, 2005a) which identifies ecological values and management issues on the site. This report identifies the need to control the spread of weeds during construction as part of the environmental considerations;

- the *Fern Bay Estate Landscape Master Plan* (Verge Landscape Architects, 2007) which illustrates the layout and management of landscaping within the proposed development area of Fern Bay Estate;

- the *Port Stephens Vertebrate Pest Management Strategy* (Hunter Water Corporation, 1999) which provides details on the management of vertebrate pests within the Port Stephens area; and

- Vegetation Management Plan, Worimi Regional Park (ERM, 2008), which identifies vegetation management strategies, including weed control and waste management within the adjacent Worimi Regional Park.

3 METHODOLOGY

3.1 METHODOLOGY OVERVIEW

This Community Lands EMP has been developed based on a desktop review of previous specialist studies and their recommendations together with on site survey of weed presence and abundance.

3.2 DESKTOP ASSESSMENT

A review of relevant documents was undertaken to provide background information on the existing environment of the Fern Bay Seaside Village and to identify the key recommendations from specific environmental studies undertaken at the site, including:

- the Fern Bay Estate Species Impact Statement (ERM, 2005b) which identifies the likely impact on threatened flora and fauna and recommended mitigation measures to minimise impacts;
- the Fern Bay Estate Water Cycle Management Strategy (Urban Water Cycle Solutions, 2007), which identifies the proposed water cycle process and treatment at the site and maintenance requirements to ensure optimum operation of the system;
- the Fern Bay Seaside Village Conservation Offset Package: Worimi Regional Park Vegetation Management Plan (ERM, 2008), which identifies the management strategies to be undertaken within the adjacent Worimi Regional Park, and in which the on site strategies should be consistent;
- the Fern Bay Estate Vegetation Management Plan (ERM, 2005c), which identifies the rehabilitation and restoration program and weed management within the site;
- the Fern Bay Estate Weed Management Plan, Emergency Fire Trail (ERM, 2006);
- the draft Bushfire Assessment Report (ERM, 2007), identifying the requirements for bushfire hazard management throughout the site; and
- the Mosquito Risk Assessment, Fern Bay Estate (Institute of Clinical Pathology and Medical Research, 2004).

3.3 FIELD INVESTIGATIONS AND DATA ANALYSIS

Information on particular weed species and broad distribution was obtained from Clements *et al.* (1992) and Gunninah (1996 revised 1997 and 2002) and through field surveys by ERM (2005c). Discussions with the Senior Weeds Officer for Port Stephens Council in 2008 also identified additional weeds now occurring at the site. The results from broad weed maps were prepared using aerial photographs, topographic maps, past vegetation maps, reports and surveys. During field surveys notes were taken on the dominant weed species within each vegetation community. A GPS was used to record general locations of weed infestations. Bushland condition was mapped according to the level of high, medium or low levels of weed infestation.

4 EXISTING ENVIRONMENT

4.1 CLIMATE

The site is situated in an area that experiences a warm temperate climate. According to data obtained from the Bureau of Meteorology's Williamtown weather station (approximately six kilometres to the north of the site) for the period 1942 to 2003, mean temperature ranges from a minimum of 6.4 degrees Celsius in July to a maximum of 27.8 degrees Celsius in January. Average annual rainfall is 1124 millimetres, with 137 mean number of raindays per year. The period of highest rainfall is from January to June.

During summer, the predominant wind direction is from the east and south east, with stronger winds during the afternoon. In autumn and winter months, morning breezes are predominantly from the west and north west, with south and south east breezes increasing in the afternoons. In winter, stronger winds generally blow from the west to north west. The impact of prevailing winds is decreased by the undulating topography of the site and surrounding area.

4.2 GEOLOGY, TOPOGRAPHY, SLOPES AND SOILS

The site is situated within the Newcastle Bight barrier dune system and is situated within the outer Holocene dune system, which was deposited from off-shore sand deposits 6000 years ago. The outer barrier has undergone three major transgressions, with the most recent being the presently active frontal dune.

The transgression of dunes across the site has resulted in a series of prominent ridges and distinct sandy knolls, principally north south in orientation and separated by interdunal valleys. Elevation on site varies from sea level up to 26.3 metres AHD in the north eastern part of the site. Slopes vary significantly across the site.

Soils on the site consist of a topsoil layer, about 0.2 metres thick, of silty sand over a sand layer with a thickness that varies from 13 to 27 metres that overlays sandy clay. The soils are underlain by rock at a depth of approximately 60 metres. Peat has been found in the low lying areas of the site adjacent to Nelson Bay Road.

High infiltration rates are expected in the sand layer. Observations from Coffey Partners (1992 and 1996) indicate that 75 percent to 90 percent of rainfall falling on the site is infiltrated in the sand layer.

According to the Williamtown Acid Sulfate Soil Risk Map (Soil Conservation Service of NSW, 1995), the majority of the site is mapped as having a low probability of acid sulfate soils greater than three metres below the surface.

Two areas along the eastern boundary of the site and one along the southern boundary have been mapped as having a low probability of containing acid sulfate soils between one and three metres below the surface. Two small areas along the northern boundary of the site and one in the western corner of the site have been mapped as having a high probability of containing acid sulfate soils within one metre of the surface. A Acid Sulfate Soils Management Plan will be prepared for the site.

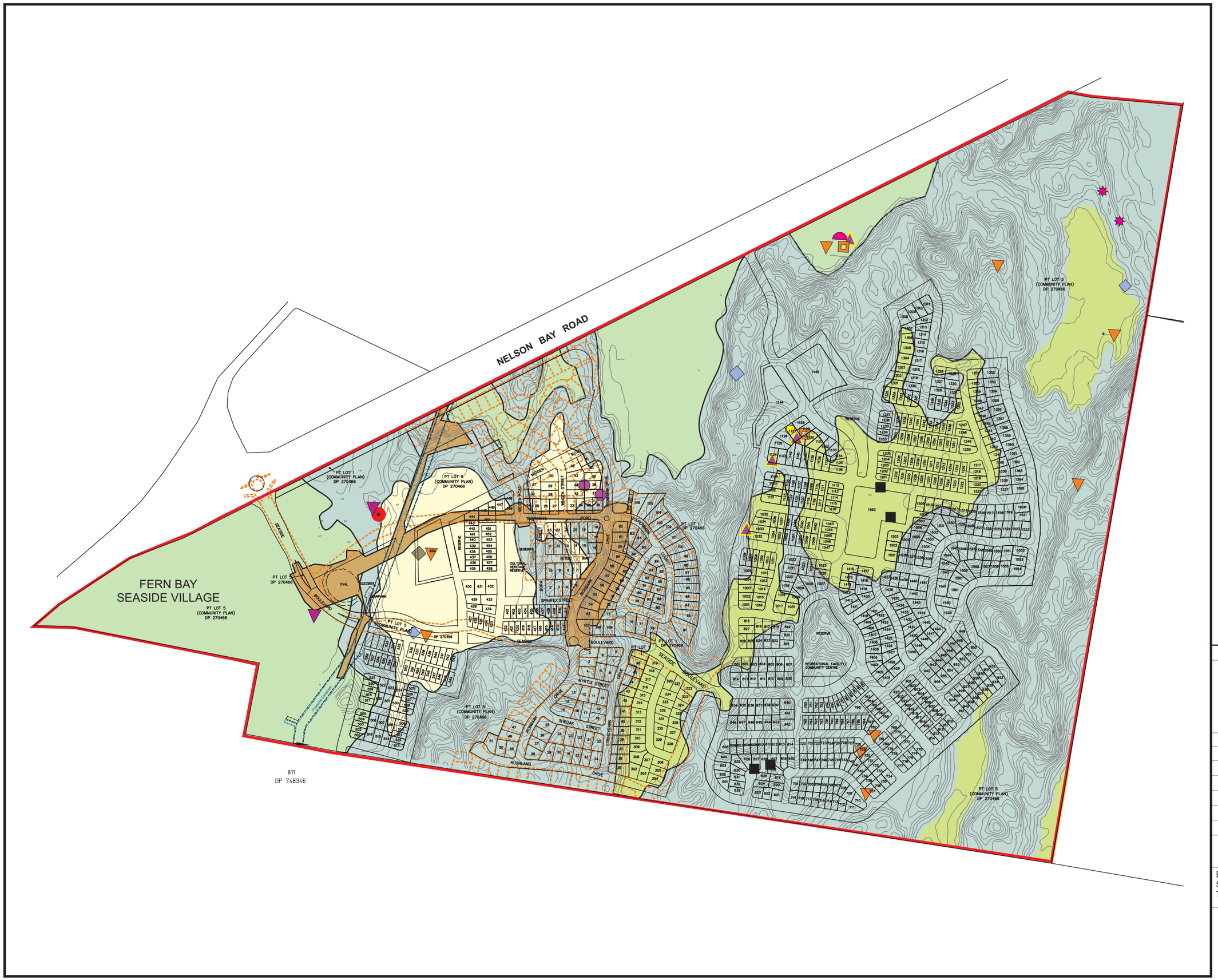
4.3 NATIVE VEGETATION COMMUNITIES

Gunninah Consultants (1996 revised 1997 and 2002) identified the flora species present on the site (refer to *Annex C*). Broad vegetation communities in the locality have also been mapped in the Lower Hunter and Central Coast Regional Environmental Management Strategy (LHCCREMS) (House 2003). The site includes three vegetation communities: Coastal Sand Apple – Blackbutt forest, Swamp Oak Rushland forest and Swamp Mahogany – Paperbark forest. Refinement of the LHCCREMS mapping by ERM (2005b), based on the vegetation mapping of Clements *et al*. (1992), delineated these vegetation communities into Dry Sclerophyll forest (Coastal Sand Apple – Blackbutt forest) and Swamp forest (Swamp Oak Rushland forest and Swamp Mahogany – Paperbark forest). The 'wet heath' community described by Clements *et al*. (1992) was determined by ERM to correspond to the LHCCREMS mapping unit of 'Tomago sand swamp woodland'. These vegetation communities are illustrated on *Figure 4.1* and are described below.

It was determined by ERM that the swamp forest on site where it adjoins Nelson Bay Road is representative of the 'Swamp Sclerophyll forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East corner Bioregions' Endangered Ecological Community (refer to *Figure 4.1*).

Dry Sclerophyll Open Forest (Coastal Sand Apple – Blackbutt Forest)

The dry sclerophyll open forest community occupies the greatest area and is dominated by Smooth-barked Apple (*Angophora costata*), Blackbutt (*Eucalyptus pilularis*) and Old Man Banksia (*Banksia serrata*), with occasional Red Bloodwood (*Corymbia gummifera*) and Black She-Oak (*Allocasuarina littoralis*). The canopy density ranges from 30 to 70 percent and the mid-storey is sparse, reflecting the likely fire history of the site. There is a well-developed understorey, mainly of shrubs, although some herbaceous species are also present. Some Bitou Bush occurs in this community. This community corresponds to the Lower Hunter and Central Coast Regional Environmental Management Strategy (LHCCREMS) mapping unit of Coastal Sand Apple – Blackbutt forest.



Legend

- Fern Bay Seaside Village
- Cleared Vegetation
- Swamp Mahogany - Paperbark Forest
- Coastal Sand Apple Blackbutt Forest
- Wet Heath - Tomago Sand Swamp Woodland
- Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South-East Corner Bioregion
- 1(a) 1(a) Rural Agriculture Zone
- 2(a) 2(a) Residential Zone
- 7(a) 7(a) Environment Protection Zone
- Powerful Owl Roost Tree

Threatened Species

- Powerful Owl
- Masked Owl
- Squirrel Glider
- Grey-headed Flying-fox
- *Diuris praecox*
- Greater Broad-nosed Bat
- Eastern Bentwing-bat
- Little Bentwing-bat
- Hoary Wattled Bat
- Wallum Froglet
- *Eucalyptus parramattensis* subsp. *decadens E.robusta*
- Approved Subdivision
- Approved Master Plan Footprint

Figure 4.1

Vegetation Communities and Threatened Species in the Study Area

Client:	Aspen Group Pty Ltd		
Project:	Fern Bay Seaside Village		
Drawing No:	0063154hv_CL-EMP_01		
Date:	10/2/2009	Drawing size:	A3
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Swamp Forest (Swamp Mahogany – Paperbark Forest)

The swamp forest is dominated by Broad-leaved Paperbark (*Melaleuca quinquenervia*), Swamp Mahogany (*Eucalyptus robusta*), Swamp Oak (*Casuarina glauca*) and Cabbage Tree Palm (*Livistona australis*). The community mainly occurs along the Nelson Bay Road boundary of the site, with an extensive patch in the western corner of the site. The canopy density is 70 percent or greater and there is a sparse mid-storey of occasional Broad-leaved Paperbark. The ground cover is sparse and is dominated by Swamp Water Fern *(Blechnum indicum*), Jointed Twigrush (*Baumea articulata*) and Saw Sedge (*Gahnia clarkei*). Weeds such as Pennywort (*Hydrocotyle bonariensis*) are present, due to the favourable moisture conditions.

This community corresponds to the LHCCREMS mapping unit Swamp Mahogany – Paperbark forest. Although the western half of the site has been mapped by LHCCREMS as Swamp Oak - Rushland forest, this area of swamp forest is more characteristic of Swamp Mahogany – Paperbark forest due to the dominant plant species present in the canopy, mid and ground strata.

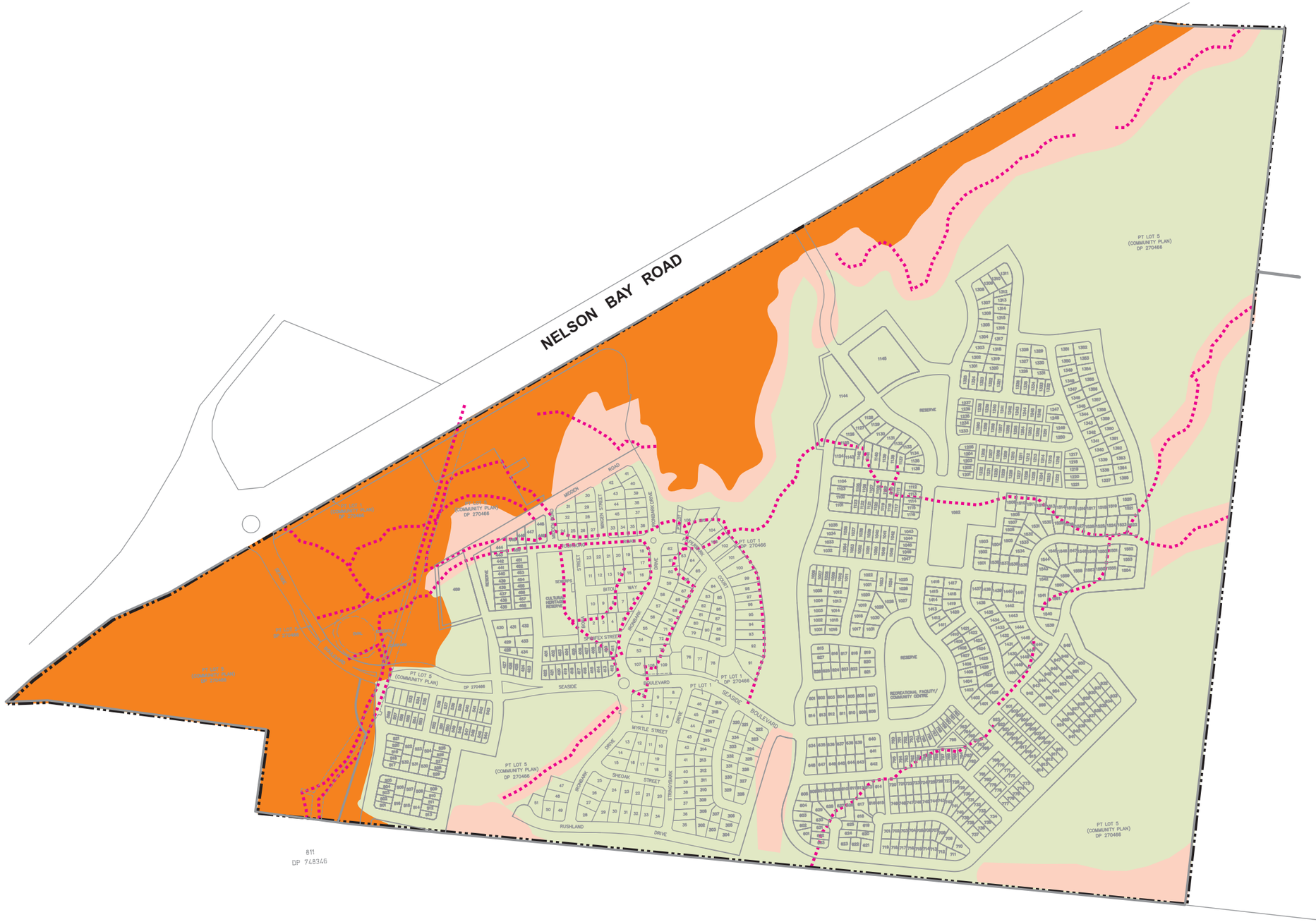
Coastal Scrub (Wet Heath)

The coastal scrub community is dominated by Swamp Mahogany, Red Bloodwood and Old Man Banksia as occasional emergent trees, although the community is generally less than three metres in height. This community corresponds to the wet heath community identified by Clements *et al.* (1992), and can be delineated into heath occurring on a 2000 year BP sand transgression, dominated by red bloodwood, and a 4000 year BP sand mass dominated by swamp mahogany that occurs further inland. Wet heath species such as *Melaleuca nodosa* and *Restio tetraphyllus* dominate the community. This community corresponds to the LHCCREMS mapping unit of Tomago sand swamp woodland on the 4000 year BP sand transgression.

4.4 WEEDS

A map of broad distribution and abundance of weeds has been prepared (see *Figure 4.2)*. Information on the particular species and broad distribution of weed species was obtained from Clements *et al.* (1992) and Gunninah (1996 revised 1997 and 2002), through field surveys by ERM (2005c) and discussions in 2008 with the Port Stephens Council Senior Weeds Officer. The low local occurrence of exotic weed species in the undisturbed areas of the site (as opposed to the cleared areas) is indicative of soil nutrient levels unfavourable to their growth. Off road vehicles and garbage dumping are likely to have contributed to the transportation of weeds to the site.

A wide variety of significant weeds occur in the site including perennial and annual grasses, herbs, shrubs and climbers. On the site the greatest variety



Legend

- Fern Bay Study Area
- Major Walking Trail
- Existing Tracks

Weed Infestation Levels	*Weed Species Present*
High	Lantana, Morning Glory, Blackberry Nightshade,Turkey Rhubarb, Love Grass, Inkweed, Bitou Bush, African Lovegrass,Guinea Grass,Whiskey Grass, Fleabane, Pennywort, Paddy's Lucerne, Blackberry, Purpletop, Fishbone Fern, Ambrosia
Medium	Bitou Bush, Fireweed, Fleabane, Variable Groundsel, African Lovegrass,Cyperus, Guinea Grass, Lantana
Low	Variable Groundsel, Cyperus, Fleabane, Bitou Bush, Toothed Hebenstrentia

Figure 4.2

Weed Mapping Areas

Client:	Aspen Group Pty Ltd		
Project:	Fern Bay Seaside Village		
Drawing No:	0063154hv_CL-EMP_02		
Date:	10/02/09	Drawing size:	A3
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Scale:	Refer to Scale Bar		

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and density of weeds occurs within the northern and western parts of the property. The main weed infestations generally occur and have established:

- within cleared areas where rubbish has been dumped and spread;
- along Nelson Bay Road;
- within the electricity easement;
- along four-wheel drive tracks; and
- in parts of the native swamp forest and the hind dune dry open forest where the highly invasive species Lantana and Bitou Bush have established.

Table 4.1 lists the significant weed species identified on site and provides a description of their abundance and distribution and level of control priority. Significant weed species are those with the highest densities which pose the most significant threat to the conservation values of the site. Noxious weed species for the Port Stephens local government area occur in much lower densities and are identified *Table 4.1*. These include Alligator Weed, Bitou Bush, Blackberry, Chinese Violet and Lantana, which are also Weeds of National Significance.

Table 4.1 Dominant Weed Species on Site

Common Name	Species Name	Description of Weeds from Previous Surveys	Control Priority
African Love Grass	*Eragrostis curvula*	Sides of the tracks and in disturbed areas.[1] Invaded some disturbed areas although mostly confined to vegetation edges.[2]	high
Aligator Weed	*Alternanthera phitoxeroides* Class 3, N	Cleared areas, largely associated with previously disturbed areas from construction, spreading into conservation lands.[5]	high
Ambrosia	*Ambrosia tenuifolia*	Cleared areas.[4]	low
Bitou Bush	*Chysanthemoides monilifera subsp. rotundata* Class 4, N	Forms clumps on the foredune and is dominant in small patches of the hind dune vegetation and seedlings were widespread throughout the dry sclerophyll forest. Bitou Bush appears to require open sand and perhaps continuous nutrient enrichment for establishment. Occurs on the boundaries between the swamp forest and dry sclerophyll open forest.[1] Occurs extensively through the site especially along edges of disturbed swamp forests. Common along edges of dune vegetation.[2] One of the main weed species present in the dry sclerophyll open forest.[3]	high
Blackberry	*Rubus fruticosu*s ssp. *aggregate* Class 4, N	Not common and is generally confined to large cleared areas where dumping has occurred. [2]	high
Chinese Violet	*Asystasia gangetica ssp. Micrantha* Class 1, N, AW	Within conservation lands. [5]	high
Cyperus	*Cyperus dubius* and *C. flavus*	Localised to the Newcastle region. Appears to be naturalised in the dry sclerophyll open forest.[1]	moderate
Fire Weed	*Senecio madagascariensis*	This wind and tyre carried species was relatively widespread in the dry sclerophyll open forest.[1]	moderate
Fishbone Fern	*Nephrolepsis cordifolia*	Small but dense infestations along entry road.[4]	moderate
Fleabanes	(*Conzya albida, C.canadensis* and *C parva)*	These wind and tyre carried species were relatively widespread in the dry sclerophyll open forest.[1]	moderate
Guinea Grass	*Panicum maximum*	Sides of the tracks and in disturbed areas.[1]	high
Ink Weed	*Phytolacca octandra*	Not common and is generally confined to large cleared areas where dumping has occurred. [2]	low
Lantana	*Lantana camara* Class 5, N	Occurs on the boundaries between the swamp forest and dry sclerophyll forest.[2] Large patches of infestation within swamp forest.[4]	high
Mile- a -Minute	*Ipomoea cairica*	Common along Nelson Bay Road. Particularly noticeable growing over the canopies of a number of	high

Common Name	Species Name	Description of Weeds from Previous Surveys	Control Priority
		swamp forest stands.[2]	
Paddy's Lucerne	*Sida rhombifolia*	Common along Nelson Bay Road.[2]	moderate
Pennywort	*Hydrocotyle bonariensis*	Has become naturalised on the NSW coast including the site.[1] Commonly occurring species beneath the swamp forest canopy.[2] Found in swamp forest due to favourable moisture conditions.[3]	low
Purpletop	*Verbena bonariensis*	Common within cleared areas.[4]	moderate
Toothed Hebenstretia	*Hebenstretia dentata*	Weeds of disturbed sandy places, localised to the Hunter Region.[1]	low
Turkey Rhubarb	*Acetosa sagittata*	Common along Nelson Bay Road.[2]	low
Variable Groundsel	*Senecio lautus*	Few weeds are present, but one of the main weed species in the dry sclerophyll open forest.[3]	low
Whisky Grass	*Andropogon virginicus*	On the sides of the tracks a higher abundance and number than within the natural vegetation. The most widespread with a habitat preference for open areas in low nutrient soils. It does not occur in natural vegetation unless the vegetation has been cleared or disturbed.[1] Invaded some disturbed areas mostly confined to vegetation edges.[2]	high
Wild Tobacco Plant	*Solanum mauritianum*	Not common and is generally confined to large cleared areas where dumping has occurred.[2]	Moderate

Common Name	Species Name	Description of Weeds from Previous Surveys	Control Priority

References

[1] Clements *et al*, 1992; [2] Gunninah, 2002; [3] Gunninah 1996 revised 1997; [4] ERM 2005 field surveys; [5] Senior Weeds Officer, Port Stephens Council (pers com)

Noxious Weeds in Port Stephens LGA

Class 1* - Notifiable weed, must be fully and continuously suppressed and destroyed

Class 2* –Notificable weed, must be fully and continuously suppressed and destroyed

Class 3 - The plant must be fully and continuously suppressed and destroyed

Class 4 - The growth and spread of the plant must be controlled according to the measures specified in a management plan published by the local control authority

Class 5* - There are no requirements to control existing plants

* Classes 1,2 and 5 weeds are prohibited from sale in NSW.

National Environmental Alert Weeds

[AW] – national environmental alert weeds

Weeds of National Significance

[N]- nationally significant

4.5 *FAUNA HABITAT*

The dry sclerophyll open forest community provides fauna habitat in the form of tree hollows, logs and ground cover such as grasses and bracken. Logs and ground cover provide shelter and foraging habitat for reptiles and small ground-dwelling mammals. The sandy substrate enables small to medium-sized mammals to create burrows for shelter. Tree hollows of this community provide suitable roosting habitat for the Squirrel Glider, Powerful Owl, Masked Owl and microchiropteran bats. No habitat in the form of bush rock or rock platform was identified on the site. The presence of banksia in the mid-strata provides foraging resources for nectivorous birds and the Squirrel Glider.

The coastal scrub community has little to no fauna habitat in the form of tree hollows, however, the dense grass cover and presence of Acacia, Banksia and Leptospermum provides extensive foraging habitat for granivorous and nectivorous birds, and some sheltering habitat for reptiles and small ground-dwelling mammals.

The swamp forest community provides potential foraging habitat for Koalas, Squirrel Gliders, the Powerful Owl, Grey-headed Flying-fox and migrating nectivorous birds such as the Swift Parrot. Swamp Mahogany comprises the primary winter foraging resource in this community, although melaleucas also provides a flowering resource. Some hollow-bearing trees are also present in this community, providing potential roost sites for the Squirrel Glider and microchiropteran bats. This vegetation community also supports a ephemeral wetland that provides suitable habitat for frog species such as the Wallum Froglet. This community acts as a biological filter for the movement of water between the site and Fullerton Cove. Management of the on site conservation lands within Fern Bay Seaside Village will be undertaken consistent with the requirements to protect and enhance the ephemeral wetland environment.

4.6 *THREATENED POPULATIONS AND ECOLOGICAL COMMUNITIES*

No threatened populations currently listed under the *TSC Act 1995* and *EPBC Act 1999* have been recorded within the site.

The Endangered Ecological Community 'Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions' is represented in the swamp forest that adjoins Nelson Bay Road (refer to *Figure 4.1*).

4.7 THREATENED SPECIES

There are 41 threatened species listed under the *TSC Act 1995* that have the potential to occur within a 10 kilometre radius of the site (ERM, 2005b). Thirty-seven of these threatened species have the potential to be impacted by development on the site. These species are listed in *Table 4.2*.

Table 4.2 Threatened Species under the TSC Act 1995 with Potential to be Impacted by Development on Site

Type of Animal / Plant	Species
Hollow-dependent bird	Glossy Black-Cockatoo (*Calyptorhynchus lathamii*)
	Masked Owl (*Tyto novaehollandiae*)
	Barking Owl (*Ninox connivens*)
	Powerful Owl (*Ninox strenua*)
Other birds	Swift Parrot (*Lathamus discolor*)
	Brown Treecreeper (eastern species*) (Climacteris picumnus victoriae)*
	Square-tailed Kite (*Lophoictinia isura*)
	Osprey (*Pandion haliaetus*)
	Grey-crowned Babbler (eastern subspecies) (*Pomatostomus temporalis temporalis*)
	Wompoo Fruit-dove (*Ptilinopus magnificus*)
	Rose-crowned Fruit-dove (*Ptilinopus regina*)
	Superb Fruit-dove (*Ptilinopus superbus*)
	Regent Honeyeater (*Xanthomyza phrygia*)
Cave-roosting bats	Large-eared Pied Bat (*Chalinolobus dwyeri*)
	Little Bentwing-bat (*Miniopterus australis*)
	Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*)
	Large-footed Myotis (*Myotis adversus*)
Hollow-dependent mammals	Hoary Wattled Bat (*Chalinolobus nigrogriseus*)
	Spotted Tailed Quoll (*Dasyurus maculatus*)
	Eastern False Pipistrelle (*Falsistrellus tasmaniensis*)
	Eastern Freetail-bat (*Mormopterus norfolkensis*)
	Squirrel Glider (*Petaurus norfolcensis*)
	Brush-tailed Phascogale (*Phascogale tapoatafa*)
	Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris*)
	Greater Broad-nosed Bat (*Scoteanax rueppellii*)
Other mammals	Koala (*Phascolarctos cinereus*)
	Grey-headed Flying-fox (*Pteropus poliocephalus*)
Frogs	Wallum Froglet (*Crinia tinnula*)
	Green and Golden Bell Frog (*Litoria aurea*)
	Green-thighed Frog (*Litoria brevipalmata*)
Plants	Netted Bottlebrush (*Callistemon linearifolius*)
	Leafless Tongue Orchid *Cryptostylis hunteriana*
	Sand Doubletail (*Diuris arenaria*)
	Newcastle Rough Doubletail (*Diuris praecox*)
	Parramatta Red Gum (*Eucalyptus parramattensis* subsp. *decadens*)
	Heath Wrinklewort (*Rutidosis heterogama*)
	Dwarf Kerrawang (*Rulingia prostrata*)

Three flora species and five fauna species listed as threatened in the EPBC Act are considered to have a moderate to high likelihood of occurring on site, as well as four bird species listed in the migratory provisions of this Act. These species are listed in *Table 4.3*.

Table 4.3 ***Threatened Species Listed under the EPBC Act 1999 with potential to be impacted by Development on Site***

Type of Animal / Plant	Species
Plants	Newcastle Doubletail (*Diuris praecox*)
	Parramatta Red Gum (*Eucalyptus parramattensis* subsp. *decadens*)
	Dwarf Kerrawang (*Rulingia prostrata*)
Fauna	Swift Parrot (*Lathamus discolor*)
	Regent Honeyeater (*Xanthomyza phrygia*)
	Large-eared Pied Bat (*Chalinolobus dwyeri*)
	Spotted Tailed Quoll (*Dasyurus maculatus*)
	Grey-headed Flying-fox (*Pteropus poliocephalus*)
Migratory birds	White-throated Needletail (*Hirundapus caudacutus*)
	Black-faced Monarch (*Monarcha melanopsis*)
	Satin Flycatcher (*Myiagra cyanoleuca*)
	White-Bellied Sea-eagle (*Haliaeetus leucogaster*)

Of those threatened species listed in *Tables 4.2* and *4.3*, 12 have been recorded on site during ecological investigations (ERM, 2005b):

- Newcastle Doubletail Orchid (*Diuris praecox*);
- Wallum Froglet (*Crinia tinnula*);
- Hoary Wattled Bat (*Chalinolobus nigrogriseus*);
- Eastern Freetail-bat (*Mormopterus norfolkensis*);
- Greater Broad-nosed Bat (*Scoteanax rueppellii*);
- Little Bentwing-bat (*Miniopterus australis*);
- Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*);
- Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris*);
- Grey-headed Flying-fox (*Pteropus poliocephalus*);
- Powerful Owl (*Ninox strenua*);
- Masked Owl (*Tyto novaehollandiae*) and
- Squirrel Glider (*Petaurus norfolcensis*).

The impact of the proposed development on these species is addressed in the Fern Bay Estate Species Impact Statement (ERM, 2005b).

Many of these species have been recorded within areas of the site zoned 7(a) Environment Protection and 1(a) Rural Agriculture under the Port Stephens Local Environmental Plan 2000 as shown in *Figure 4.1*.

A Powerful Owl roost tree was recorded in 2002 in the north western part of the site and an individual was observed roosting nearby. A 100 metre buffer will be maintained around this roost tree (see *Figure 4.1*).

There are no recent records of Koalas on the site, with the last recorded siting in 1992. However, the site supports both preferred and supplementary Koala habitat as defined in the Port Stephens Comprehensive Koala Plan of Management (Port Stephens Council 2001).

Previous investigations identified approximately 20 clumps of the hybrid *Eucalyptus parramattensis* subsp *decadens* species and an estimated population size of approximately 74 trees have been identified in the immediate locality (ERM 2007). Of these only seven trees occur within the Fern Bay Seaside Village development area, with the remaining 67 located within the adjacent Worimi Regional Park. Further taxonomic investigations of flowering specimens collected in June 2008 have been identified the trees as *Eucalyptus parramattensis* subsp *decadens* x *E. robusta*. This species is not listed as threatened under State or Commonwealth legislation however it is considered to have a very high conservation value.

The majority of the population of *Eucalyptus parramattensis* subsp *decadens* x *E. robusta* will not be impacted directly by the project, however all seven individual trees located within the Fern Bay Seaside Village site will be removed.

No threatened fish species listed under the *Fisheries Management Act 1994* occur on the site.

4.8 ABORIGINAL HERITAGE

Twenty-five Aboriginal archaeological sites have been recorded within the site, including middens, open artefact scatters, a hearth, and a Worimi Cleaver. The low ridgeline in the western part of the site has been identified as being of high archaeological significance because of the hearth and Worimi cleaver that were recovered from this area. This area is to be conserved.

The sub-surface investigations also demonstrated that Aboriginal objects could be present across the entire site. The highest densities of Aboriginal objects are likely to be found along the low ridgelines.

Archaeological sites should be clearly identified prior to any works to avoid disturbance and damage. Weed removal, other restoration or access should not be undertaken within or through significant archaeological sites. If works are essential within close proximity of these sites, it is particularly important that informed and qualified bush regeneration contractors undertake this work in consultation with Archaeologists.

5 ISSUES AND IMPACTS

There are a range of potential impacts arising from the proposal that could affect species and ecological communities on site. The following is an overview of the management issues relating to the site, including potential impacts that may rise from the development of part of the site.

5.1 DIRECT LOSS OF HABITAT

Fern Bay Seaside Village will involve the direct loss of approximately 93 hectares of vegetation comprising swamp forest, wet heath and dry sclerophyll open forest. Approximately 22.8 hectares of vegetation proposed to be cleared has been approved to be cleared under the existing development consent that applies over part of the site. Most of the vegetation that is likely to be cleared is dry sclerophyll open forest.

A significant proportion of the site's vegetation will be conserved, rehabilitated and maintained. Relative to the area that will be conserved, the greatest loss of habitat in the site will be wet heath, with 27 percent of the total area being conserved. Approximately 70 percent of the swamp forest will be conserved, mostly within the minimum 200 metre wide ecological corridor along Nelson Bay Road. Over half of the dry sclerophyll forest in the site will be conserved.

Figure 5.1 illustrates the areas proposed to be developed, reserved and landscaped on the site. The community conservation lands are to be managed for their ecological and environmental values. Managed community services / parks are active and passive recreation areas for community purposes.

5.2 CORRIDORS AND HABITAT FRAGMENTATION

The development of Fern Bay Seaside Village will involve the removal of approximately 46 percent of the site's native vegetation. This vegetation forms part of an existing vegetative corridor along the sand dunes of Stockton Bight. A minimum 200 metre wide ecological corridor is to be retained along the northern boundary of the site, to provide connectivity of swamp forest in the Fern Bay area. Two access roads into the estate will fragment this corridor although it is currently fragmented by a powerline easement. Two areas of wet heath will be cleared, leaving a smaller area isolated in the northern portion of the site. Although an area of wet heath occurs on Boral's land holdings to the north, it is discontinuous with the wet heath on the site.

Dry sclerophyll open forest will be fragmented throughout the site, leaving the only intact corridor of this vegetation near the eastern boundary of the site. The design of Fern Bay Seaside Village facilitates the retention of

Legend

- Managed Community Reserves/Parks[1]
- Community Conservation Lands[2]
- Local Activity Centre
- Mixed Use Residential Development
- Commercial Development
- Cultural Heritage Reserve
- Part of the Approved Subdivision Area
- Potential Stormwater Management Infrastructure
- Pathway
- Fire Trail
- 10 metre Asset Protection Zone
- 20 metre Asset Protection Zone
- 25 metre Asset Protection Zone

Notes:

1 Managed Community Reserves/Parks are areas of active and passive recreation for community purposes and do not form part of the community land.

2 Community lands are the 'Conservation Lands' to be managed for ecological and environmental values.

Figure 5.1

Project Plan

Client:	Aspen Group Pty Ltd		
Project:	Fern Bay Seaside Village		
Drawing No:	0063154hv_CL-EMP_03		
Date:	10/2/09	Drawing size:	A3
Drawn by:	SP	Reviewed by:	PD
Source:			
Scale:	Refer to Scale Bar		

N

0 50 100 150m

Environmental Resources Management Australia Pty Ltd
53 Bonville Avenue, Thornton, NSW 2322
Telephone +61 2 4964 2150

ERM

approximately 300 metres of existing bushland between the proposed residential allotments and the mobile dunes of Stockton Bight, providing a movement corridor for fauna through dry sclerophyll open forest.

The corridors of swamp forest and dry sclerophyll open forest will facilitate the movement of fauna so that threatened species, populations and ecological communities will not become isolated from the currently interconnecting areas of habitat to the south and north. Nelson Bay Road presently disrupts fauna movement west of the site, although some fauna such as the Squirrel Glider may be able to glide across the canopy above the road. Cleared agricultural land west of Nelson Bay Road also presents a barrier to the movement of terrestrial fauna.

5.3 EDGE IMPACTS

Edge effects in the swamp forest have been minimised by the inclusion of a 50 metre wide buffer around the boundary of the communities to be reserved. Most edge effects disappear over the first 50 metres into a remnant of native vegetation. Edge effects are likely to be greatest in the dry sclerophyll open forest due to the large interface area between this community and the development footprint.

Physical changes that have the potential to occur at the interface between the development and natural bushland include changes in soil and water conditions and potentially an increase in light penetration to the understorey. However, this can be prevented through effective rehabilitation and ongoing monitoring and management of the reserves and in particular the interface.

5.4 WEED DISPERSAL

Weeds are currently a problem within the site. Weed invasion into low nutrient environments such as dry sclerophyll forest is a potential issue, given this vegetation community will be fragmented by the proposed development.

Most weeds produce prolific numbers of seeds or other propagules. They typically benefit from disturbance to soils or native vegetation through rapid colonisation of bare substrates and disturbance niches, although some are aggressive and can invade relatively undisturbed vegetation. Clearing and fires can trigger major outbreaks of weeds. Such outbreaks often occur from seeds that have laid dormant in the soil until the disturbance provides the conditions necessary for germination. Weeds can spread from infested areas to weed free areas via wind or water or by travelling as seeds or propagules on vehicles, people or animals from one place to another. A reduction in tree cover and the undertaking of earthworks are likely to facilitate weed dispersal and establishment.

Weed removal and treatment is required as part of restoration works within the reserves and the proposed development area. This should be followed by ongoing management and monitoring of weeds at the site to remove regrowth. Works will focus on areas particularly susceptible to weed invasion, such as road edges, asset protection zones and parks.

5.5 PESTS

5.5.1 Predation by Vertebrate Pests

Vertebrate pests such as dogs, cats, foxes and rabbits are present within the development area and surrounding areas. Impacts associated with these species would include predation on native fauna species by dogs, foxes and cats. Rabbits may impact native vegetation through erosion and ground instability associated with rabbit warrens. In the absence of restriction on dog and cat ownership, increases may occur, thereby directly impacting fauna through predation. The development does however have the potential to aid in the dispersal of vertebrate pests through construction activities.

5.5.2 Mosquitoes

Mosquito impact on the Fern Bay Seaside Village is influenced by both the potential for mosquito populations dispersing in the area from surrounding areas, and / or being produced from habitats within the area. This not only generates impacts associated with nuisance biting, but also the potential for the transmission of disease causing pathogens, which are an increasing concern in the Hunter Region (ICPMR, 2004).

5.6 STORMWATER RUNOFF AND EROSION

The absence of streams and drainage lines on the site reduces the potential issue of sedimentation as a result of the proposed development, however urban development usually increases the proportion of impervious services in a stormwater catchment that increase runoff volumes and peak discharges to a receiving environment whilst decreasing or eliminating infiltration of rainwater into soils (Urban Water Cycle Solutions, 2007). Increases in stormwater runoff can also convey pollutants (including high nutrient loads) that are generated by urban development to receiving waters and resultant environmental impacts.

Weed invasion at the site is already a problem and increased stormwater runoff with the increase of hard surfaces and nutrients could increase the level of weed invasion of the reserved areas. The implementation of the stormwater management strategies (Urban Water Cycle Solutions 2007) will control the movement of stormwater and sediment within and off the site.

5.7 *ROAD TRAFFIC*

The construction of roads increases the risk of traffic strike to fauna. Fauna are particularly vulnerable to being killed when crossing roads especially in urban areas and / or areas where prime habitat has been fragmented. Fauna may also be impacted by machinery associated with the construction phases of the development.

5.8 *BUSH FIRE*

The site is regarded as having a high bush fire hazard potential. A Bush Fire Hazard Assessment (ERM 2007) has been prepared for the site. This identifies various bush fire management measures to reduce bush fire hazard including the provision of appropriate asset protection zones around future residential areas. These are generally provided by the perimeter roads and road reserves. In some instances asset protection zones will be provided by parks. These are required to be established and maintained in accordance with the requirements of *Planning for Bushfire Protection* (NSW Rural Fire Service 2001). Asset protection zones do not extend into environmental protection zones. *Figure 5.1* identifies the location of asset protection zone within the site.

5.9 *RUBBISH DUMPING*

Garden and non–compostable household rubbish dumping is currently occurring on site. This has primarily occurred along tracks with easy access from Nelson Bay Road and has occurred despite signage warning against this practice.

With residential development of the site, garden rubbish dumping may become a greater problem and could potentially introduce more weeds to the reserves. Rubbish dumping also introduces nutrients and provides ideal conditions for the establishment of the dumped weeds. The sheer weight of the rubbish can smother and break native plants (Buchanan 1989).

Non-compostable household rubbish is currently located on site. Assuming this rubbish is non-toxic this group of rubbish is less damaging than garden rubbish. It looks unsightly but it does not introduce weeds or plant nutrients.

5.10 *KEY THREATENING PROCESSES*

The following key threatening processes as listed under the *TSC Act* are relevant to the site and require appropriate management:

- clearing of native vegetation;
- invasion of native plant communities by exotic perennial grasses;
- invasion of native plant communities by Bitou Bush (*Chrysanthemoides monilifera*);
- invasion of native plant communities by exotic vines and scramblers;
- invasion, establishment and spread of Lantana camara;
- high frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition;
- predation by the Red Fox (*Vulpes vulpes*);
- predation by the Feral Cat (*Felis catus*)
- competition and grazing by the feral European Rabbit (*Oryctolagus cuniculus*);
- feral pigs;
- removal of dead trees and dead wood; and
- loss of hollow bearing trees.

6 IMPACT MANAGEMENT

6.1 IMPACT MANAGEMENT

There is potential for a variety of direct and indirect impacts as a consequence of the proposed works during construction and the subsequent activities at the site following the completion of the development. Outlined below are the objectives and measures for managing the potential impacts on the vegetation communities and fauna habitat on the site and in undertaking restoration works. Management actions have been separated into pre construction, construction and post construction mitigation measures to clearly identify the stages to the management activities.

6.2 INDICATIVE PROGRAM

An indicative work program is provided in *Annex D*. Individual programs have been developed for pre construction, construction and post construction activities. The programs will apply to each stage of the development. Given the actual timing for the construction of the development (both commencement and the duration of the stages) is unknown, the program provides indicative timing only in this respect. However the actual times identified for each individual task is considered appropriate.

Prior to the commencement of each stage, the programs should be revised based on the specific commencement and predicted durations.

6.3 MANAGEMENT OBJECTIVES

The objective for managing the site involves the protection and enhancement of vegetation communities and fauna habitat on site over time through enforced strategies, weed management, ongoing bush regeneration works, pest animal control, stormwater management, fire management, traffic management, waste and domestic pet management. An appropriate monitoring program is required in order to ensure mitigation measures are achieving the desired outcome.

6.4 MANAGEMENT OF POTENTIAL IMPACT PRIOR TO CONSTRUCTION

During the planning phase of development, the potential impacts of the proposed development on the conservation areas and reserves can be minimised through design principles such as the incorporation of local provenance species into landscaping plans and revegetation works. General pre-construction management measures include:

- clear identification of the boundaries between clearance areas and those set aside for conservation;

- clear identification of individual habitat trees that are to be retained within the development area and/or interface;

- pre clearance surveys of hollow bearing trees is to be conducted by a suitably qualified wildlife professional. Wildlife recovered by the wildlife professionals are to be released by the professional into the environmental protection zone within the site at appropriate times. If microchiropteran bat roosts are located, the wildlife professional may attempt to relocate the roost to nearby habitat in reserved areas.

- collection of seed from *Eucalyptus parramattensis* subsp *decadens* hybrid plants and subsequent propagation and planting of the plants within the wet health area to be retained (refer to *Section 7.1*);

- specific guidelines developed for contractors to avoid soil compaction and damage to the roots, stems and branches of trees to be retained, for example appropriate placement of stockpiles, machinery and location of digging;

- specific strategies to avoid the introduction and further spread of weeds onto and within the site (refer to *Section 5.4* and *Chapter 7*) ;

- collection of seed, vegetative material or translocatable individuals within the development area to be grown or used in restoration and reconstructive landscaping;

- engagement of bushland regeneration contractors; and

- beginning weed control and regeneration in areas of natural bushland not directly impacted within the proposed development area.

6.5 MANAGEMENT OF POTENTIAL IMPACT DURING CONSTRUCTION

It is important that measures are put in place during the construction of the proposed development. These measures will include:

- construction activities are to be generally restricted to daylight hours to minimise impacts to nocturnal fauna such as the Powerful Owl;

- tree clearing operations are to be undertaken generally in accordance with the Habitat Clearing Protocol of the Squirrel Glider Conservation Management Plan (Smith, 2002) detailed in *Section 7.1.1*, in order to minimise mortality to adult and juvenile squirrel gliders. In essence this process requires the clearing of non habitat trees first, followed by an interval before felling of habitat trees (refer to *Section 7.1.1*);

- placement of dead wood and dead mature trees removed from the construction footprint into reserves and open space areas and / or reused within landscaping works in accordance with the bush fire hazard requirements. This will reduce the impact of the key threatening process 'removal of dead wood and dead trees';

- any wildlife observed ahead of / during clearing works are to be removed by a qualified wildlife professional and relocated to the conservation area within the site at an appropriate time. Any injured wildlife are to be provided to wildlife care organisations for rehabilitation prior to release within the site. This strategy is however not recommended for the management of Squirrel Gliders as individuals are likely to return to the den tree. The tree clearing strategy is the recommended management strategy for this species;

- construction of the asset protection zones in accordance of the Bush Fire Hazard Assessment. Habitat trees within the zones are to be retained where possible;

- phase construction activities to minimise erosion and impacts on the stormwater management system and infiltration processes;

- erecting temporary fencing along the construction area and bushland interface to prevent the disturbance of bushland in conservation areas and the transport of weeds;

- containing runoff from impermeable surfaces within the development areas of the site and minimising soil erosion;

- placing stockpiles and storing machinery away from the conservation areas and any other vegetation to be retained. Temporary fencing will be erected around the immediate area of construction activities in order to protect adjacent conservation areas;

- ensuring that any soil or vegetative material from the site that may contain weed seed is not deposited in or in close proximity to the conservation areas;

- vegetation removed from the proposed development footprint should not be dumped within or in close proximity to the conservation areas;

- informing contractors about environmental responsibilities either through pamphlets or inductions;

- re-establishing native vegetation cover as soon as possible after earthworks;

- removal of all waste generated during construction activities from the site in accordance with the requirements of the *NSW POEO Act*;

- avoiding the disturbance of areas of heavy weed infestation when the weeds are flowering or seeding (see *Table 4.1* for significant weed species occurring on the site);

- installation of wildlife warning signs along the two access roads into the subdivision to warn road users of potential presence of wildlife. The signs should provide contact details for wildlife carers that can be contacted in the event of wildlife being injured; and
- removing weeds immediately adjacent to roads that are constructed on site (particularly the access roads) to prevent the transport of weeds by vehicles.

Table 6.1 Weed Species Flowering and Fruiting Periods

Species	Peak Flowering	Peak Fruiting
Bitou Bush	April to July. Can occur all year round (DEC 2004).	June to September
Lantana	Usually October to April. Almost continuous whenever soil is moist (DEH 2003).	November to June
Chinese Violet		
Alligator Weed	Mid summer	
Blackberry	November to February (DEH 2003).	December to April

Note:
DEC – NSW Department of Environment and Conservation.
DEH - Department of Environment and Heritage (Cwth)

6.6 *MANAGEMENT OF POTENTIAL IMPACT AFTER CONSTRUCTION*

Management after construction will focus on:

- the ongoing management and monitoring of natural vegetation, weeds and pests. Refer to *Section 7* for specific information regarding their management;
- education and involvement of future residents and the formation of a local environmental group;
- continued management of stormwater runoff from impermeable surfaces and provision of management that avoids runoff into reserves;
- management of passive access to reserves to prevent degradation, the spread of weeds and waste; and
- management of bush fire hazard.

Post construction measures will be implemented over a period of 20 years from the date of development consent, the need for which will be assessed during the review of the CLEMP as identified in *Section 10.4*.

7 SPECIFIC MANAGEMENT REQUIREMENTS

7.1 THREATENED SPECIES MANAGEMENT

In addition to the conservation of habitat areas, the following specific mitigation measures are required in order to mitigate the impact on threatened species:

- clear identification of individual habitat trees that are to be retained within the development area and/or interface;
- pre clearance surveys of hollow bearing trees is to be conducted by a suitably qualified wildlife professional. Wildlife recovered by the wildlife professionals are to be released by the professional into the conservation areas within the site at appropriate times. If microchiropteran bat roosts are located, the wildlife professional may attempt to relocate the roost to nearby habitat in reserved areas;
- the use of salvaged tree hollows and nest boxes are not recommended for the Squirrel Glider or other hollow dependent fauna due to the abundance of hollows in the conservation areas; and
- placement of dead wood and dead mature trees removed from the construction footprint into reserves and open space areas and / or reused within landscaping works in accordance with the bush fire hazard requirements to reduce the impact of the key threatening process 'removal of dead wood and dead trees'.

7.1.1 *Protocol for Management of the Squirrel Glider*

Tree clearing operations are to be undertaken generally in accordance with the Habitat Clearing Protocol of the Squirrel Glider Conservation Management Plan (Smith, 2002). The protocol states that where clearing of habitat with known Squirrel Glider populations occur, the following procedures should be observed:

- all potential Squirrel Glider habitat trees in the area to be cleared will be identified (by survey) and marked;
- marked habitat trees and corridors of retained trees linking marked habitat trees with the nearest uncleared (secure) habitat areas will be left standing after initial vegetation clearing for a period of at least three weeks (to encourage gliders to disperse into adjacent uncleared habitat);
- after the three waiting period, standing habitat trees and corridors may be felled commencing with the most distant trees from secure habitat;
- where possible, clearing should be undertaken in the Spring to Autumn period to facilitate survival of displaced animals;

- if habitat trees are in short supply (<4 suitable trees per hectare) artificial nest sites (nest boxes) should be installed in adjacent (secure) habitat before clearing; and
- if no secure habitat exists nearby to areas to be cleared, land owners should seek advice from DECC before proceeding with clearing.

7.1.2 Protocol for Management of Diruis praecox

Two individual *Diuris praecox* were identified in 2002 along a track in the north east corner of the Fern Bay Seaside Village site, external to the development footprint. This access track will be closed as part of the management of the community lands. No other active management of the species is recommended for the first year of the CLEMP.

It is recognised that over time, regrowth of vegetation along the track is expected to overshadow the recorded individuals, reducing habitat suitability. Conversely, the creation of asset protection zones within the Fern Bay Seaside Village site may provide potential habitat for this species to colonise.

Therefore, long term management of the two individuals located along the track will be required. Such management may include reducing competition from other plants in the immediate vicinity of the individuals, for example via slashing. Any such control works will be subject to prior liaison with DECC to determine the most effective management strategy for this species. Liaison will occur with DECC during the first review of this CLEMP.

7.2 REGENERATION, RESTORATION AND WEED MANAGEMENT

7.2.1 Restoration Objectives

Given the large areas of natural bushland and parkland within the development area, it is likely that a combination of rejuvenation (lower level of intervention) and regeneration (including planting) (higher level of intervention) would be required. Restoration of the site will take place prior to, during and after construction and the techniques and timing at each stage will depend on their practicability.

The main objective of site restoration is to establish self-sustaining vegetation communities through the treatment and reduction of weeds, natural rejuvenation and regeneration and re-planting of native species local to the area to:

- restore similar composition and diversity of vegetation in reserves; and
- reinstate basic functions.

7.2.2 Principles

The following principles of rejuvenation and regeneration should be applied to the restoration of the site:

- apply the minimum intervention necessary for success;
- carefully assess potential for natural rejuventation prior to determining whether a regeneration / replanting approach is necessary;
- planting and or direct seeding may be necessary for establishing indigenous vegetation where regeneration potential is severely depleted;
- in cases where the site conditions have been so altered that the pre-existing community cannot perpetuate on site in the long term, construction of an alternative locally occurring indigenous vegetation community is a potential option;
- always work from good areas with native plants towards more degraded weed infested areas ie. from good bush to bad bush;
- minimise disturbance;
- let native plant regeneration dictate rate of weed removal; and
- undertake several stages of weed removal ie. primary, consolidation and long term maintenance (Greening Australia, 1999 and Buchanan, 1999).

7.2.3 Methods

The following methods of rejuvenation and regeneration should be applied to the restoration of the site:

- reverse degradation processes and causes;
- reintroduce seed sources where known to be missing;
- appropriate selection of species for regeneration;
- ensuring genetic integrity and diversity;
- appropriate site preparation and maintenance;
- undertake weed control in accordance with the methods detailed in *Section 7.2.4;*
- ensure disturbed areas are stabilised, mulched with weed free mulch or revegetated as quickly as possible;
- consider the use of tree guards, fencing or signage to protect regenerating areas from disturbance or predation;

- ensure that the bush regeneration does not increase the bush fire risk within the proposed development area or interface; and

- all rubbish such as pots and tree guards, should be removed from the site, when no longer necessary (Greening Australia, 1999 and Buchanan, 1999).

Annex E contains fact sheets providing an overview of suggested techniques for weed removal and dune planting for specific weed species.

7.2.4 Weed Control

The objective of the weed control program at Fern Bay Seaside Village is to improve the environmental values of Fern Bay Seaside Village through a reduction in weed species occurrence and distribution, ensuring legislative requirements are met. Protocols should be introduced at all stages of the development to reduce the spread of weeds, particularly minimising disturbance. Establishing and maintaining such protocols will reduce the costs of weed management in the long term. Weed control throughout the site should be consistent with the management of weeds within the adjacent Worimi Regional Park (ERM, 2008) and the Weed Management Plan, Fern Bay Estate Emergency Fire Trail (ERM, 2006).

Weed management and control will depend on the correct identification and the abundance, distribution and ecology of native and exotic species present. The treatment of noxious weeds and dominant weeds are the focus of weed management. Profiles describing the ecological characteristics (appearance, life cycle, dispersal mechanisms) and control recommendations for the Noxious and Nationally Significant Bitou Bush, Lantana and Blackberry, are provided in *Annex E.* The environmental alert for Chinese Violet and Alligator Weed is also included in this Annex.

As detailed in *Section 4.4*, there are a range of weeds evident at the site. Weed management will be initially undertaken on the higher priority weeds as identified in *Table 4.1*.

Baseline Assessment and Treatment

Baseline field survey and review of recent aerial photographs of Fern Bay Seaside Village would be undertaken at commencement of the weed removal program to update the data presented in *Figure 4.2* and to identify any additional areas of weed infestation.

The results of the baseline field survey would be used as a benchmark against which the success of weed control treatments will be assessed. The baseline survey will include the establishment of photo points and/or plot based surveys to measure the density (number of plants per unit area over different age classes) and cover abundance. Quantitative surveys would be replicated in treated and untreated areas. Priority native species as identified in the

Bitou Bush Threat Abatement Plan would also be identified. The presence or absence of threatened flora species would be noted.

Other features such as size and shape of area to be treated, accessibility and topography should be noted.

The baseline assessment would identify target weed species and appropriate treatment regime (method of application, choice of herbicide, timing of treatment) and operational plan for each infestation. Where flora species of conservation significance are present appropriate management measures would be identified to avoid impacts (eg no foliar spray to avoid spray drift).

Primary weed removal will be undertaken based on the results of the baseline field survey within the first year of the CLEMP. Treatment will commence in areas of low infestation using species appropriate treatment techniques as identified further below and in *Annex E*. Treatment would avoid disturbance of heavy weed infested areas during flowering or seeding. Where weed seeds and/or fruit are present in treatment areas these would be bagged and disposed off site. All treatment and records of herbicide use would be logged and maintained for annual reporting.

It is recommended that weed control works be undertaken at a similar time to weed control works within adjacent lands, such as the Worimi Regional Park in order to maximise effectiveness of control.

In subsequent years, annual weed surveys will be undertaken to ascertain weed occurrence and densities, assess the effectiveness of weed control (against the baseline year) and identify future weed treatments.

Benchmarks and Targets

The treatment regime would identify benchmarks against which post treatment monitoring would be compared. It is noted that various factors influence the occurrence of weeds species and the success of weed control treatment (for example drought conditions, prevalence of seed stock in the ground, vehicle and pedestrian spread of seeds etc).

The target of the weed control program within the Fern Bay Seaside Village is to achieve a 40% reduction in mature weed plants within the first three (3) of treatment. This target is consistent with the Natural Resources Commission target of "*By 2015 there is a reduction in the number of invasive species*".

This target will be reviewed following each annual weed survey to ensure the target is relevant and achievable based on the species and densities evident. Additionally, the weed control project will aim for a 95% weed treatment application within surveyed areas each year (ie a minimum of 95% of all weeds surveyed will have some form of treatment annually).

The weeds targeted in weed control works will be consistent with the classification of the weeds and the Natural Resources Commissions defined invasive species (refer to *Section 2.2.8*).

Methods

The following methods of weed control should be applied to the site:

- where possible weed removal by hand should take place in small patches to reduce the amount of bare ground. These areas should be maintained and allowed to naturally regenerate or be replanted with local provenance species;

- herbicide spraying of dense infestations of weeds using herbicides that are suitable for use near aquatic situations (eg glyphosate). The chosen methods for treating weeds will depend on the characteristics and densities of weed and native species;

- cut and paint, stem injection and frill/chip methods should be used for plants whose stems are greater that 10 centimetres;

- biological control methods should be considered where possible, particularly for Bitou Bush; and

- seeds or fruit should be bagged and disposed of off site.

The selection of each method is dependent on the extent of weed infestation and potential affects on surrounding native vegetation.

A log should be maintained by the weed contractor describing baseline density and species based on age (eg seedlings or mature plants), removal methods and time spent.

In areas containing significant infestations of target weed species such as Bitou Bush and Lantana, consideration should be given to the provision of erosion control structures if large areas of sand are likely to be exposed. This should be determined at the discretion of personnel undertaking weed management activities. Appropriate control methods may include keeping dead plants in situ, the provision of fences, brush matting, planting of tube stock and synthetic ground covering for larger areas of exposed sand. It is particularly important that such control strategies be adopted in areas in close proximity to wetlands and steeper dune slopes.

Any weed control works should target reproductive potential for each species and provide appropriately timed inspections and removal prior to seedset. Monitoring of weed control works is discussed in *Section 9.1*.

7.2.5 Revegetation

Vegetation clearance and weed removal will be followed by a revegetation strategy and maintenance schedule. Reconstructive landscaping within the proposed development area will be designed to integrate natural bushland with the built environment. This involves selecting species that will not invade the surrounding natural bushland and provide fauna habitat. This is particularly important at the interface of the development and the native bushland including the exclusion of invasive exotic grass species such as Kikuyu. The street planting concept plan has been prepared by Verge Landscape Architects (2007) and planting palettes are shown in *Figure 7.1.*

Once weeds are removed from bushland competition for light, water and nutrients is lowered and native plants may naturally establish from the soil seed bank. Natural regeneration is an effective management technique in areas of natural bushland that are likely to regenerate when weeds are removed. Areas that are more degraded may need assistance to bring back the vegetation given a lack of a soil seed bank or large amounts of weeds. This would involve planting of a range of plants at varying densities.

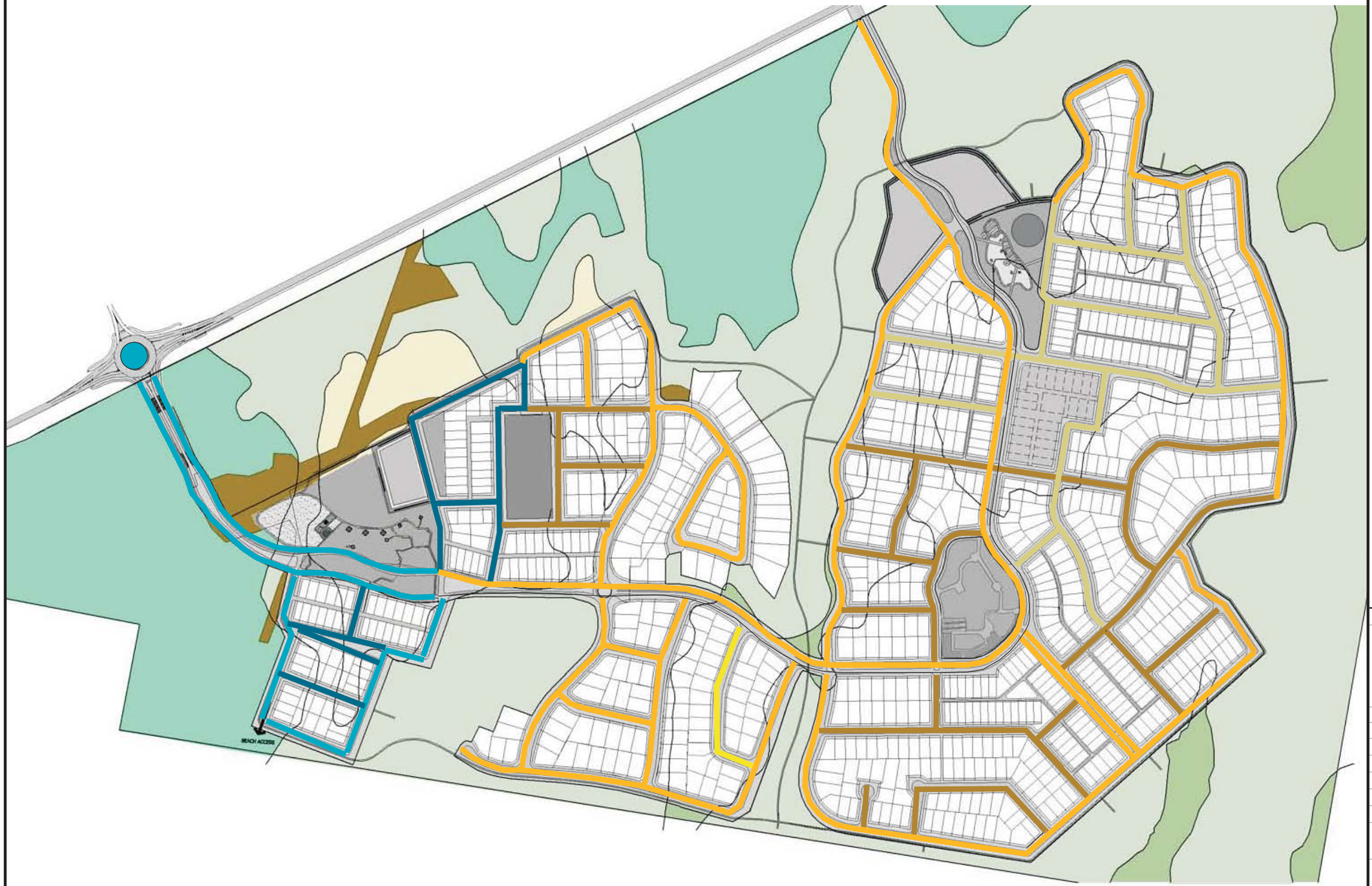
7.3 FIRE CONTROL

A Bush Fire Hazard Assessment Report (ERM, 2007) has been prepared for the site, which identifies asset protection zones (APZs) for the site. The APZs will need to maintain minimal fuel loads, have minimal continuous vegetation and not contain any woodpiles, garden mulch or other combustible materials. APZ's for the site are identified in *Figure 5.1.* Any planting in APZs will require the selection of species that are less flammable or are fire resistant.

7.4 ACCESS

Future residents will be able to enjoy the natural bushland within the reserves and open space areas, within its carrying capacity. The site must be accessed and utilised in a way that does not cause damage to the natural vegetation or degrade threatened species habitat. This can be undertaken by:

- well designed pedestrian trails that minimise disturbance of native vegetation and are located away from important threatened species habitat and archaeological areas;
- provision of waste receptacles within public reserve areas if required;
- providing a buffer around any environmentally sensitive areas, such as the owl roost tree;
- utilising interpretive signage and directive fencing;



Legend

Proposed Streetscape Planting

- refer to p. 7 for description of planting palettes.

- Swamp Mahogany Paperbark Forest - bush palette with complementary street trees.
- Swamp Mahogany Paperbark Forest - urban palette with complementary street trees.
- Apple Blackbutt Forest - bush palette with complementary street trees.
- Apple Blackbutt Forest - urban palette with complementary street trees.
- Heath - bush palette with complementary street trees.
- Heath - urban palette with complementary street trees.

Note: Streetscape planting will also apply to the Controlled Vegetation Zones (CVZ) within individual lots

Existing Vegetation

- to be retained and managed according to ecological principles and bushfire reuirements

- Swamp Mahogany Paperbark Forest
- Apple Blackbutt Forest
- Wet Heath
- Swamp Sclerophyll Forest
- Bush Regeneration Areas

Figure 7.1

Street Planting Concept Plan

Client:	Aspen Group Pty Ltd		
Project:	Fern Bay Seaside Village		
Drawing No:	0063154hv_CL-EMP_04		
Date:	11/02/09	Drawing size:	A3
Drawn by:	SP	Reviewed by:	AA
Source:	Landscape Masterplan - May 2007		
Scale:	Refer to Scale Bar		

N

0 155m

Environmental Resources Management Australia Pty Ltd
53 Bonville Avenue, Thornton, NSW 2322
Telephone +61 2 4964 2150

ERM

- excluding trail bikes and vehicles from walking tracks to avoid erosion, weed spread, waste and noise through gates only wide enough to allow for pedestrian access;

- excluding unleashed domestic dogs and horses from walking trails; and

- undertaking annual inspections of on site conservation areas and reserves to determine the presence of illegally deposited waste material and the subsequent removal of the material.

7.5 PEST MANAGEMENT

7.5.1 Vertebrate Pests

Vertebrate pest control works will be undertaken consistent with control programs being implemented by Port Stephens Council. Works should be undertaken in consultation with DECC to ensure coordinated control works between Fern Bay Seaside Village and the adjacent Worimi Conservation Lands. This may include a coordinated baiting program for wild dogs and foxes and other pest species.

The Port Stephens Feral Animal Management Committee, comprising a number of government and non government landholders in the Port Stephens area, including DECC, generally undertake a coordinated 1080 baiting program for wild dogs and foxes on an annual basis. Given the benefits of a coordinated program, the Fern Bay Seaside Village should consider participating and / or baiting at the same time to maximise results should the site be a harbourage for foxes and / or wild dogs. This should be done in consultation with DECC in relation to the adjacent Worimi Regional Park and Worimi State Conservation Area. Baiting for wild dogs and foxes should be undertaken by appropriately qualified persons and any program should include sand pad monitoring at bait stations to assess the potential impact on non target species.

Other control programs, particularly for rabbits and cats, should be undertaken when there is evidence that there may be or is an impact on the environment through erosion and ground instability and / or if there is evidence that the population is increasing. Control programs for rabbits may include biological control, fumigation or ripping of warrens, however warren ripping has the potential to create erosion issues and damage habitat and must therefore be appropriately managed. Control programs for feral cats include trapping. Consultation with DECC should occur prior to implementing a control program.

Vertebrate pest sighting forms should be developed and distributed to all residents within Fern Bay Seaside Village for use in reporting sightings of vertebrate pests, including foxes, wild dogs, cats and rabbits. This

information is to be forwarded by residents to the community association for use to determine the presence and relative abundance of the pest animals, which will inform the implementation of control actions.

7.5.2 Mosquitoes

The management of mosquitoes within the Fern Bay Seaside Village should be undertaken generally in accordance with the Mosquito Risk Assessment, Fern Bay Estate (ICPMR, 2004), and the management measures identified in "*Living with Mosquitoes in the Lower Hunter and Mid-North Coast Region of NSW*' (Webb and Russell, 2005).

Management measures may include:

- community education, providing not only public health messages, but also information regarding the ecology of the local mosquito habitat areas and the importance of environmentally sensitive mosquito control measures;
- management of stormwater management structures, including stormwater inlet pits, gross pollutant traps or surface storage areas by ensuring that the structures are self draining, have the siltation depth shallow enough to encourage evaporative drying and that the accumulation of organic material is maintained at low levels;
- the use of personal insect repellents, mosquito coils (containing insecticide) is highly recommended to provide protection for individuals and households and education of residents;
- the use of adulticides (usually applied as an ultra low volume fog or mist), however they are generally expensive, time consuming and often ineffective unless routinely applied; and
- treatment with a approved larval control agent.

The application of herbicides for mosquito control would require a permit under the *Threatened Species Conservation Act 1995*, however a permit for mosquito control for amenity reasons only is unlikely to be approved by DECC.

Should mosquito populations be excessive, consideration should be given to undertaking mosquito faunal studies during the period December through to March to assess the species present, population sizes and harbourage areas. '*Living with Mosquitoes in the Lower Hunter and Mid-North Coast Region of NSW*' (Webb and Russell, 2005) provides monitoring data sheets for undertaking fauna studies of mosquito populations that could be utilised at the site.

7.6 STORMWATER MANAGEMENT

Ongoing maintenance of the stormwater system is required in order to ensure optimum operation of the Water Sensitive Urban Design treatment train. It is important to periodically remove litter and sediment from the inlet pits in the street drainage system. Failure to do so may result in decreased stormwater quality and greater water levels in the swales within road reserves. The implementation of erosion and sediment control during construction activities is essential in order to minimise impacts.

The requirements for stormwater management include:

- inspecting and cleaning the inlet pits in the street drainage system on a quarterly basis;
- phasing construction activities to minimise erosion and minimise impacts on the stormwater management measures that rely on infiltration processes;
- minimising vegetation clearing;
- using sediment basins, silt fences and perimeter banks during construction to minimise erosion and sediment transport to receiving waters; and
- restoring vegetated ground cover as soon as possible following construction.

7.7 EDUCATION

Education and raising the awareness of residents about environmental issues on the site is important. Relevant issues include native vegetation communities, fauna habitat, weeds, nutrient runoff, appropriate use of pesticides and fertilisers, snakes, responsible ownership of domestic animals, and bush fire. This will include the placement of signage and provision of pamphlets and/or information sessions to residents on the purchase of their property. Residents will be involved in the management and protection of the conservation reserves on the site, which will be subdivided and managed under Community Title.

8 STAGING OF RESTORATION / WEED CONTROL WORKS

8.1 STAGING

Restoration, landscaping and weed control works across the site will be extensive and will require a staged approach to their implementation. It is proposed that these works will be undertaken in four stages. These four stages of restoration and weed control works apply to each stage of the development.

Annex D provides an indicative work program. The timing of the works is indicative only and will be abased on the approval date of the development, as well as the construction start date. The total time required for the carrying out of works, specifically weed control and waste removal is also indicative. Baseline surveys undertaken prior to construction will identify the current weed species present and extent of occurrence on site. The baseline assessment would identify target weed species and appropriate treatment regime (method of application, choice of herbicide, timing of treatment) and operational plan for each infestation.

8.1.1 Stage 1 (Prior To Construction Phase)

Stage 1 will involve the engagement of qualified bush regeneration and landscape contractors. There will be a clear and documented identification of restoration approaches, selection of species to be acquired and vegetative collection, weed removal in areas not proposed to be developed, site stabilisation and preparation for planting. Specific vegetation protection measures will be determined and measures explained to all contractors during the site induction in which all contractors will be required to attend prior to commencing work on site. Additional information regarding the contents of the induction program is identified in *Section 10.2*.

Species Selection and Seed Collection

The species utilised in revegetation and landscaping will be dependent on the vegetation community present and/or likely to be present and local conditions. Seed stock and vegetative material will be collected from native species present on the site. This will be undertaken over several years to cover a variety of flowering seasons and to account for annual variation. Collection at this stage will concentrate on the proposed development area. It is important that seeds and vegetative material are collected from healthy, vigorous plants. Similar quantities of seeds will be collected from several well-spaced plants to encourage genetic diversity. These activities will follow Florabank's (1999) Best Practice Guidelines.

In undertaking species selection and seed collection, the following will be considered:

- the availability of appropriate local species that can be acquired/propagated to suit the design intent and program of the first stage of development;
- suitable local indigenous species to be reintroduced to the site; and
- consider positions and design of walking tracks and interpretive signage within reserves and development of weeding strategies.

Weed Removal and Site Preparation

Regeneration and weed control could begin within areas not directly impacted by the proposed development. Works will commence in areas of low weed infestation (see *Figure 4.2*), in areas where natural regeneration is likely to occur and then move into areas of heavier infestation where additional replanting may be necessary. Control works will target invasive species. Appropriate treatments for control will be implemented based on the target species and will typically involve hand removal of large wood species plus the painting of herbicides on these species.

At this stage tracks will be closed and regenerated with spreading of brush and weed removal works will commence along the tracks. These works will commence in areas of low infestation and then move into areas of heavier infestation. Tracks will be monitored to assess rehabilitation.

8.1.2 Stage 2 Rehabilitation during Construction (1 year +)

Stage 2 will focus on the site for the duration of construction of the proposed development, which includes land clearance, creation of infrastructure and dwelling construction. Management will involve the protection of threatened species habitat, archaeological sites and areas of vegetation to be retained, weed management and replanting on site.

Flora and Fauna Habitat

Plants that can be translocated should be removed and replanted in areas to be retained or landscaped. Branches, logs and brush material should be utilised in regeneration, stabilisation and landscaping works where possible. Additional cleared vegetative matter should be mulched and utilised in landscaping and/or regeneration where possible and in accordance with bushfire management measures.

Weed Removal and Revegetation

Weed removal will continue on site and the proposed development area will be landscaped and maintained as specified in the landscaping plan. Restoration will continue in reserves with natural regeneration encouraged and some planting to be undertaken. Transplanted plants are to be maintained and additional seed collected if required for use in open spaces and private gardens.

As each stage is constructed, weed management works will commence in areas of low weed infestation (see *Figure 4.2*) and then move into areas of heavier infestation where additional replanting may be necessary. Areas of low weed infestation include the conservation areas that support Coastal Sand-Apple Blackbutt forest and the area of Swamp Mahogany-Paperbark forest near the playing fields.

8.1.3 Stage 3 Regeneration and Maintenance after Construction

Stage 3 will be undertaken at the end of and following the construction phase. This will involve continued weed removal and restoration within landscaped areas and within and on the fringe of the development, around infrastructure and heavily infested areas. The monitoring and maintenance of areas already treated within reserves, planting of any additional landscaping at appropriate times of the year, maintenance and replacement of any failed plantings. Signage and interpretive tracks and permanent fencing will be put in place as required. Educational pamphlets will be prepared for distribution to property owners.

8.1.4 Stage 4 Maintenance (> 3 years)

Stage 4 will be undertaken over the long term and will involve continued weed monitoring and maintenance weeding, and monitoring of the regeneration areas and bushfire hazard management. Specifically, long term maintenance activities will involve (for a period of up to 20 years from the date of development consent):

- annual weed survey to identify weed species present, location and densities;
- development of an annual weed maintenance program following the weed survey , specifying weed control works over a 12 month period, taking into consideration weeds present and weed control timing requirements based on seasonality factors;
- annual survey of regeneration areas to determine health of vegetation and identify need for replacement or additional planting. The survey is to additionally assess the regeneration of closed tracks and assess vegetation

within asset protection zones and identify the need for maintenance activities to minimise bushfire risk within the APZ's;

- annual waste survey and subsequent development of a waste removal program for the following 12 month period.

The community will be encouraged and assisted in establishing a local environmental group to undertake ongoing maintenance.

9 MONITORING PROGRAM

9.1 MONITORING

Regular monitoring of the effectiveness of management measures and regeneration, including pre construction, construction and post construction activities will be undertaken.

9.1.1 Monitoring during Construction

A monitoring program will be implemented during the construction phase of the development and will involve regular audits of the construction activities against the requirements of this CLEMP. All areas of disturbance will be subject to inspection during the audits to ensure appropriate measures are in place to minimise environmental impact. The monitoring of construction activities will include (but is not limited to):

- ensuring the appropriate placement of stockpiles, machinery storage and machinery movement;
- assessing the effectiveness of weed control and revegetation / landscaping works;
- ensuring construction hours of operation are limited to daylight hours;
- ensuring the management of displaced fauna is as per the requirements of this management plan;
- ensuring that dead wood and dead mature trees have been relocated to conservation areas and reserves consistent with the Bush Fire Hazard Assessment Report (ERM, 2007);
- ensuring vegetation cleared and not relocated is wood chipped / mulched for use in site landscaping;
- checking the temporary fence erected to delineate between the construction and conservation areas is appropriately sited and maintained; and
- checking erosion and sediment control measures are installed and being regularly maintained.

An Audit Checklist for use during construction is provided in *Annex F*.

9.1.2 Post Construction Monitoring

Monitoring post construction will include both short term and long term monitoring and is the responsibility of the Community Association. It is noted that the DECC are currently developing standardised monitoring protocols for the monitoring of weeds, however this has not been released to date. Accordingly, the monitoring proposed within the CLEMP will be modified to be consistent with the DECC monitoring program following its release.

Short Term Monitoring

Short term monitoring will be undertaken as a follow up after weed control, revegetation and landscaping works, to ensure that the works have been successful and identify where follow up works may be required, for example re-treatment of weeds or watering of plants.

Follow up inspections of revegetation and landscaping works should occur within one week of the works being undertaken to maximise survival rates of the plants.

Follow up inspections of weed control works is to be undertaken no greater than six months after treatment or prior to seed production. During the inspection, the treated and untreated replicate plots would be resurveyed noting the following:

- species presence and abundance;
- age structure;
- photographic record;
- success of treatment (eg number of dead plants, regrowth, seedling recruitment);
- any adverse impacts on non-target species; and
- response of other weed species.

All monitoring data would be logged and maintained for annual reporting. Data provided at six month monitoring would provide the basis for planning of treatment for the next year.

Once the densities of weeds have been initially reduced they need to be regularly monitored to suppress any outbreak or spread. This will prevent weeds from re-establishing in the site and to maximise the effect of the initial control works. This type of monitoring is essential for grassy and herbaceous weeds, which could remain hidden amongst non-target vegetation during the initial control activities. A short term monitoring checklist is included in *Annex F*. Additional inspections of revegetation and landscaping works should also be undertaken during weed control monitoring to assess the effectiveness of the works and identify required following up actions.

Monitoring would also provide data on condition and regeneration of native species. Natural regeneration of native plants will be encouraged in preference to active revegetation. It is possible that the seed bank will be too severely depleted in some areas and the need for supplementary planting will be assessed after 12 months.

The receipt of feedback forms by the Community Association pertaining to feral animal sightings will be ongoing and will be used by the Community Association to make decisions on the need to implement control works.

Long Term Monitoring

Annual inspections will be undertaken throughout the conservation and reserve areas to assess (but not limited to):

- the success, or otherwise of weed control works, including the identification of weed infestations throughout the areas and changes to weed densities (this weed survey will inform weed control works over the following 12 month period);
- the success, or otherwise of revegetation and regeneration, including changes in species composition, extent of native plant regeneration and general health of native vegetation and plant communities. This may involve the establishment of photo points and quantitative measures such as plot or transect based surveys to measure density and cover. This approach could also be used for monitoring weed infestations;
- evidence of waste disposal within the areas and recommendations for the removal of waste;
- evidence of pest activity – to add to the ongoing community sightings received via a feedback form; and
- evidence of illegal public access (for example vehicles accessing the conservation areas).

The objective of the long-term monitoring program is to provide sufficient feedback on the success of the overall weed control strategies including suppression and prevention of weed spread and establishment. It will provide information about the successful regeneration of native vegetation communities and success of revegetation programs. It will also provide the Community Association with information pertaining to waste and pest animal issues throughout the site, with recommendations regarding management actions to address identified issues.

The annual long term monitoring inspections will be reported to the Community Association via an annual report incorporating recommendations (including timeframes). The Community Association will be responsible for ensuring annual monitoring is undertaken, and the recommendations are implemented.

Each annual report will identify whether recommendations in previous annual reports have been implemented and their effectiveness.

10 IMPLEMENTATION RESPONSIBILITIES

10.1 IMPLEMENTATION OF RESPONSIBILITIES

The developer, Aspen Group, will be responsible for implementing all management strategies outlined in this document during the construction and establishment stages of the development. Aspen will be responsible for the implementation of environmental auditing and monitoring during construction activities and implementing the short term monitoring program during the site establishment works. Where appropriate these responsibilities will be delegated to environmental consultants, bush regenerators and building and landscape contractors. The strategies outlined in this document will be implemented in consultation with Port Stephens Council, the Department of Environment and Climate Change (DECC), the Fern Bay Seaside Village Community Association and other relevant parties.

The Community Association, established under Community Title will be responsible for the management of the conservation areas and reserves following the establishment of these areas. The Community Association will also be responsible for the long term monitoring of the site in accordance with these procedures.

10.2 INDUCTION PROGRAM

All contractors will be required to attend an induction program prior to commencing works on site. The induction will incorporate health and safety matters, as well as environmental management requirements for construction activities. The induction program will involve the presentation of environmental requirements, as well as the provision of information flyers and fact sheets to assist the construction workforce in the field to implement appropriate management measures. The induction program will be supported by site signage advising the workforce of key environmental requirements, including incident response and reporting requirements as appropriate.

Specifically, the induction program will incorporate the following environmental management requirements:

- approved construction site ingress and egress;
- operational requirements and activities, including:
  - areas approved for clearing and procedures for the protection of conservation areas;
  - clearing procedures;
  - management of fauna during clearing;

- procedures for managing Aboriginal items and relics that may be encountered during construction;
- incident response and reporting procedures;

- information regarding ecological and Aboriginal values of the site; and
- waste management requirements;

10.3 CONTACTS

10.3.1 List of Contacts

The following contacts are likely to provide additional direction and advice in relation to issues of vegetation management on the site:

Aspen Group
Level 5, 33 York Street, Sydney NSW 2000
Ph: 02 8916 6700

Australia Association of Bush Regenerators
c/- Total Environment Centre
Level 2 362 Kent Street Sydney NSW 2000
Ph: 0407 002 921
Email: aabt@zip.com.au

Graham Prichard
Senior Weeds/ Pest Management Officer
Port Stephens Council
PO Box 42 Raymond Terrace, NSW 2324.
Ph: 02 4980 0392
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Greening Australia NSW
142 Addison Road
Marrickville NSW 2204
Ph: 02 9560 9144
Fax: 02 9550 0576

Gordon Patrick
Trees in Newcastle
Parry Street Newcastle 2300
Ph: 02 969 1500
Email: tin@bravo.net.au

Mel Schroder
Pest Species Officer
Department of Environment and Conservation
Ph: 02 4984 8200

Bruce Peterson
Environmental Services Manager
Port Stephens Council
PO Box 42 Raymond Terrace, NSW 2324.
Ph: 02 4980 0255

10.3.2 Community Programs

The following programs are likely to be relevant to vegetation management on site and provide additional information for management of the site. The community will be encouraged to become involved in voluntary groups such as Landcare, Bushcare and Coastcare in order to promote community involvement and an awareness of environmental issues.

Natural Heritage Trust

There are three Natural Heritage Trust programs relevant to the site including Bushcare, Rivercare and Coastcare programs. Bushcare invests in activities that contribute to conserving and restoring habitat for our unique native flora and fauna which underpin the health of our landscapes. The Rivercare program invests in activities that contribute to improved water quality and environmental conditions in our river systems and wetlands. The Coastcare program invests in activities that contribute to protecting our coastal catchments, ecosystems and the marine environment (EA 2003a in DEC, 2004).

Environmental Trust

The Environmental Trust, delivered through the DECC provides an opportunity for community groups and members to seek funding for rehabilitation and restoration projects.

City and Country Environmental Restoration Program

This funding program delivered by the DECC provides funds under different categories, including an urban sustainability program that seeks to reduce the ecological footprint of urban areas, focusing on urban bushland to provide habitat for rare and endangered flora and fauna.

10.4 REVIEW OF CLEMP

This CLEMP will be reviewed regularly by suitably qualified persons engaged by the Community Association. The reviews will be undertaken in consultation with Port Stephens Council and the Department of Environment and Climate Change to determine the efficacy of the original plan and schedule.

The reviews are proposed to be undertaken annually for the first three years, after which an assessment of the frequency of the review will be undertaken and a revised review period agreed. The review will:

- assess the effectiveness of the CLEMP in managing the community lands on site, including the proposed works schedule and modify as appropriate;
- assess the ongoing need and frequency of the implementation of management measures identified in the CLEMP if previous control works have sufficiently managed the issues;
- update targets and monitoring requirements based on DECC developed statewide weed monitoring protocols and targets; and
- identify and include additional issues relating to the community lands that may need to be incorporated into the CLEMP.

The reviewed report will be submitted to the Community Association and will be available to Port Stephens Council, DECC and residents of Fern Bay Seaside Village.

The Community Association will be responsible for ensuring that the CLEMP reviews are undertaken in accordance with the frequency identified in the plan. In this way the document will become flexible, changing in response to the changing needs of the reserves and conservations areas as rehabilitation and development progresses.

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Annex A

Nationally Significant Weed Species

Table:A1 WEEDS OF NATIONAL SIGNIFICANCE

Scientific Name	**Common Name**
Alternanthera philoxeroides	alligator weed
Tamarix aphylla	athel pine
Chrysanthemoides monilifera	bitou bush / boneseed
Rubus fruticosus agg.	blackberry
Asparagus asparagoides	bridal creeper
Cabomba caroliniana	cabomba
Nassella neesiana	Chilean needle grass
Ulex europaeus	gorse
Hymenachne amplexicaulis	hymenachne
Lantana camara	lantana
Prosopis spp.	mesquite
Mimosa pigra	mimosa
Parkinsonia aculeata	Parkinsonia
Parthenium hysterophorus	parthenium weed
Annona glabra	pond apple
Acacia nilotica spp. indica	prickly acacia
Cryptostegia grandiflora	rubber vine
Salvinia molesta	salvinia
Nassella trichotoma	serrated tussock
Salix spp. except S. babylonica, S. X calodendron and S. X reichardtiji	Willows except weeping willows, pussy willow and sterile pussy willow

Annex B

Noxious Weeds in Port Stephens LGA

Class 2 Regionally Prohibited Plants
Control Requirements- The plant must be eradicated from the land and the land must be kept free of the plant.

Common name	Scientific name
Hygrophila	*Hygrophila costata*

Class 3 Regionally Controlled Plants
Control Requirements-The plant must be fully and continuously suppressed and destroyed.

Common name	Scientific name
Alligator Weed	*Alternanthera philoxeroides*
Groundsel Bush	*Baccharis halimifolia*
Mother-of-millions	*Bryophyllum* species and hybrids
Green Cestrum	*Cestrum parqui*
Salvinia	*Salvinia molesta*
Giant Parramatta Grass	*Sporobolus fertilis*


Alligator Weed

Weedbusters
Local Heroes - Global Champions

Class 4 Locally Controlled Plants
Control Requirements-The growth and spread of the plant must be controlled according to the measures specified in a management plan published by the local control authority.
*The plant may not be sold, propagated or knowingly distributed.

Common name	Scientific name
Crofton Weed	*Ageratina adenophora*
Mistflower	*Ageratina riparia*
Spiny Burrgrass	*Cenchrus incertus**
Spiny Burrgrass	*Cenchrus longispinus**
Boneseed	*Chrysanthemoides monilifera* subspecies *monilifera*
Bitou Bush	*Chrysanthemoides monilifera* subspecies *rotunda*
Pampas Grass	*Cortaderia* species
Prickly Pear	*Cylindropuntia* species*
Paterson's Curse,Vipers Bugloss, Italian Bugloss	*Echium* species
Water Hyacinth	*Eichhornia crassipes*
Spiny emex	*Emex australis*
Harrisia Cactus	*Harrisia* species*
St. John's Wort	*Hypericum perforatum*
Long-leaf Willow Primrose	*Ludwigia longifolia*
African Boxthorn	*Lycium ferocissimum*
Cape Tulip	*Moraea* species
Chilean Needle Grass	*Nassella neesiana**
Serrated tussock	*Nassella trichotoma**
Prickly pear	*Opuntia* species except *O. ficus-indica**
Blackberry	*Rubus fruticosus* aggregate species*
Johnson Grass	*Sorghum halepense*
Columbus Grass	*Sorghum x almum*
Rhus Tree	*Toxicodendron succedanea*
Bathurst & Noogoora Burrs	*Xanthium* species

Local control plans for class 4 noxious plants can be viewed on the council website at http://portstephens.local-e.nsw.gov.au/

Salvinia

Mother of Millions

Green Cestrum

Port Stephens COUNCIL
... a community partnership

Noxious Weeds List


Bitou Bush

This brochure contains a list of plants declared noxious for the Port Stephens Council area. There are five classes of noxious weeds with differing control requirements. Classes 1, 2 and 5 are notifiable weeds and new outbreaks must be reported to council.
Occupiers of land have obligations to control noxious weeds in accordance with the control requirements for the class the weed is in.
To report known or suspected noxious weeds and for information on controlling noxious weeds contact 49800392.


Chinese Violet


Lantana

Class 1 State Prohibited Plants
Control Requirements- The plant must be eradicated from the land and the land must be kept free of the plant.

Common name	**Scientific name**
Karoo Thorn	*Acacia karroo*
Prickly Acacia	*Acacia nilotica*
Pond Apple	*Annona glabra*
Chinese Violet	*Asystasia gangetica* subspecies *micrantha*
Kochia	*Bassia scoparia*
Spotted Knapweed	*Centaurea maculosa*
Black Knapweed	*Centaurea nigra*
Siam Weed	*Chromolaena odorata*
Rubbervine	*Cryptostegia grandiflora*
Anchored Water Hyacinth	*Eichhornia azurea*
Horsetail	*Equisetum* species
Senegal Tea Plant	*Gymnocoronis spilanthoides*
Hawkweed	*Hieracium species*
East Indian Hygrophila	*Hygrophila polysperma*
Hymenachne	*Hymenachne amplexicaulis*
Lagarosiphon	*Lagarosiphon major*
Yellow Burrhead	*Limnocharis flava*
Miconia	*Miconia* species
Mimosa	*Mimosa pigra*
Eurasian Water Milfoil	*Myriophyllum spicatum*
Mexican Feather Grass	*Nassella tenuissima*
Broomrapes	*Orobanche species except the native O. cernua variety australiana and O. minor*
Parthenium Weed	*Parthenium hysterophorus*
Water Lettuce	*Pistia stratiotes*
Water Soldier	*Stratiotes aloides*
Witchweed	*Striga species except native species and Striga parviflora*
Water Caltrop	*Trapa* species


Senegal Tea Plant


Horsetail


Water Lettuce

Class 5 Restricted Plants
Control Requirements- The requirements in the Noxious Weeds Act 1993 for a notifiable plant must be complied with (the plants must not be purchased, sold or moved without a written permit).

Common name	**Scientific name**
Espartillo	*Achnatherum brachychaetum*
Dodder	All *Cuscuta* species except the native species *C. australis, C. tasmanica* and *C. victoriana*
Oxalis	All Oxalis species and varieties except the native species *O. chnoodes, O. exilis, O. perennans, O. radicosa, O. rubens*, and *O. thompsoniae*
Onion Grass	All *Romulea* species and varieties except *R. rosea* var. *australis*
Annual Ragweed	*Ambrosia artemisiifolia*
Burr Ragweed	*Ambrosia confertiflor*a
Mexican Poppy	*Argemone mexicana*
Bridal Creeper	*Asparagus asparagoide*s
Sand Oat	*Avena strigosa*
Smooth-stemmed Turnip	*Brassica barrelieri* subspecies *oxyrrhina*
Cabomba	*Cabomba caroliniana*
Glaucous Star Thistle	*Carthamus glaucus*
Gallon's Curse	*Cenchrus biflorus*
Fine-bristled burr grass	*Cenchrus brownii*
Mossman River Grass	*Cenchrus echinatus*
Artichoke Thistle	*Cynara cardunculus*
Yellow Nutgrass	*Cyperus esculentus*
Leafy Elodea	*Egeria densa*
Clockweed	*Gaura lindheimeri*
Clockweed	*Gaura parviflora*
Texas Blueweed	*Helianthus ciliari*s
Lantana	*Lantana* species
Long-leaf Willow Primrose	*Ludwigia longifolia*
Red Rice	*Oryza rufipogon*
African Feather Grass	*Pennisetum macrourum*
Fountain Grass	*Pennisetum setaceum*
Soldier Thistle	*Picnomon acarna*
Arrowhead	*Sagittaria montevidensis*
Sagittaria	*Sagittaria platyphylla*
Willows	*Salix* species except *S. babylonica, S.* x *reichardtii, S.* x *calodendron*
Golden Thistle	*Scolymus hispanicu*s
African Turnip Weed	*Sisymbrium runcinatum*
African Turnip Weed	*Sisymbrium thellungii*
Corn Sowthistle	*Sonchus arvensis*
Cayenne Snakeweed	*Stachytarpheta cayennensis*
Athel Tree/Athel Pine	*Tamarix aphylla*


Long Leaf Willow-primrose

Notifiable plants in other parts of NSW. A person must not sell or purchase the plant, or any animal or thing which has on it or contains such plant material.

Common name	**Scientific name**
Mesquite	*Prosopis* species
Parkinsonia	*Parkinsonia aculeata*
Blue Hound's Tongue	*Cynoglossum creticum*
Cape Broom	*Genista monspessulana*
Gorse	*Ulex europaeus*

Annex C

Flora Species List (Gunninah Environmental Consultants 1997)

PROPOSED RESIDENTIAL DEVELOPMENT

NELSON BAY ROAD FERN BAY

APPENDIX 1

FLORA SPECIES RECORDED DURING PREVIOUS INVESTIGATIONS on the SUBJECT SITE and in the GENERAL VICINITY

Codes for Appendix 1

1	Species recorded throughout the study area
2	Species recorded on the Howship Holdings site
A	Clements *et al* 1992
B	Corkery & Co Pty Ltd 1988
C	Fanning & Clark 1993
D	NP&WS Wildlife Atlas within 10km of the study area (taken from the Newcastle 1:100 000 map sheet)
*	introduced species
#	Threatened species as listed in the *NSW Threatened Species Conservation Act 1995.*

Gunninah Environmental Consultants
PO Box 513 Crows Nest NSW 2065
ph: 02 - 9906 5436 fax: 02 - 9906 7770 email: gunninah@s054.aone.net.au

APPENDIX 1 Flora species recorded on the Howship Holdings site at Fern Bay and in the vicinity.

SPECIES NAME	1	2
FILICOPSIDA		
Blechnaceae		
Blechnum indicum	A,B,C	●
Doodia aspera	B	●
Dennstaedtiaceae		
Hypolepis glandulifera	A	●
Pteridium esculentum	A,B,C	●
Polypodiaceae		
Pyrrosia confluens	A	●
Sinopteridaceae		
Cheilanthes sieberi	A	
Pellaea falcata	A	●
Thelypteridaceae		
Cyclosorus interruptus	A	●
MAGNOLIOPSIDA - DICOTYLEDONS		
Acanthaceae		
**Justica* sp	A	●
Aizoaceae		
Carpobrotus glaucescens	A,B,C	●
**Galenia pubescens*	A	●
Anacardiaceae		
Euroschinus falcata	A,B	●
Apiaceae		
Actinotus helianthi	A,B,C	●
Centella cordifolia	A	●
**Eryngium maritimum*	A	
Hydrocotyle algida	A	●
**Hydrocotyle bonariensis*	A	●
Platysace ericoides	A,B,C	●
Platysace lanceolata	A,C	●
Apocynaceae		
Parsonsia straminea	A,B	●
Asclepiadaceae		
**Gomphocarpus fruticosus*	A	●
Marsdenia sp	B	●
Asteraceae		
**Acanthospermum australe*	A	●
**Ambrosia tenuifolia*	A	●
**Aster subulatus*	A	●
Cassinia longifolia	A	
Chrysanthemoides monilifera	A,B,C	●
**Cirsium vulgare*	A	●
Conyza albida	A,C	●
**Conyza canadensis*	A	●
**Conyza parva*	A	●
Enydra fluctuans	A	●
**Erechtites valerianifolia*	A	●
**Gnaphalium americanum*	A	
Helichrysum diosmifolium	A	●
**Heterotheca grandiflora*	A	
Senecio bipinnatisectus	A	
**Senecio crassiflorus*	A	
Senecio hispidulus	A,C	●
Senecio sp E *aspargifolius*	A	●
Senecio lautus	A,B,C	●

APPENDIX 1 contd Flora species recorded on the site at Fern Bay and in the vicinity.

SPECIES NAME	1	2
Asteraceae contd		
**Senecio madagascariensis*	A	●
**Sigesbekia orientalis*	A	●
Solenogyne bellioides	A	●
Vernonia cinerea	A	●
Xanthium occidentale	A	●
Bigoniaceae		
Pandorea pandorana	A,B	●
Brassicaceae		
**Cakile edentula*	A	
Cactaceae		
Opuntia stricta	C	
Campanulaceae		
Wahlenbergia stricta	A,B,C	●
Casuarinaceae		
Allocasuarina littoralis	A,B,C	●
Casuarina glauca	A,B	●
Chenopodiaceae		
Einadia hastata	A,C	
Convolvulaceae		
Calystegia marginata	A	●
Cuscula australis	A	●
Ipomoea sp	C	
Cucurbitaceae		
**Citrullus lanatus*	A	●
Cunoniaceae		
Ceratopetalum gummiferum	A	
Dilleniaceae		
Hibbertia acicularis	A	●
Hibbertia fasciculata	A,C	●
Hibbertia linearis	A,B,C	●
Hibbertia scandens	A,B	●
Droseraceae		
Drosera sp	B	●
Elaeocarpaceae		
Elaeocarpus obovatus	A	
Epacridaceae		
Brachyloma daphnoides	A,B,C	●
Leucopogon ericoides	A,B,C	●
Leucopogon parviflorus	A	●
Monotoca elliptica	A,B,C	●
Monotoca scoparia	A,B,C	●
Euphorbiaceae		
Amperea xiphoclada	A,B,C	●
Breynia oblongifolia	A,B,C	●
Glochidion ferdinandi	A,B	●
Omalanthus populifolius	A,B	●
Poranthera microphylla	A	●
Ricinocarpos pinifolius	A,B,C	●
Ricinus communis	C	
Fabaceae-Faboideae		
Aotus ericoides	A,B,C	●
Bossiaea ensata	A,B,C	●
Bossiaea heterophylla	A,B,C	●
Bossiaea rhombifolia	A,B,C	●

APPENDIX 1 contd Flora species recorded on the site at Fern Bay and in the vicinity.

SPECIES NAME	1	2
Fabaceae-Faboideae contd		
Desmodium sp	B	●
Desmodium brachypodum	A	●
Desmodium rhytipophyllum	A	●
Desmodium varians	A	●
Dillwynia retorta	A,B,C	●
Glycine clandestina	A,B,C	●
Gompholobium latifolium	A,B,C	●
Hardenbergia violacea	A,B,C	●
Indigophora australis	A,B,C	●
Kennedia rubicunda	A,B,C	●
Viminaria juncea	A	●
Fabaceae-Mimosoideae		
Acacia sp	B	●
Acacia irrorata	A	●
Acacia longifolia	A,B,C	●
Acacia myrtifolia	B	●
Acacia sophorae	A,C	
Acacia suaveolens	A,B,C	●
Acacia ulicifolia	A,B,C	●
Goodeniaceae		
Dampiera stricta	A,B,C	●
Goodenia ovata	B	●
Haloragaceae		
Gonocarpus chinensis	A	●
Gonocarpus micranthus	A,C	●
Gonocarpus teucrioides	A,B,C	●
Lamiaceae		
Lycopus australis	A	●
Lauraceae		
Cassytha sp	B	●
Cassytha glabella	A,C	●
Cassytha pubescens	A,C	●
Endiandra sieberi	A,B,C	●
Lobeliaceae		
Lobelia alata	A	●
Pratia purpurascens	A	●
Loranthaceae		
Dendrophthoe vitellina	A	
Lythraceae		
Lythrum salicaria	A	●
Malvaceae		
Hibiscus trionum	A	●
Sida rhombifolia	A	
Meliaceae		
Dysoxylum fraserianum	A	
Menispermaceae		
Sarcopetalum harveyanum	A,B	●
Menyanthaceae		
Villarsia exaltata	A	●
Moraceae		
Ficus henneana	B	●
Maclura cochinchinensis	A,B	●
Myrsinaceae		
Rapanea howittiana	A	●
Rapanea variabilis	A,B	●

APPENDIX 1 contd Flora species recorded on the site at Fern Bay and in the vicinity.

SPECIES NAME	1	2
Myrtaceae		
Acmena smithii	A,B	●
Angophora costata	A,B,C	●
Baeckea linearis	C	
Callistemon salignus	A,B	●
Calytrix tetragona	A	●
Eucalyptus acmenoides	A	
Eucalyptus gummifera	A,C	
Eucalyptus pilularis	A,B,C	●
Eucalyptus robusta	A,B,C	●
Leptospermum attenuatum	B,C	●
Leptospermum flavescens	B,C	●
Leptospermum juniperinum	A,C	●
Leptospermum laevigatum	A,B,C	●
Leptospermum polygalifolium	A	●
Leptospermum trinervium	A	●
Melaleuca linariifolia	A	●
Melaleuca nodosa	A,B,C	●
Melaleuca quinquenervia	A,B	●
Melaleuca sieberi	A	
Melaleuca styphelioides	A,B	●
Oleaceae		
Notelaea longifolia	A,B,C	●
Olax stricta	A	●
Onagraceae		
**Oenothera drummondii*	A	
**Oenothera mollissima*	A	
Oxalidaceae		
Oxalis sp aff *corniculata*	A,C	
Passifloraceae		
Passiflora herbertiana	A	●
Pittosporaceae		
Billardiera scandens	A,B	●
Citriobatus pauciflorus	B	●
Pittosporum revolutum	A,B	●
Polygalaceae		
Comesperma ericinum	A,C	●
Polygonaceae		
Muehlenbeckia gracillima	A	●
Persicaria decipiens	A	●
Persicaria strigosa	A	●
Proteaceae		
Banksia integrifolia	A,C	
Banksia serrata	A,B,C	●
Conospermum taxifolium	A,B,C	●
Persoonia lanceolata	B	●
Persoonia levis	A,C	●
Ranunculaceae		
Clemantis aristata	A,B	●
Rhamnaceae		
Alphitonia excelsa	A,B	●
Pomaderris ferruginea	A	●
Rosaceae		
**Rubus discolor*	A	●
Rubus parvifolius	A	
Rubiaceae		
Opercularia aspera	A	●
Pomax umbellata	A,B,C	●

APPENDIX 1 contd Flora species recorded on the site at Fern Bay and in the vicinity.

SPECIES NAME	1	2
Rutaceae		
Acronychia oblongifolia	A	●
Zieria smithii	A	●
Santalaceae		
Exocarpos cupressiformis	A,C	●
Sapindaceae		
Cupaniopsis anacardioides	A	
Dodonaea triquetra	C	
Solanaceae		
Duboisia myoporoides	A,B	●
Solanum americanum	A	●
Thymelaeaceae		
Wilkstroemia indica	A,B	●
Verbenaceae		
Clerodendrum tomentosum	A,B	●
**Lantana camara*	A,B,C	●
Violaceae		
Viola hederaceae	A	●
Vitaceae		
Cayratia clematidea	A	●
Cissus antarctica	A,B	●
Cissus hypoglauca	B	●
MAGNOLIOPSIDA - MONOCOTYLEDONS		
Amaryllidaceae		
Crinum pedunculatum	A,B	●
Anthericaceae		
Tricoryne elatior	A,B	●
Araceae		
Alocasia macrorrhizos	A,B	●
Arecaceae		
Livistona australis	A,B	●
Commelinaceae		
Commelina cyanea	A	●
Cyperaceae		
Baumea articulata	A	●
Baumea rubiginosa	A	●
Baumea juncea	A	●
Carex appressa	A	●
Carex neurochlamys	A	●
Cladium procerum	A	●
**Cyperus dubius*	A	●
**Cyperus flavus*	A	●
Gahnia clarkei	A,B,C	●
Gahnia sieberiana	A	●
Isolepis nodosa	A	
Lepidosperma laterale	A,B	●
Lepidosperma urophorum	A	
Schoenus ericetorum	A,C	●
Iridaceae		
**Gladiolus gueinzii*	A	
Juncaceae		
Juncus pallidus	A	
Juncus polyanthemus	A	
Juncus prismatocarpus	A	●

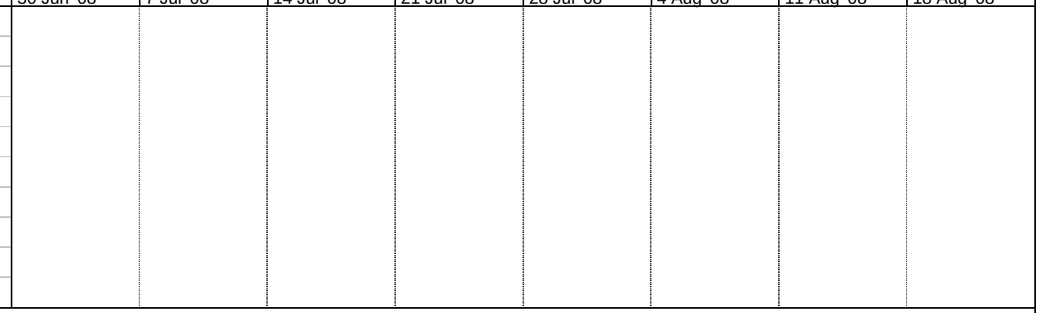
APPENDIX 1 contd Flora species recorded on the site at Fern Bay and in the vicinity.

SPECIES NAME	1	2
Juncaginaceae		
Triglochin procera	A	●
Lomandraceae		
Lomandra longifolia	A,B,C	●
Orchidaceae		
Acianthus sp.	A,B,C	●
Caladenia alba	B,C	●
#*Diurus* sp 5	D	
Pterostylis acuminata	A	●
Pterostylis longifolia	B	●
Pterostylis nutans	B	●
Philesiaceae		
Eustrephus latifolius	A	●
Geitonoplesium cymesum	A	●
Phormiaceae		
Dianella caerulea	A,B,C	●
Poaceae		
Andropogon virginicus	A	●
Axonopus affinis	A	●
**Chloris virgata*	A	
Cymbopogon refractus	A	●
Cynodon dactylon	A	●
Danthonia tenuior	A	
Dichelachne micrantha	A	●
Dichelachne crinita	A	
Digitaria parviflora	A	●
Echinopogon sp	B	●
**Ehrharta erecta*	A	
Entolasia marginata	A	●
Entolasia stricta	A,C	●
Eragrostis brownii	A,C	●
**Eragrostis curvula*	A	
Hemarthria uncinata	A	●
Imperata cylindrica	A,B,C	●
Isachne globosa	A	●
Oplismenus aemulus	A	●
Oplismenus imbecillis	A,B	●
Panicum bisulcatum	A	●
**Panicum maximum*	A	●
Paniculum simile	A	
Paspalidium distans	A	●
**Paspalum orbiculare*	A	●
Phragmites australis	A,B	●
**Setaria viridis*	A	●
Spinifex sericeus	A	
Sporobolus elongatus	A	●
**Stenotaphrum secundatum*	A	●
Themeda australis	A,B,C	●
Restionaceae		
Leptocarpus tenax	B	●
Restio pallens	A,C	●
Restio tetraphyllus	A,B,C	●
Smilacaceae		
Smilax australis	A,B	●
Smilax glyciphylla	A,B	●
Tremandraceae		
#*Tetratheca juncea*	D	
Typhaceae		
Typha orientalis	A	●
Zannichelliaceae		
#*Zannichellia palustris*	D	

Annex D

Indicative Work Program

ID	Task Name	Duration	Start	Finish	Predecessors	Resource Names
1	**Community Lands Environmental Management Plan**	**33 days**	**Mon 2/03/09**	**Wed 15/04/09**		
2	Project Start	0 days	Mon 2/03/09	Mon 2/03/09		
3	**Pre Construction Management Measures for each Stage**	**33 days**	**Mon 2/03/09**	**Wed 15/04/09**	**2**	
4	Boundary identification and demarcation	3 days	Mon 2/03/09	Wed 4/03/09		
5	Identification of habitat trees	5 days	Thu 5/03/09	Wed 11/03/09	4	
6	Pre clearance surveys of hollow bearing trees ahead of clearing	5 days	Thu 12/03/09	Wed 18/03/09	5	
7	Seed collection	5 days	Thu 12/03/09	Wed 18/03/09	5	
8	Contractor guidleline development	5 days	Thu 12/03/09	Wed 18/03/09	5	
9	Weed removal	10 days	Thu 19/03/09	Wed 1/04/09	8	
10	Regeneration works	20 days	Thu 19/03/09	Wed 15/04/09	8	



Project: Pre Construction Measures to apply to each development stage
Date: Wed 17/12/08

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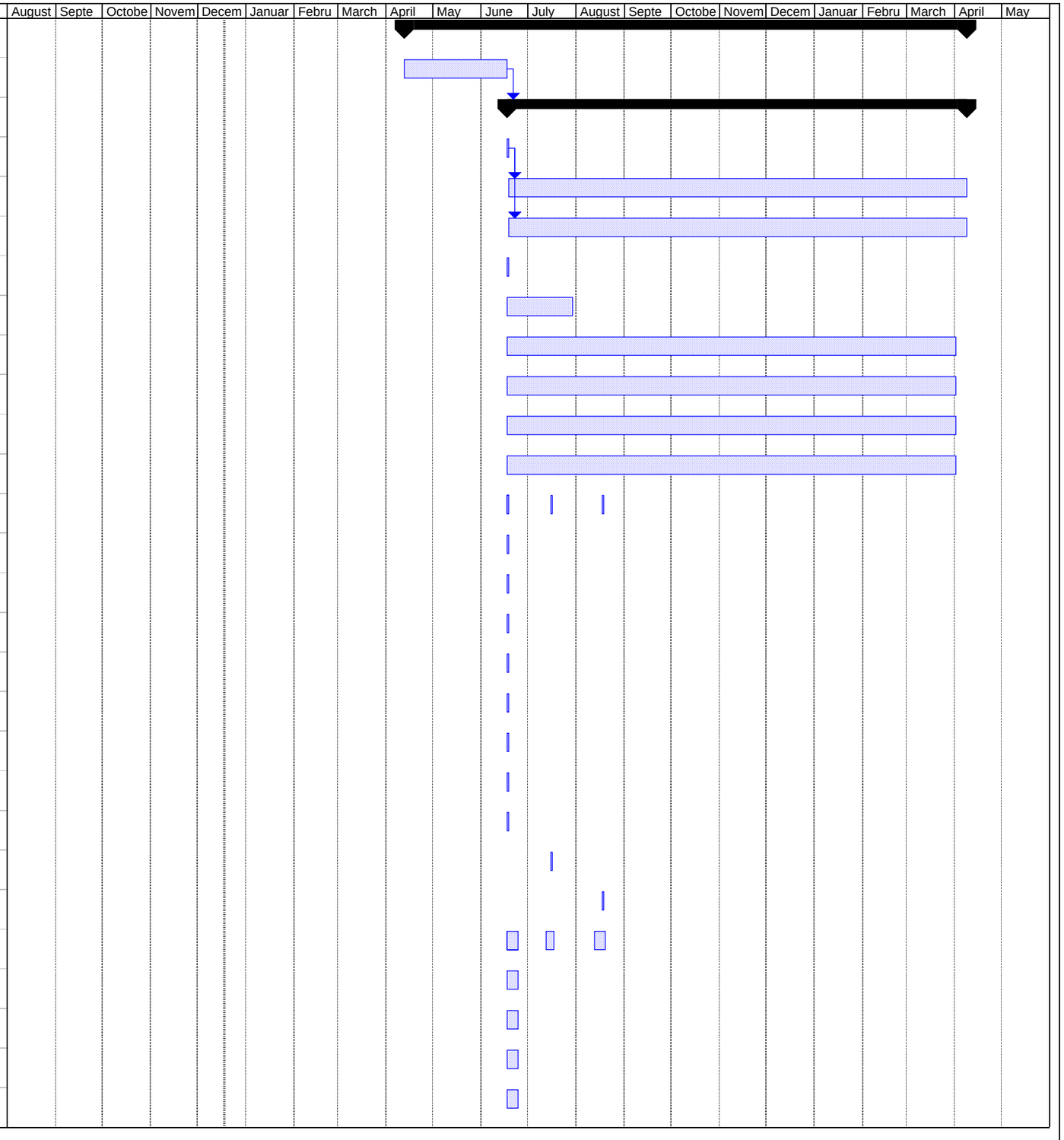
ID	Task Name	Duration	Start	Finish	Predecessors
1	**Community Lands Environmental Management Plan**	**259 days**	**Mon 13/04/09**	**Thu 8/04/10**	
2	Construction start	48 days	Mon 13/04/09	Wed 17/06/09	
3	**Construction Measures for each stage**	**211 days**	**Thu 18/06/09**	**Thu 8/04/10**	**2**
4	Environmental inductions	1 day	Thu 18/06/09	Thu 18/06/09	
5	Temporary fencing	210 days	Fri 19/06/09	Thu 8/04/10	4
6	Erosion and sediment control measures	210 days	Fri 19/06/09	Thu 8/04/10	4
7	Installation of wildlife signs	1 day	Thu 18/06/09	Thu 18/06/09	
8	Tree clearing	30 days	Thu 18/06/09	Wed 29/07/09	
9	Release of wildlife from areas of clearing to conserva	206 days	Thu 18/06/09	Thu 1/04/10	
10	Stockpile management	206 days	Thu 18/06/09	Thu 1/04/10	
11	Re-establishment of vegetative cover	206 days	Thu 18/06/09	Thu 1/04/10	
12	Establishment of open space / reserve - vegetation p	206 days	Thu 18/06/09	Thu 1/04/10	
13	**Waste Removal - as required**	**44 days**	**Thu 18/06/09**	**Tue 18/08/09**	
14	Waste Removal - Month 1	1 day	Thu 18/06/09	Thu 18/06/09	
15	Waste Removal 2	1 day	Thu 18/06/09	Thu 18/06/09	
16	Waste Removal 3	1 day	Thu 18/06/09	Thu 18/06/09	
17	Waste Removal 4	1 day	Thu 18/06/09	Thu 18/06/09	
18	Waste Removal 5	1 day	Thu 18/06/09	Thu 18/06/09	
19	Waste Removal 6	1 day	Thu 18/06/09	Thu 18/06/09	
20	Waste Removal 7	1 day	Thu 18/06/09	Thu 18/06/09	
21	Waste Removal 8	1 day	Thu 18/06/09	Thu 18/06/09	
22	Waste Removal 9	1 day	Thu 16/07/09	Thu 16/07/09	
23	Waste Removal 10	1 day	Tue 18/08/09	Tue 18/08/09	
24	**Weed Management - as required**	**45 days**	**Thu 18/06/09**	**Wed 19/08/09**	
25	Weed Management 1	5 days	Thu 18/06/09	Wed 24/06/09	
26	Weed Management 2	5 days	Thu 18/06/09	Wed 24/06/09	
27	Weed Management 3	5 days	Thu 18/06/09	Wed 24/06/09	
28	Weed Management 4	5 days	Thu 18/06/09	Wed 24/06/09	



Project: Construction Measures.mpp
Date: Thu 18/12/08

Task
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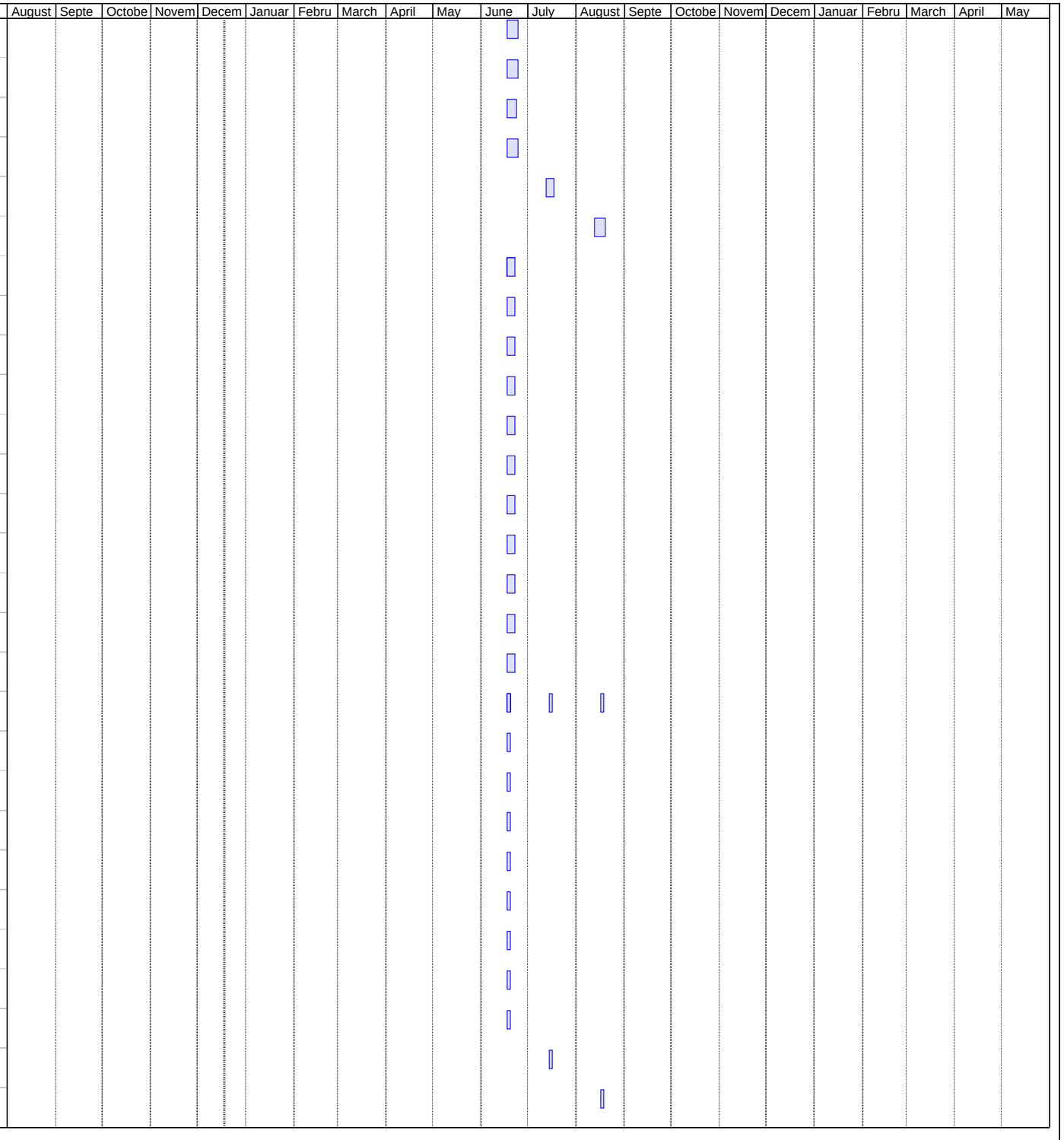
ID	Task Name	Duration	Start	Finish	Predecessors
29	Weed Management 5	5 days	Thu 18/06/09	Wed 24/06/09	
30	Weed Management 6	5 days	Thu 18/06/09	Wed 24/06/09	
31	Weed Management 7	4 days	Thu 18/06/09	Tue 23/06/09	
32	Weed Management 8	5 days	Thu 18/06/09	Wed 24/06/09	
33	Weed Management 9	5 days	Mon 13/07/09	Fri 17/07/09	
34	Weed Management 10	5 days	Thu 13/08/09	Wed 19/08/09	
35	**Regeneration - as required**	**3 days**	**Thu 18/06/09**	**Mon 22/06/09**	
36	Regeneration Month 1	3 days	Thu 18/06/09	Mon 22/06/09	
37	Regeneration Month 2	3 days	Thu 18/06/09	Mon 22/06/09	
38	Regeneration Month 3	3 days	Thu 18/06/09	Mon 22/06/09	
39	Regeneration Month 4	3 days	Thu 18/06/09	Mon 22/06/09	
40	Regeneration Month 5	3 days	Thu 18/06/09	Mon 22/06/09	
41	Regeneration Month 6	3 days	Thu 18/06/09	Mon 22/06/09	
42	Regeneration Month 7	3 days	Thu 18/06/09	Mon 22/06/09	
43	Regeneration Month 8	3 days	Thu 18/06/09	Mon 22/06/09	
44	Regeneration Month 9	3 days	Thu 18/06/09	Mon 22/06/09	
45	Regeneration Month 10	3 days	Thu 18/06/09	Mon 22/06/09	
46	**Placement of dead wood - as available**	**44 days**	**Thu 18/06/09**	**Tue 18/08/09**	
47	Placement of dead wood 1	2 days	Thu 18/06/09	Fri 19/06/09	
48	Placement of dead wood 2	2 days	Thu 18/06/09	Fri 19/06/09	
49	Placement of dead wood 3	2 days	Thu 18/06/09	Fri 19/06/09	
50	Placement of dead wood 4	2 days	Thu 18/06/09	Fri 19/06/09	
51	Placement of dead wood 5	2 days	Thu 18/06/09	Fri 19/06/09	
52	Placement of dead wood 6	2 days	Thu 18/06/09	Fri 19/06/09	
53	Placement of dead wood 7	2 days	Thu 18/06/09	Fri 19/06/09	
54	Placement of dead wood 8	2 days	Thu 18/06/09	Fri 19/06/09	
55	Placement of dead wood 9	2 days	Wed 15/07/09	Thu 16/07/09	
56	Placement of dead wood 10	2 days	Mon 17/08/09	Tue 18/08/09	



Project: Construction Measures.mpp
Date: Thu 18/12/08

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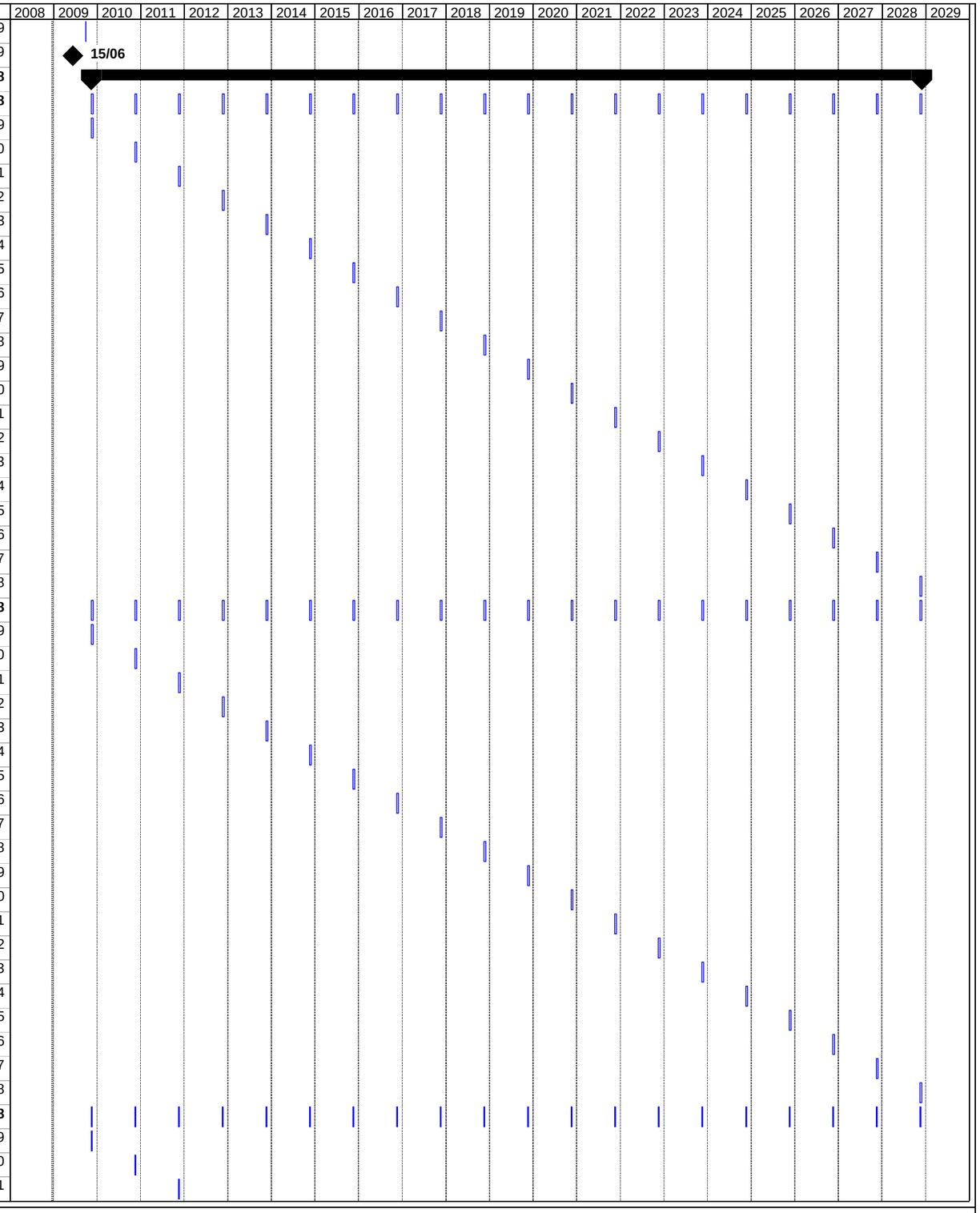
ID	Task Name	Duration	Start	Finish
1	Community Lands Environmental Management Plan	1 day	Thu 1/10/09	Thu 1/10/09
2	Post Construction start	0 days	Mon 15/06/09	Mon 15/06/09
3	**Post Construction Measures following each stage**	**4970 days**	**Mon 16/11/09**	**Fri 1/12/28**
4	**Yearly Weed Management**	**4970 days**	**Mon 16/11/09**	**Fri 1/12/28**
5	Yearly Weed Management 1	12 days	Mon 16/11/09	Tue 1/12/09
6	Yearly Weed Management 2	12 days	Tue 16/11/10	Wed 1/12/10
7	Yearly Weed Management 3	12 days	Wed 16/11/11	Thu 1/12/11
8	Yearly Weed Management 4	12 days	Fri 16/11/12	Mon 3/12/12
9	Yearly Weed Management 5	12 days	Mon 18/11/13	Tue 3/12/13
10	Yearly Weed Management 6	12 days	Mon 17/11/14	Tue 2/12/14
11	Yearly Weed Management 7	12 days	Mon 16/11/15	Tue 1/12/15
12	Yearly Weed Management 8	12 days	Wed 16/11/16	Thu 1/12/16
13	Yearly Weed Management 9	12 days	Thu 16/11/17	Fri 1/12/17
14	Yearly Weed Management 10	12 days	Fri 16/11/18	Mon 3/12/18
15	Yearly Weed Management 11	12 days	Mon 18/11/19	Tue 3/12/19
16	Yearly Weed Management 12	12 days	Mon 16/11/20	Tue 1/12/20
17	Yearly Weed Management 13	12 days	Tue 16/11/21	Wed 1/12/21
18	Yearly Weed Management 14	12 days	Wed 16/11/22	Thu 1/12/22
19	Yearly Weed Management 15	12 days	Thu 16/11/23	Fri 1/12/23
20	Yearly Weed Management 16	12 days	Mon 18/11/24	Tue 3/12/24
21	Yearly Weed Management 17	12 days	Mon 17/11/25	Tue 2/12/25
22	Yearly Weed Management 18	12 days	Mon 16/11/26	Tue 1/12/26
23	Yearly Weed Management 19	12 days	Tue 16/11/27	Wed 1/12/27
24	Yearly Weed Management 20	12 days	Thu 16/11/28	Fri 1/12/28
25	**Revegetation / Rejuvenation**	**4970 days**	**Mon 16/11/09**	**Fri 1/12/28**
26	Revegetation / Rejuvenation 1	12 days	Mon 16/11/09	Tue 1/12/09
27	Revegetation / Rejuvenation 2	12 days	Tue 16/11/10	Wed 1/12/10
28	Revegetation / Rejuvenation 3	12 days	Wed 16/11/11	Thu 1/12/11
29	Revegetation / Rejuvenation 4	12 days	Fri 16/11/12	Mon 3/12/12
30	Revegetation / Rejuvenation 5	12 days	Mon 18/11/13	Tue 3/12/13
31	Revegetation / Rejuvenation 6	12 days	Mon 17/11/14	Tue 2/12/14
32	Revegetation / Rejuvenation 7	12 days	Mon 16/11/15	Tue 1/12/15
33	Revegetation / Rejuvenation 8	12 days	Wed 16/11/16	Thu 1/12/16
34	Revegetation / Rejuvenation 9	12 days	Thu 16/11/17	Fri 1/12/17
35	Revegetation / Rejuvenation 10	12 days	Fri 16/11/18	Mon 3/12/18
36	Revegetation / Rejuvenation 11	12 days	Mon 18/11/19	Tue 3/12/19
37	Revegetation / Rejuvenation 12	12 days	Mon 16/11/20	Tue 1/12/20
38	Revegetation / Rejuvenation 13	12 days	Tue 16/11/21	Wed 1/12/21
39	Revegetation / Rejuvenation 14	12 days	Wed 16/11/22	Thu 1/12/22
40	Revegetation / Rejuvenation 15	12 days	Thu 16/11/23	Fri 1/12/23
41	Revegetation / Rejuvenation 16	12 days	Mon 18/11/24	Tue 3/12/24
42	Revegetation / Rejuvenation 17	12 days	Mon 17/11/25	Tue 2/12/25
43	Revegetation / Rejuvenation 18	12 days	Mon 16/11/26	Tue 1/12/26
44	Revegetation / Rejuvenation 19	12 days	Tue 16/11/27	Wed 1/12/27
45	Revegetation / Rejuvenation 20	12 days	Thu 16/11/28	Fri 1/12/28
46	**Maintenance of APZ's**	**4964 days**	**Mon 16/11/09**	**Thu 23/11/28**
47	Maintenance of APZ's 1	6 days	Mon 16/11/09	Mon 23/11/09
48	Maintenance of APZ's 2	6 days	Tue 16/11/10	Tue 23/11/10
49	Maintenance of APZ's 3	6 days	Wed 16/11/11	Wed 23/11/11



Project: Post Construction Measures
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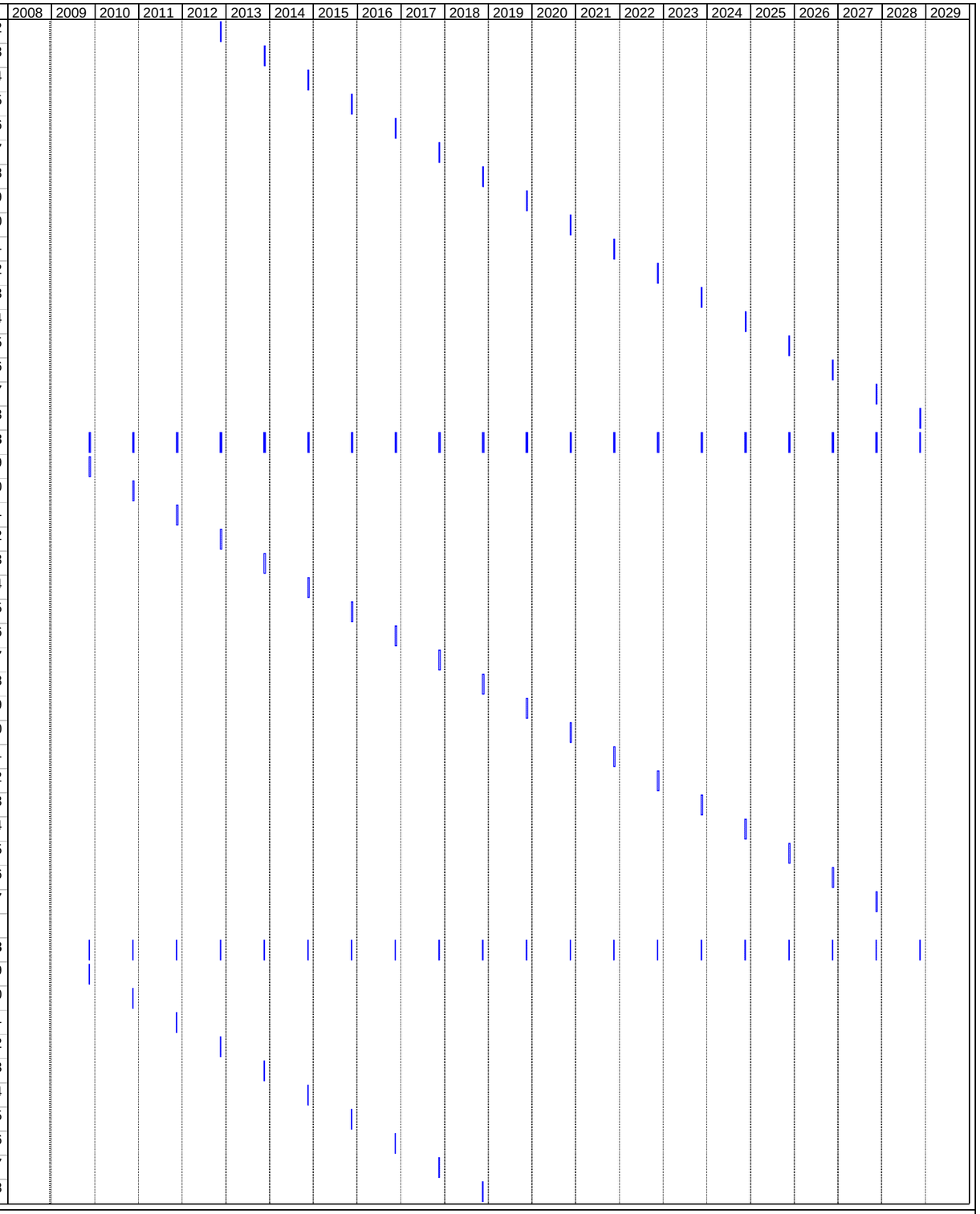
ID	Task Name	Duration	Start	Finish
50	Maintenance of APZ's 4	6 days	Fri 16/11/12	Fri 23/11/12
51	Maintenance of APZ's 5	6 days	Mon 18/11/13	Mon 25/11/13
52	Maintenance of APZ's 6	6 days	Mon 17/11/14	Mon 24/11/14
53	Maintenance of APZ's 7	6 days	Mon 16/11/15	Mon 23/11/15
54	Maintenance of APZ's 8	6 days	Wed 16/11/16	Wed 23/11/16
55	Maintenance of APZ's 9	6 days	Thu 16/11/17	Thu 23/11/17
56	Maintenance of APZ's 10	6 days	Fri 16/11/18	Fri 23/11/18
57	Maintenance of APZ's 11	6 days	Mon 18/11/19	Mon 25/11/19
58	Maintenance of APZ's 12	6 days	Mon 16/11/20	Mon 23/11/20
59	Maintenance of APZ's 13	6 days	Tue 16/11/21	Tue 23/11/21
60	Maintenance of APZ's 14	6 days	Wed 16/11/22	Wed 23/11/22
61	Maintenance of APZ's 15	6 days	Thu 16/11/23	Thu 23/11/23
62	Maintenance of APZ's 16	6 days	Mon 18/11/24	Mon 25/11/24
63	Maintenance of APZ's 17	6 days	Mon 17/11/25	Mon 24/11/25
64	Maintenance of APZ's 18	6 days	Mon 16/11/26	Mon 23/11/26
65	Maintenance of APZ's 19	6 days	Tue 16/11/27	Tue 23/11/27
66	Maintenance of APZ's 20	6 days	Thu 16/11/28	Thu 23/11/28
67	**Vertebrate Pest Management**	**4962 days**	**Mon 16/11/09**	**Tue 21/11/28**
68	Vertebrate Pest Management 1	10 days	Mon 16/11/09	Fri 27/11/09
69	Vertebrate Pest Management 2	10 days	Mon 15/11/10	Fri 26/11/10
70	Vertebrate Pest Management 3	10 days	Tue 15/11/11	Mon 28/11/11
71	Vertebrate Pest Management 4	10 days	Thu 15/11/12	Wed 28/11/12
72	Vertebrate Pest Management 5	10 days	Fri 15/11/13	Thu 28/11/13
73	Vertebrate Pest Management 6	10 days	Mon 17/11/14	Fri 28/11/14
74	Vertebrate Pest Management 7	10 days	Mon 16/11/15	Fri 27/11/15
75	Vertebrate Pest Management 8	10 days	Tue 15/11/16	Mon 28/11/16
76	Vertebrate Pest Management 9	10 days	Wed 15/11/17	Tue 28/11/17
77	Vertebrate Pest Management 10	10 days	Thu 15/11/18	Wed 28/11/18
78	Vertebrate Pest Management 11	10 days	Fri 15/11/19	Thu 28/11/19
79	Vertebrate Pest Management 12	10 days	Mon 16/11/20	Fri 27/11/20
80	Vertebrate Pest Management 13	10 days	Mon 15/11/21	Fri 26/11/21
81	Vertebrate Pest Management 14	10 days	Tue 15/11/22	Mon 28/11/22
82	Vertebrate Pest Management 15	10 days	Wed 15/11/23	Tue 28/11/23
83	Vertebrate Pest Management 16	10 days	Fri 15/11/24	Thu 28/11/24
84	Vertebrate Pest Management 17	10 days	Mon 17/11/25	Fri 28/11/25
85	Vertebrate Pest Management 18	10 days	Mon 16/11/26	Fri 27/11/26
86	Vertebrate Pest Management 19	10 days	Mon 15/11/27	Fri 26/11/27
87				
88	**Stormwater System Management**	**4961 days**	**Mon 16/11/09**	**Mon 20/11/28**
89	Stormwater System Management 1	4 days	Mon 16/11/09	Thu 19/11/09
90	Stormwater System Management 2	4 days	Mon 15/11/10	Thu 18/11/10
91	Stormwater System Management 3	4 days	Tue 15/11/11	Fri 18/11/11
92	Stormwater System Management 4	4 days	Thu 15/11/12	Tue 20/11/12
93	Stormwater System Management 5	4 days	Fri 15/11/13	Wed 20/11/13
94	Stormwater System Management 6	4 days	Mon 17/11/14	Thu 20/11/14
95	Stormwater System Management 7	4 days	Mon 16/11/15	Thu 19/11/15
96	Stormwater System Management 8	4 days	Tue 15/11/16	Fri 18/11/16
97	Stormwater System Management 9	4 days	Wed 15/11/17	Mon 20/11/17
98	Stormwater System Management 10	4 days	Thu 15/11/18	Tue 20/11/18



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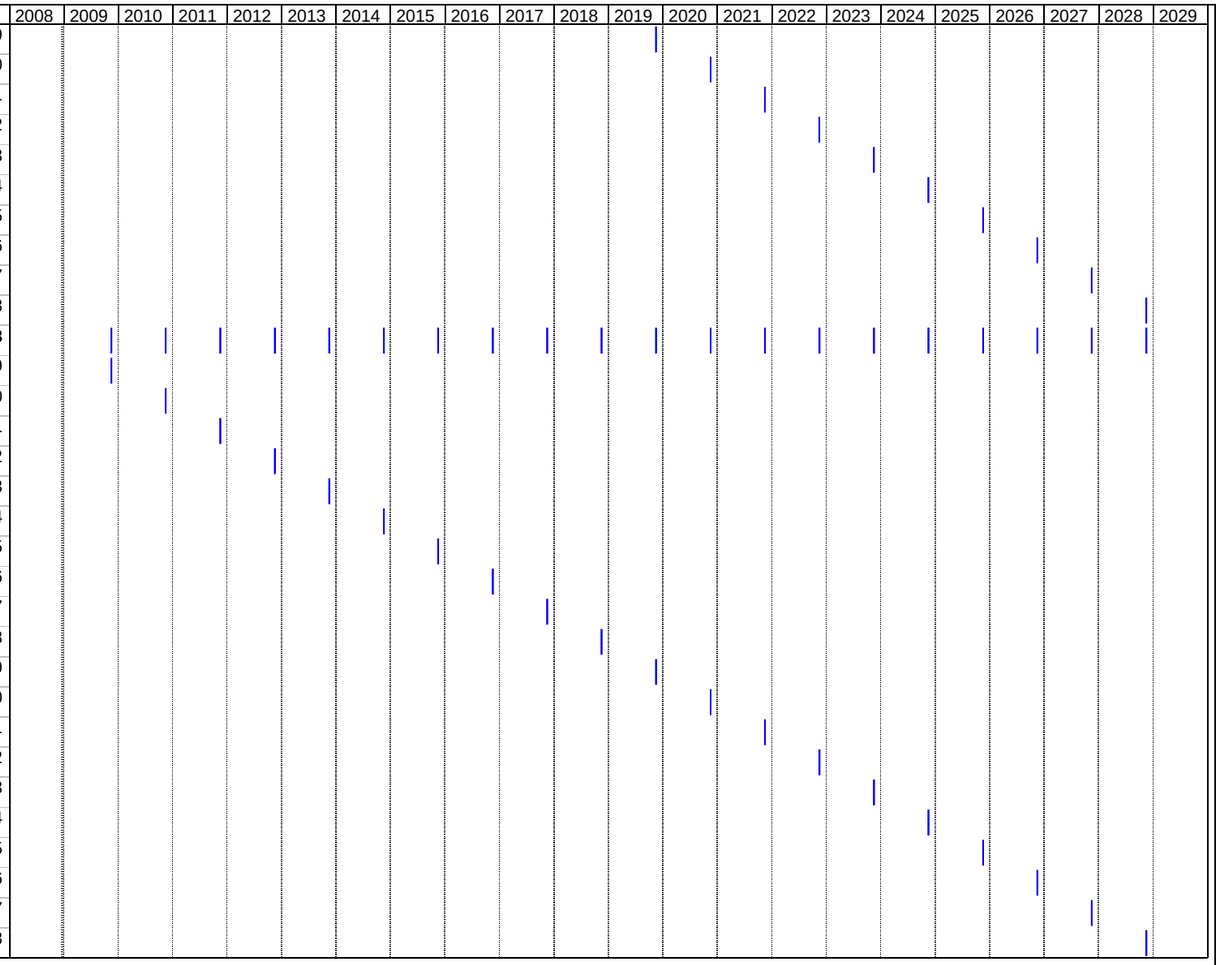
ID	Task Name	Duration	Start	Finish
99	Stormwater System Management 11	4 days	Fri 15/11/19	Wed 20/11/19
100	Stormwater System Management 12	4 days	Mon 16/11/20	Thu 19/11/20
101	Stormwater System Management 13	4 days	Mon 15/11/21	Thu 18/11/21
102	Stormwater System Management 14	4 days	Tue 15/11/22	Fri 18/11/22
103	Stormwater System Management 15	4 days	Wed 15/11/23	Mon 20/11/23
104	Stormwater System Management 16	4 days	Fri 15/11/24	Wed 20/11/24
105	Stormwater System Management 17	4 days	Mon 17/11/25	Thu 20/11/25
106	Stormwater System Management 18	4 days	Mon 16/11/26	Thu 19/11/26
107	Stormwater System Management 19	4 days	Mon 15/11/27	Thu 18/11/27
108	Stormwater System Management 20	4 days	Wed 15/11/28	Mon 20/11/28
109	**Ongoing Monitoring**	**4962 days**	**Mon 16/11/09**	**Tue 21/11/28**
110	Ongoing Monitoring 1	5 days	Mon 16/11/09	Fri 20/11/09
111	Ongoing Monitoring 2	5 days	Mon 15/11/10	Fri 19/11/10
112	Ongoing Monitoring 3	5 days	Tue 15/11/11	Mon 21/11/11
113	Ongoing Monitoring 4	5 days	Thu 15/11/12	Wed 21/11/12
114	Ongoing Monitoring 5	5 days	Fri 15/11/13	Thu 21/11/13
115	Ongoing Monitoring 6	5 days	Mon 17/11/14	Fri 21/11/14
116	Ongoing Monitoring 7	5 days	Mon 16/11/15	Fri 20/11/15
117	Ongoing Monitoring 8	5 days	Tue 15/11/16	Mon 21/11/16
118	Ongoing Monitoring 9	5 days	Wed 15/11/17	Tue 21/11/17
119	Ongoing Monitoring 10	5 days	Thu 15/11/18	Wed 21/11/18
120	Ongoing Monitoring 11	5 days	Fri 15/11/19	Thu 21/11/19
121	Ongoing Monitoring 12	5 days	Mon 16/11/20	Fri 20/11/20
122	Ongoing Monitoring 13	5 days	Mon 15/11/21	Fri 19/11/21
123	Ongoing Monitoring 14	5 days	Tue 15/11/22	Mon 21/11/22
124	Ongoing Monitoring 15	5 days	Wed 15/11/23	Tue 21/11/23
125	Ongoing Monitoring 16	5 days	Fri 15/11/24	Thu 21/11/24
126	Ongoing Monitoring 17	5 days	Mon 17/11/25	Fri 21/11/25
127	Ongoing Monitoring 18	5 days	Mon 16/11/26	Fri 20/11/26
128	Ongoing Monitoring 19	5 days	Mon 15/11/27	Fri 19/11/27
129	Ongoing Monitoring 20	5 days	Wed 15/11/28	Tue 21/11/28



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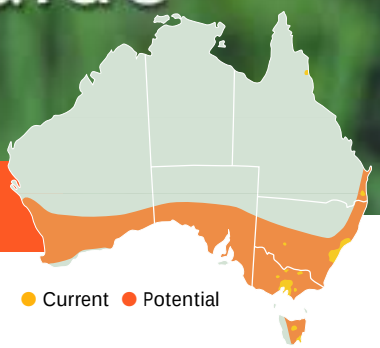
Annex E

Weed Profiles and Fact Sheet

Weed Management Guide

Alligator weed –
Alternanthera philoxeroides



Alligator weed (*Alternanthera philoxeroides*)

The problem

Alligator weed is a *Weed of National Significance.* It is regarded as one of the worst weeds in Australia because of its invasiveness, potential for spread, and economic and environmental impacts. It is an especially troublesome weed because it invades both land and water, and is very hard to control.

When growing on land it displaces other more favourable plants such as crops or native vegetation, and can be harmful to animals. When growing in fresh water, alligator weed can cover the entire water surface, preventing flow, blocking up drainage channels and potentially increasing flood damage. Weed mats can also reduce oxygen exchange, affecting instream plants and animals and reducing water quality.

Alligator weed caused the failure of small crop and turf farms in parts of the lower Hunter region in New South Wales. Another infestation, in Barren Box Swamp, would have cost irrigation farmers in the Murrumbidgee Irrigation Area up to $250 million annually if left unchecked. So far, more than $3 million has been spent controlling this infestation alone.

The weed

Alligator weed can grow with roots embedded in the bank or on the bottom of shallow water bodies, or float freely on the water surface. It spreads its leaves across the water surface, forming dense mats. The long spreading stems are hollow, helping it to float. The roots are thin and stringy, and trail in the water from the joints between plant segments (the nodes).

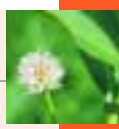
When growing on land alligator weed is quite different in structure. The stems are shorter and barely hollow. Reddish-brown tap roots can reach depths exceeding 500 mm.

Whether it grows in water or on land, the shiny, dark green leaves occur in opposite pairs along the stem. The leaves are 20–70 mm long and 5–40 mm wide, with smaller veins almost perpendicular to a characteristic mid-line along the length of the leaf. The silvery-white flower is small (12–14 mm wide) and papery, with a short stalk growing from either the axil (where the leaf joins the stem) or the very end of the stem.

Infestations can take over wetlands such as creeks and drainage channels and spread onto adjacent land.
Photo: Graham Prichard

Key points

- Alligator weed poses a significant economic and environmental threat.
- It can grow in water or on land, and has been mistakenly grown in the past as a food.
- Prevention is the most cost-effective form of weed control. Quarantine, early detection and good hygiene within infestations will prevent its spread.
- Mechanical and chemical control, integrated with biological control, is effective on established aquatic growth forms.
- However, care must be taken because it spreads easily from fragments.
- Ongoing follow-up control will be required.



Natural Heritage Trust
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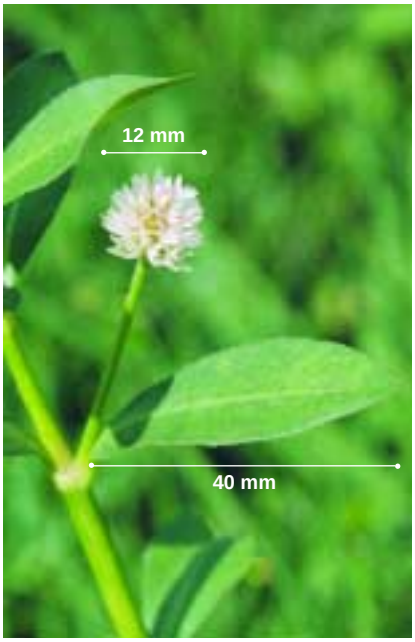
Growth calendar

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
New growth									■	■	■	
Active growth	■	■	■						■	■	■	■
Flowering	■	■	■									
Seed formation	No viable seed yet found in Australia											
Seed drop												
Germination												

■ General growth pattern

Growth in alligator weed commences during spring and continues in the warmer weather. New stems formed in spring grow quickly during summer, producing flowers by mid-summer. Flowering continues until the weather becomes cooler and the days shorter. In cooler climates leaves drop off and frost kills off most of the exposed vegetation during winter. However, some roots, rhizomes and protected stems survive and recommence growth during the following spring.



Silvery-white flowers are borne on short stalks during mid-summer.
Photo: Colin G. Wilson

How it spreads

Alligator weed does not produce viable seed in Australia, although it can in its native range. It spreads in Australia through vegetative reproduction, when fragments containing at least one node are moved from one place to another and take root in suitable habitat. It is commonly spread downstream when the plant is broken up into smaller fragments (eg by floods, or following mechanical or chemical control). Movement between river catchments is most commonly due to human activities. It has been spread in garden mulch and landfill, and attached to machinery and vehicles (eg bulldozers, trailers, boats and other watercraft). Animals may also spread the fragments (eg by transport of nesting material by ducks or in cows' hooves).

In water fine roots grow from the nodes.
Photo: Rebecca Coventry

It is believed that alligator weed first reached Australia near Newcastle in the 1940s in ballast. It has since spread to infest many waterways in New South Wales, including the lower Hunter region, Barren Box Swamp, the Sydney region, Griffith, Albury (which threatens the Murray River) and infestations in Brisbane, Cairns and Canberra.

Where it grows

One of the reasons that alligator weed poses such a dramatic threat is its ability to live in both aquatic and terrestrial habitats. It can tolerate brackish (slightly salty) water but thrives in nutrient-rich water. Ideal terrestrial habitats include places that are regularly inundated or that have high rainfall or irrigation. Alligator weed can survive in tropical and sub-tropical regions such as Darwin and Brisbane, and also cooler climates such as Victoria and Tasmania where the survival of some stems and rhizomes over winter allows it to regenerate during the warmer months.

Alligator weed is native to temperate regions of South America, especially Argentina. It is now found as a serious weed throughout tropical and warm-temperate regions, including the US, China, India, South-East Asia and New Zealand.

Potential distribution

The potential range of alligator weed, based on climate, includes waterways throughout most of southern Australia, extending south from Bundaberg in Queensland, through New South Wales, Victoria, Tasmania and South Australia, and north to Kalbarri in Western Australia. However, a different model predicts that alligator weed could also survive in the tropics, which may explain an infestation surviving in Cairns.

What to do about it?

Early detection is most cost-effective

Alligator weed has rarely, if ever, been successfully eradicated once it has infested a water body, despite numerous costly attempts. For this reason, the highest priority for the management of alligator weed in Australia is an effective system of early detection and eradication before infestations become established.

In the past alligator weed was mistaken as a traditional Sri Lankan herb and planted in gardens around Australia.
Photo: Lalith Gunasekera

The success of an early detection and eradication program depends on:

- maintenance of quarantine to prevent further introductions
- enhanced awareness and education to reduce the risk of spread
- the identification and monitoring of high-risk sites
- adherence to weed hygiene protocols (eg not removing material from infestations, carefully washing down equipment after contact with alligator weed)
- coordination between stakeholders and local and state/territory governments.

Some successes with small infestations

Much of this work is ongoing but significant inroads have recently been made. For example, alligator weed was being cultivated in backyards and mistakenly used in traditional Sri Lankan cooking instead of another herb known as 'mukunewenna' or 'pononcarni'. A campaign was initiated to educate the Sri Lankan community about the dangers of alligator weed, to eradicate infestations and to replace it with a less weedy species. In Victoria 784 backyard infestations were identified following an awareness campaign that included newspaper articles, radio segments, leaflets and fridge magnets. By working closely with the Sri Lankan community, the infestations have been controlled via repeated herbicidal treatments. An Australian native species, common joy weed *Alternanthera denticulata*, has been accepted as a suitable replacement.

Don't try and treat alligator weed on your own

The successful control of alligator weed in backyard situations has been achieved using the considerable experience and resources of local councils and state/territory weed management agencies. However, there is still much that is unknown about alligator weed. For example, the effectiveness of different herbicides in different environments is still being examined. For these reasons, and because it can spread so easily from small fragments, you must contact your local council or state/territory weed management agency to help you control alligator weed.

In aquatic situations the hollow stem helps floatation.
Photo: Rebecca Coventry

It is extremely difficult to control alligator weed in aquatic situations

In some aquatic habitats, alligator weed infestations can be reduced with weed harvesters or by manual removal, but small fragments are inevitably left behind or dislodged. These fragments readily create new infestations. Therefore, any living plant material must be very carefully disposed of to prevent further spread.

In water alligator weed can be treated with a registered herbicide. However, this rarely kills the entire plant, which often breaks up into smaller pieces. These smaller pieces can drift downstream and lead to new infestations. Additionally, there are restrictions on the use of herbicides in waterways, including concerns about impacts to non-target plants and the environmental health of waterways.

Therefore, both the chemical and mechanical control of alligator weed in aquatic habitats is extremely difficult and can lead to further downstream infestations.

Alligator weed has an extensive root system when growing on land.
Photo: Graham Prichard

Weed control contacts

State / Territory	Department	Phone	Email	Website
ACT	Environment ACT	(02) 6207 9777	EnvironmentACT@act.gov.au	www.environment.act.gov.au
NSW	NSW Agriculture	1800 680 244	weeds@agric.nsw.gov.au	www.agric.nsw.gov.au
NT	Dept of Natural Resources, Environment and the Arts	(08) 8999 4567	weedinfo.nreta@nt.gov.au	www.nt.gov.au
Qld	Dept of Natural Resources and Mines	(07) 3896 3111	enquiries@nrm.qld.gov.au	www.nrm.qld.gov.au
SA	Dept of Water, Land and Biodiversity Conservation	(08) 8303 9500	apc@saugov.sa.gov.au	www.dwlbc.sa.gov.au
Tas	Dept of Primary Industries, Water and Environment	1300 368 550	Weeds.Enquiries@dpiwe.tas.gov.au	www.dpiwe.tas.gov.au
Vic	Dept of Primary Industries/Dept of Sustainability and Environment	136 186	customer.service@dpi.vic.gov.au	www.dpi.vic.gov.au www.dse.vic.gov.au
WA	Dept of Agriculture	(08) 9368 3333	enquiries@agric.wa.gov.au	www.agric.wa.gov.au
Australia wide	Australian Pesticides and Veterinary Medicines Authority	(02) 6272 5852	contact@apvma.gov.au	www.apvma.gov.au

For up-to-date information on which herbicides are registered to control alligator weed and the best application methods and dosages, contact your state or territory weed management agency or local council. This information varies from state to state and from time to time. Contact details are listed above, including contacts for the Australian Pesticides and Veterinary Medicines Authority, which hosts the PUBCRIS database. This database contains information on all herbicides that are registered for use on weeds in each Australian state and territory.

When using herbicides always read the label and follow instructions carefully. Particular care should be taken when using herbicides near waterways because rainfall running off the land into waterways can carry herbicides with it. Permits from state or territory Environment Protection Authorities may be required if herbicides are to be sprayed directly onto water.

…and on land

When it grows on land, alligator weed can be controlled with repeated herbicide treatments. The Queensland Department of Natural Resources and Mines suggests three treatments during the growing season, each consisting of two applications separated by one week. Ideally, the last treatment should be undertaken close to the start of winter to target the rhizomes, which would otherwise allow the weed to survive through winter.

However, there are problems in this approach, including concerns about using herbicides near waterways, expense, and the difficulty of targeting alligator weed when other desirable species are also present.

Physical removal is also difficult because of the depth that roots and rhizomes can reach. It is recommended that all weed material be removed to a depth of one metre, and then be disposed of by deep burial. This is obviously a difficult and time-consuming task requiring mechanical assistance.

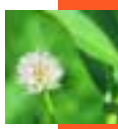
Flowering alligator weed in paddocks of the Lower Hunter, NSW, in February.
Photo: Mic Julien

Adult biocontrol agents (the alligator weed flea beetle *Agasicles hygrophila*) feed on leaves and stems.
Photo: Graham Prichard

Biological control can help manage alligator weed

Three insects have been released in Australia to control alligator weed. The aquatic alligator weed flea beetle *Agasicles hygrophila*, has been quite successful in controlling alligator weed growing in the water. It was first released in 1977 in New South Wales. The adults and larvae reduce the growth of alligator weed by feeding on the underside of the leaves and aerial parts of the plant.

Unfortunately, biological control does not yet offer a cure to the alligator weed problem. The flea beetle is only effective in warm, temperate areas that allow it to breed up to high numbers in early summer, and it does not attack alligator weed growing on land. Therefore, the search continues for new biological control agents in alligator weed's native range, particularly for agents to control the weed in cooler climates and when it grows on land.



Mechanical removal of alligator weed requires careful hygiene to prevent the spread of small fragments.
Photo: Brian Worboys

Given the difficulties and expense associated with chemical and mechanical control, biological control agents are an attractive option to tackle alligator weed in the long term. However, biological control is a complex process, requiring success at a number of separate stages. Once identified, suitable agents must be approved for release, reared in captivity and then become established in the field. The hope for future biological control agents must therefore be balanced by the possibility that they may not be available or successful.

Legislation

In all states and territories, landholders are obliged by law to control or eradicate alligator weed and to limit its spread and impacts. Most regions restrict its importation. Check with your local council or state/territory government agency about its requirements for alligator weed control.

Acknowledgments

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Maps: Australian Weeds Committee.

...case study

Integrated management of alligator weed in Botany Wetlands in Sydney

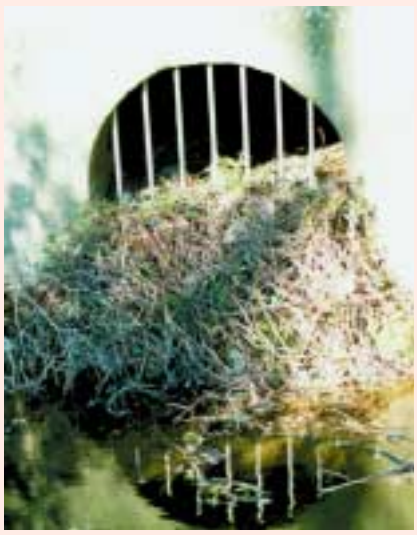
Sydney Water provides drinking water and wastewater services to over four million people in the Sydney, Blue Mountains and Illawarra areas, including the Botany Wetlands which are situated within the metropolitan area of Sydney.

The Botany Wetlands are ecologically and aesthetically significant, but are also historically important as they served as a drinking water supply for Sydney in the mid 1800s. Alligator weed was first noted in waterways around 1985, but only occasionally treated with herbicides until the mid 1990s, by which time the infestation was out of control and posed a significant threat to the wetlands.

Sydney Water has since introduced an integrated weed management approach to deal with alligator weed. This combines vigilant and systematic monitoring for any new infestations, with regular application of suitable herbicides for both terrestrial and aquatic infestations and manual removal of floating masses. Other active management strategies include the lowering of water levels to allow better control, the large scale planting of native water plants in treated areas, and the controlled burning of sedges and rushes in selected infested areas. Additionally, in order to minimise environmental damage from chemicals, herbicides are not applied when the biological control agents are most active.

In terms of actual control efforts, herbicides are applied as spot-treatments to persistent patches at monthly intervals during cooler months, and more frequently in the warmer months (September–May). New infestations are treated with herbicides or are removed by hand picking as soon as practicable, with the ultimate aim of preventing further downstream spread. Disposal of collected live plant material is by burial in the sand in selected locations, following drying and herbicide treatment.

It is estimated that, on average, 90–95% of the previous alligator weed infestation has been controlled and removed since the adoption of the new integrated management plan in 1997. Although this is a relatively successful result, the inability to completely eradicate the weed from the wetlands reflects its resilience to current control measures and its ability to spread even when being carefully managed. It must also be recognised that the current gains made on alligator weed in the Botany Wetlands have been achieved through diligent and committed action, continual assessment, persistent management intervention and investment of labour and other resources.



Impacts of alligator weed include flooding due to blocked drains.
Photo: Rebecca Coventry

How to control alligator weed

Quick reference guide

Preventing spread

The main aim of alligator weed management in Australia is to prevent its spread from core infestations into new areas by:

- preventing new plant material entering Australia
- using weed hygiene protocols, such as washing contaminated equipment
- educating people to recognise it and respond to outbreaks.

The importance of monitoring

Early detection offers the only likelihood of finding infestations that are small enough to hope to eradicate. Monitoring of likely areas is therefore crucial to successful alligator weed management.

The limitations of current control techniques

Available management techniques for controlling alligator weed include:

- mechanical (eg weed harvesters in water bodies)
- physical (eg digging all material out to a depth of one metre)
- chemical (several herbicides registered for use on land or water)
- biological (eg the flea beetle attacks alligator weed growing in water).

Unfortunately each of these techniques has its limitations. Mechanical, physical and chemical control can all leave small fragments behind and actually increase the spread of alligator weed. These techniques therefore require a great deal of care and should only be conducted with the assistance of experts.

Other issues with these techniques include expense, the intensity of work required (eg spraying land infestations requires three treatments of two sprayings each), concern over residual herbicides in and around waterways and effects on non-target plants and animals, the difficulty of disposing of collected material and the need for continual follow-up work.

This simple screen has effectively prevented the spread of alligator weed into nearby wetlands. Photo: Graham Prichard

Control options

Type of infestation	Best way to control
Backyard infestations	Backyard infestations should be reported to your local council or state/territory weed management agency. Herbicides have been used successfully in different regions, but will require many repeated treatments. Care must be taken to prevent the spread of weed through fragments escaping from the garden.
In a waterway	Alligator weed in waterways should be reported to your local council or state/territory weed management agency. Herbicides are most effective when above water vegetation is greatest. Manual or mechanical removal may also be possible. If not already present, flea beetles should be introduced. Integration of all of these techniques will ultimately provide the best results.
On land	Alligator weed on land should be reported to your local council or state/territory weed management agency. Effective herbicides are available; however, treatments must be repeated frequently during the growing season. Biological control does not yet impact on land infestations, but other management techniques such as revegetation or physical removal are useful.

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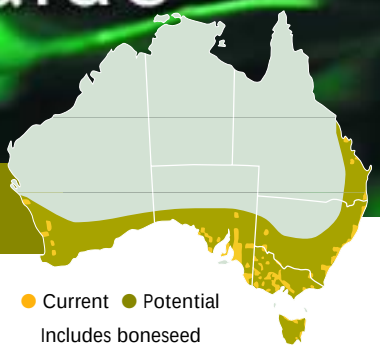
CRC Weed management

Weed Management Guide

Bitou bush – *Chrysanthemoides monilifera* ssp. *rotundata*



Bitou bush (*Chrysanthemoides monilifera* ssp. *rotundata*)

The problem

Bitou bush is a *Weed of National Significance*. It is regarded as one of the worst weeds in Australia because of its invasiveness, potential for spread, and economic and environmental impacts.

Bitou bush threatens coastal dune vegetation along Australia's east coast. It can outcompete and in many cases totally replace native flora, and it invades undisturbed as well as disturbed areas. Infestations of bitou bush drastically alter the environment for many native birds and animals. It can also create a favourable environment for other highly invasive weeds, such as asparagus fern, lantana and glory lily.

Ironically, one of the plants being choked by bitou bush along the New South Wales coast, golden wattle (*Acacia longifolia*) has become a major pest of coastal dunes in South Africa, where it was introduced to serve much the same purpose as bitou bush in Australia.

The weed

Bitou bush is a perennial, evergreen shrub, normally 1–2 m high although it can form canopies up to 10 m high. Unlike its close relative boneseed (*Chrysanthemoides monilifera* ssp. *monilifera*), which grows as an erect bush, bitou bush is a sprawling shrub.

Bitou bush aggressively invades both intact natural bushland and disturbed areas, particularly coastlines.
Photo: Paul Weiss

Its stems are branched and woody and the upper stems are often purple. The leaves, which are about 20–80 mm long, oval to oblong in shape and tapering at the base, alternate along the stems. Unlike boneseed, which has leaves with serrated edges, bitou bush has leaves with smooth edges. Bitou bush also has an extensive root system and appears more aggressive and more difficult to control than boneseed. The yellow, chrysanthemum-like flowers, up to 20 mm in diameter, are clustered at the ends of the branches. The small berries have green, fleshy skin that changes to brown and black on maturity. The fruit contains a single egg-shaped seed 5–7 mm long which is dark brown to black when dry.

Key points

- Prevention and early intervention are the most cost-effective forms of weed control. It is vital to keep clean areas free of bitou bush.
- Bitou bush infestations leave a large and persistent seedbank in the soil, so for long-term control infested areas must be treated repeatedly for several years.
- Integrated management using a range of control measures (eg mechanical, chemical and biological control, and the careful use of fire and/or grazing) is required to successfully control bitou bush.
- Monitor treated areas annually to detect and eradicate regenerating seedlings before they have a chance to produce seed.

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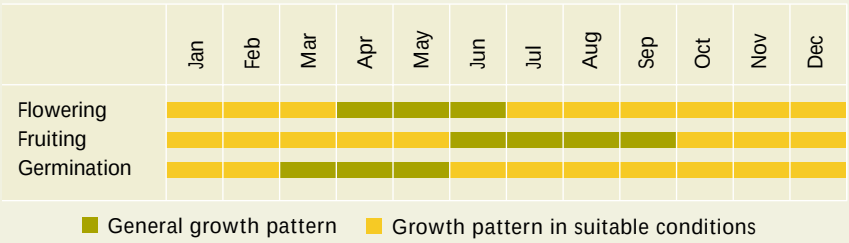
Growth calendar



Seeds germinate at any time of the year but mostly in autumn. Most seeds remain viable for at least two years. The seedlings grow rapidly during winter and a few plants may flower in the first year, particularly on burnt areas where there is little competition. However, plants are usually at least 18 months and sometimes three years old before flowering. Bitou bush can flower almost year round, but peak flowering occurs between April and June, unlike boneseed which forms flowers in late winter and spring. Bitou bush fruits ripen during winter and the start of spring.

On the south coast of New South Wales, seedlings usually reach flowering age after three years (earlier if growing in burnt or favourable conditions), while on the north coast growth is much more rapid and flowering within one year is more usual.

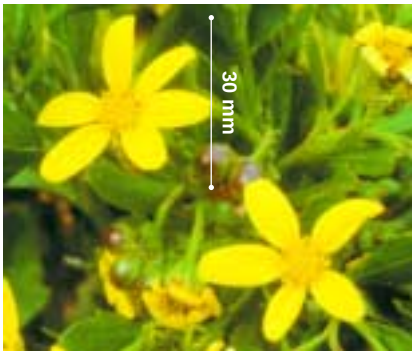
How it spreads

Bitou bush spreads primarily by seed, with each plant producing up to 50,000 seeds a year. In established infestations, soil seedbanks can contain up to 5000 seeds per square metre. Soil disturbance (eg after bulldozing), fire and ingestion of seed by birds and animals promote seed germination but seeds can still germinate in undisturbed situations.

Birds are important in spreading seed as they readily eat the fruit and then pass the seed, sometimes many kilometres from the original source. Rabbits and foxes also eat the fruit and spread the seed in their droppings. Seeds are also spread by water, in ocean currents or through coastal creeks and waterways. Human activities can lead to the spread of bitou bush by vehicles and equipment. On a local scale, seeds may be spread in windblown sand.

Bitou bush can resprout after fire, slashing and herbicide application.

Flowering can occur year round. This specimen was flowering in November near Byron Bay, NSW.
Photo: Kate Blood



The closely related boneseed has 5–8 yellow petals on its flowers and serrated-edged leaves. For more information see other guide in this series.
Photo: Colin G. Wilson

Where it grows

Bitou bush was first recorded in Australia near Newcastle, New South Wales, about 1908, probably introduced through dumping of ships' ballast. From 1946 to 1968 it was planted along the coast to revegetate areas after sandmining. It was also planted on sand dunes near Menindee in western New South Wales where a small infestation still persists.

Bitou bush is naturalised in all states and territories except the Northern Territory. It is mainly restricted to coastal ecosystems with summer rainfall, similar to its range in South Africa.

Bitou bush grows in a range of environments – from open exposed dunes to shaded forests. It is tolerant of shade, salinity, strong wind, wind-blown sand and water, drought, low nutrients and, to some extent, disturbances such as fire. It grows poorly in wet or swampy soils and has a low tolerance to frost.

A recent survey recorded bitou bush on 900 km, or 80%, of the NSW coastline, with an estimated 36, 000 ha infested. Around Sydney there are mixed populations of boneseed and bitou bush. National containment zones for bitou bush have been established in New South Wales on the far north coast and the south coast. In Queensland bitou bush occurred on coastal sandmining areas

Bitou bush threatens coastal dunes and rainforests across southern Australia.
Photo: John Vranjic

but has been targeted for eradication for the past decade. Smaller isolated infestations occur on Lord Howe Island and near Melbourne.

Potential distribution

Bitou bush is spreading further into the understorey of forests and woodlands next to the coastal strip. Recent mapping has recorded infestations up to 10 km inland. There are still large areas outside its current distribution which are potentially at risk, including the whole of Tasmania and much of southern Australia.

The sprawling bitou bush plants have branched, woody stems, which are often purple near the top.
Photo: Kate Blood

What to do about it

Preventing spread

It is important to keep clean areas free of bitou bush. Once an infestation is established, preventing the spread of seeds into surrounding areas should be a priority. This means destroying established plants before they flower and produce fruit.

Any bitou bush plants in gardens should be destroyed since they represent a seed source and hence potential for further spread.

Much of southern Australia including the whole of Tasmania is climatically suitable for bitou bush

Raising awareness amongst recreational vehicle users is important, particularly in coastal areas where seed may be spread by their activities.

Management strategies

In order to minimise the amount of seed produced, it is necessary to detect as many plants as possible. In areas where access is difficult, tracks may need to be cut to make control efforts easier. The greatest difficulty is the large area infested and the rapid reinvasion of an area after initial attempts at control. A sustained control effort is required for up to ten years.

Bitou bush responds much more quickly than native plants after burning or land clearing, and with a large seed bank in the soil it will quickly form a dense growth of seedlings, swamping native species.

Shallow roots make mechanical control easier

Unlike many other woody weeds, bitou bush has a shallow root system with no distinct taproot, so pulling the bushes is possible. Seedlings and plants up to 1 m in height can be hand pulled.

Bitou bush does not persist when grazed or cultivated. Slashing alone is not effective as regrowth occurs from the stump, but applying herbicide to stems immediately after cutting should prevent regrowth. The removal of adult plants stimulates seed germination so new seedlings must be removed before they produce further seeds.

Herbicides are effective

Herbicides registered for bitou bush can be applied in winter at low rates that effectively kill the weed, yet have minimal impacts on coastal vegetation. However, in northern parts of the weed's range where it matures more quickly, two spraying programs a year may be necessary to prevent seeding.

Herbicides registered for bitou bush can be applied from the air, from the ground or by a cut and paint method. Plants coated with dust or seaspray (eg those close to tracks or the beach) will be less affected by herbicides.

Isolated plants can be treated with herbicide applied by spot spraying. As infestations become larger, a strategically staged approach for removal is advisable to ensure that treated areas are not reinfested.

In New South Wales low dosages of herbicides have been applied from helicopters in winter, allowing large areas to be treated rapidly with minimum impact on native species. Reports indicate better than 95% control.

Weed control contacts

State / Territory	Department	Phone	Email	Website
ACT	Environment ACT	(02) 6207 9777	EnvironmentACT@act.gov.au	www.environment.act.gov.au
NSW	NSW Agriculture	1800 680 244	weeds@agric.nsw.gov.au	www.agric.nsw.gov.au
Qld	Dept of Natural Resources and Mines	(07) 3896 3111	enquiries@nrm.qld.gov.au	www.nrm.qld.gov.au
SA	Dept of Water, Land and Biodiversity Conservation	(08) 8303 9500	apc@saugov.sa.gov.au	www.dwlbc.sa.gov.au
Tas	Dept of Primary Industries, Water and Environment	1300 368 550	Weeds.Enquiries@dpiwe.tas.gov.au	www.dpiwe.tas.gov.au
Vic	Dept of Primary Industries/Dept of Sustainability and Environment	136 186	customer.service@dpi.vic.gov.au	www.dpi.vic.gov.au www.dse.vic.gov.au
WA	Dept of Agriculture	(08) 9368 3333	enquiries@agric.wa.gov.au	www.agric.wa.gov.au
Australia wide	Australian Pesticides and Veterinary Medicines Authority	(02) 6272 5852	contact@apvma.gov.au	www.apvma.gov.au

For up-to-date information on which herbicides are registered to control bitou bush and the best application methods and dosages, contact your state or territory weed management agency or local council. This information varies from state to state and from time to time. Contact details are listed above, including contacts for the Australian Pesticides and Veterinary Medicines Authority, which hosts the PUBCRIS database. This database contains information on all herbicides that are registered for use on weeds in each Australian state and territory.

When using herbicides always read the label and follow instructions carefully. Particular care should be taken when using herbicides near waterways because rainfall running off the land into waterways can carry herbicides with it. Permits from state or territory Environment Protection Authorities may be required if herbicides are to be sprayed on riverbanks.

There are several effective biological control agents

The lack of natural enemies attacking bitou bush in Australia is one of the reasons it has become a serious weed. In classical biological control these natural enemies are introduced into Australia if they are shown not to attack Australian native species or other valuable plants. Biological control is a slow process and will not eradicate bitou bush. It is useful as part of an integrated approach and in areas where the application of conventional control methods is inappropriate due to economic, practical or environmental constraints.

Since 1987, when the first biocontrol agents for bitou bush and boneseed were released in Australia, seven control agents have been released. Two are well established and require no further distribution: the bitou tip moth (*Comostolopsis germana*) which destroys developing leaves, buds and flowers and reduces seed production; and the bitou seed fly (*Mesoclanis polana*) which destroys developing seeds. Leaf-feeding beetles (*Chrysolina* and *Cassida* spp.) were also released but have either not established or are colonising only slowly.

In 2001 the bitou leaf rolling moth (*Tortrix* sp.) was released on boneseed in the You Yangs in Victoria and on bitou bush in New South Wales. Although it has failed to establish on boneseed, it has established well at two sites on bitou bush. Another agent, the boneseed leaf-buckle mite, is being tested for release.

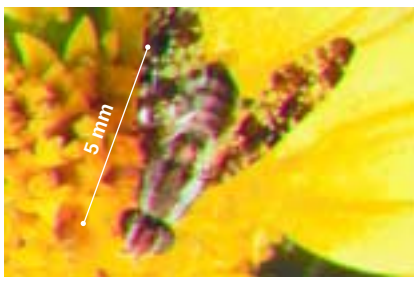
Fire can kill mature bitou bush

Intense fire kills most mature bitou bush, although a small proportion resprout. Fire also kills bitou bush seeds in the litter and topsoil and stimulates germination of seeds from lower in the soil profile. These new seedlings must be removed before they produce further seeds.

Trials have shown that the seedbank in the soil is significantly reduced following burning of mature plants previously killed with herbicide. In areas where a large proportion of the remnant vegetation is known to be fire-sensitive, fire should not be used. Fire can also cause other problems such as increased erosion potential, increased traffic and access by humans and pest animals, and further invasion by weeds. Note that permission of the landowners and a permit from the relevant state or territory fire authority are generally required to authorise the use of fire, and that the fire should be undertaken by properly trained and equipped personnel.

Grazing

Cattle eat bitou bush and this limits its spread onto grazed properties next to heavily infested areas. But grazing in many bitou bush infested areas is not appropriate due to problems associated with stock, such as browsing of native plants, erosion from stock movement and the spread of other undesirable weeds.



The bitou seed fly (*Mesoclanis polana*) destroys developing seeds.
Photo: Weeds CRC

The caterpillar stage of the bitou leaf rolling moth (*Tortrix* sp.).
Photo: Royce Holtkamp

...case study

Restoration of native vegetation at Iluka Bluff on the north coast of New South Wales

A collaborative project at Iluka Bluff on the north coast of New South Wales is helping to restore a badly degraded, bitou-infested coastline.

Iluka Bluff is next to the largest remaining coastal rainforest in New South Wales, the Iluka Rainforest World Heritage Area.

With funding from the Commonwealth Government's Natural Heritage Trust, the Iluka Land and Dune Care Group and the New South Wales National Parks and Wildlife Service (NPWS) began working in 1996 to restore the natural vegetation of the Iluka Bluff area.

Most of the 5 ha project site consisted of dense bitou on the Iluka Bluff headland with small areas of remnant kangaroo grass (*Themeda triandra*) on the eastern and southeastern slopes. The beachfront in the project site was almost exclusively bitou bush as well.

The project involved a number of weed control methods and also saw a new biological control agent, the bitou bush seed fly (*Mesoclanis polana*), established at the site.

The initial treatments for the dense bitou infestations used a Greencorp team to cut access tracks to clear the way for high volume spraying, which was done by contractors and NPWS staff. Bitou amongst the sensitive remnant grassland was either hand removed or cut and painted, with limited spraying.

Several months later, the dead standing mass on the hillside was burnt under controlled conditions. This was done to make follow-up treatment easier, and to destroy a portion of the bitou seedbank and stimulate the remaining seedbank to germinate. Afterwards, mats of cut tea-tree were placed on the bare hillside to help reduce erosion risks.

The bitou on the beachfront was sprayed and, after a suitable time, crushed with a tractor. Areas on the hillside and the beachfront with little native regeneration were then planted by the landcare group and other volunteers. Since then the site has been treated periodically to control regrowth of bitou and other weeds.

As a result of this work, native vegetation cover from natural regeneration and plantings is now dominant over 40% of the 5 ha site.

The project has complemented other regeneration work in the rainforest and has played a large part in Iluka Bluff being named as New South Wales' cleanest beach for 2002.

Integrated management

Wherever possible, an integrated management approach needs to be adopted using several control measures. As with most weed control programs in natural ecosystems, natural regeneration or over-sowing with locally collected seed of native species is an important part of the rehabilitation process. If bitou bush is eradicated without follow-up, other weeds such as glory lily quickly fill the gaps.

Rainforests require special treatment

A combination of spot spraying, mechanical removal and biocontrol may be the most appropriate for rainforest infestations. Fire is not recommended because of the sensitive nature of rainforest plants to burning. The number of new weed seedlings in the forest may be low, as bitou bush does not flower well under heavy shade conditions. Treat vigorous infestations of bitou bush surrounding the rainforest.

Disposal

The stands of dead bitou bush left after spraying can be removed by trampling, compacting or, if appropriate, fire. If they are left standing they may provide some protection to dune environments until they eventually decompose. Small amounts of bitou bush removed by hand pulling or mechanical clearing can also be left to decompose but, if possible, the seeds should be removed and burnt.

Legislation

The Australian Quarantine and Inspection Service prohibits the entry of bitou bush into Australia. The plant is declared in New South Wales, Queensland, South Australia, Victoria and Western Australia. Landholders in these states are required to control it. Check with your local council or state/territory government agency about the latest requirements for bitou bush control.

Acknowledgments

Information and guide revisions: Richard Carter (NSW Agriculture/Weeds CRC), Nigel Ainsworth (DPI Vic/Weeds CRC), Jeff Thomas (NSW NPWS), Royce Holtkamp (Agriculture NSW/Weeds CRC), Rhonda James (Coordinator North Coast NSW Bitou Bush Strategy), Paul Downey (NSW NPWS) and John Thorp (National Weeds Management Facilitator).

Maps: Australian Weeds Committee.

In northern parts of its range, two spraying programs a year may be needed to prevent bitou bush seeding.
Photo: Rhonda James

How to control bitou bush

Quick reference guide

Applying herbicide to stems immediately after cutting should prevent regrowth.
Photo: Rhonda James

For large infestations

A sustained control effort is required for large infestations. Hand pull seedlings and plants up to 1 m tall. For larger plants, apply a recommended herbicide immediately after cutting. Match treatment areas to the resources available for follow-up works. Under the right conditions, infested areas can be burnt to encourage germination of the seedbank. New seedlings must be removed before they flower.

For small infestations

Destroy established plants before they flower and produce fruit, to prevent the spread of seed. Treat isolated plants with a recommended herbicide applied by spot spraying.

In rainforests

A combination of spot spraying, mechanical removal and biocontrol may be the most effective for rainforest infestations. Keep soil disturbance to a minimum to reduce the risk of stimulating germination. Treat healthy infestations of bitou bush near the edges of the rainforest. Once bitou bush is removed, fast-growing rainforest species will regenerate.

Revegetation in other areas

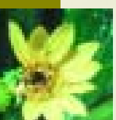
Once bitou bush is controlled other weeds may invade, so only tackle areas where follow-up control is possible. Follow up with direct seeding or planting of indigenous species.

Follow-up control

Because of the large and persistent seedbanks in the soil, follow-up control is required for about ten years.

Disposal

Remove seeds and burn them. Stands of dead bitou bush can either be left until they decompose or are physically removed.



Control options

Type of infestation	Herbicide	Biological	Physical	Burning
Large infestation – large area, many plants	Spray to kill seedlings before flowering. Contact authorities for information about registered herbicides.	The bitou tip moth and bitou seed fly are distributed along most of the range of bitou bush.	Hand pull or cut woody plants in spring.	Fire can be used to reduce the large soil seedbank.
Isolated plants or small infestations	Spot spray or use cut and paint treatment.	Not suitable.	Remove plants before they set seed.	Not suitable.
Rainforests	Spray to kill seedlings before flowering. Contact authorities for information about registered herbicides.	Use in combination with spot spraying and mechanical removal.	Hand pull or cut woody plants in spring.	Not recommended because of sensitive nature of rainforest plants to burning.

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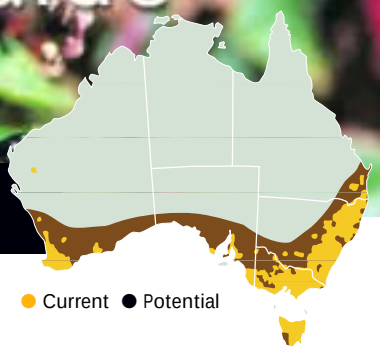
CRC Weed management

Weed Management Guide

Blackberry –
***Rubus fruticosus* aggregate**



Blackberry (*Rubus fruticosus* aggregate)

The problem

Blackberry is a *Weed of National Significance*. It is regarded as one of the worst weeds in Australia because of its invasiveness, potential for spread, and economic and environmental impacts.

Blackberry has invaded the banks of watercourses, roadsides, pastures, orchards, plantations, forests and bushland throughout temperate Australia. On farms blackberries reduce pasture production, restrict access to water and land, and provide food and shelter for pest animals such as foxes. In some cases the cost of plantation forestry may be increased, especially during establishment, because blackberries impede access for manual operations.

Other impacts are increased fire hazards caused by the large amount of dead material present in blackberry thickets and a substantial decrease in property values where heavy infestations occur. Control costs are often high.

Weeds such as blackberries also affect tourism, reducing the natural attraction of the bush and hindering recreational activities where thickets prevent access to natural features.

The weed

The name 'blackberry' covers at least 14 different but closely related species, some of which may be hybrids, that have become naturalised in Australia.

Blackberries hinder recreational activities by preventing access to natural features: Loddon River in central Vic.
Photo: Kate Blood

Blackberry is a perennial, semi-deciduous shrub with prickly stems (canes) that take root where they touch the ground, often forming thickets up to several metres high. It varies from sprawling to almost erect. The stems, which grow up to 7 m long, may be green, purplish or red, and are generally thorny and moderately hairy. Young canes emerge from buds on the woody root crown each spring and grow very rapidly (50–80 mm a day).

Leaves are usually dark green on top with a lighter green underside. The leaf veins and stalks are covered with short prickles. Clusters of flowers are white or pink.

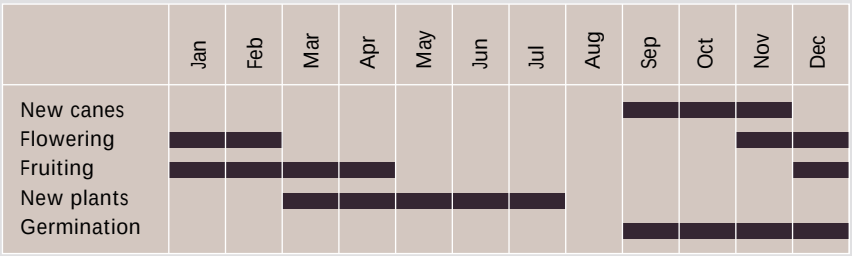
The berries change colour from green to red to black as they ripen. The plant is semi-deciduous and sheds its leaves in winter.

Key points

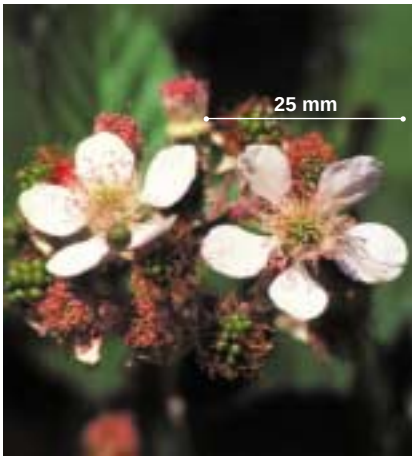
- At least 14 different but closely related species of blackberry are naturalised in Australia.
- Some species could spread further within the climatic limits of blackberry's range.
- Blackberry management programs must be planned and sustained over a number of years.
- Biological control will not eradicate blackberry, but will slow the rate of spread and allow more time for control by other means. Rust has been the most successful biocontrol so far.
- In revegetation programs, native seedlings that are able to germinate and actively grow over winter have a competitive advantage.

Natural Heritage Trust
Helping Communities Helping Australia
An Australian Government Initiative

Growth calendar



Blackberry has a two-year growth pattern. Young canes start growing in spring, flowering occurs from late November to late February and fruiting from late December to April. New (daughter) plants develop at the tips of first-year canes throughout autumn and winter. Most germination takes place during spring and early summer.



Blackberry plants produce clusters of white or pink flowers.
Photo: Kate Blood

How it spreads

One berry may contain as many as 80 seeds which are easily spread by birds, mammals (especially foxes) and water. Bushwalkers and other recreational users can also spread seeds, as can moving soil from one place to another. Blackberry roots can be spread to clean areas by cultivation.

Blackberry will persist indefinitely in an area unless it is treated. Plants that die are replaced by seedlings or daughter plants produced by nearby individuals. Plants may produce up to 13,000 seeds per square metre.

Where it grows

About 8.8 million ha of Australia is infested with blackberry, which thrives in a wide range of habitats. It can dominate pastures and native ecosystems as well as invade disturbed sites in urban areas. In badly affected areas, dense infestations often fill whole gullies and can extend for a width of tens of metres along both sides of streams.

The plant is restricted to temperate climates with an annual rainfall of at least 700 mm, and can occur at any altitude in Australia. Blackberry plants grow above the snowline in Victoria at about 1950 m altitude.

Potential distribution

Blackberry has probably reached the climatic limits (in terms of temperature and rainfall) of its potential range in Australia. However, individual species may spread further within these climatic limits. A few scattered infestations exist outside of the projected range under ideal conditions in Western Australia.

Berries change colour from green to red to black as they ripen.
Photo: Kate Blood

Blackberry bushes often form thickets up to several metres high.
Photo: John Hosking

What to do about it

The major challenges in managing blackberry are to prevent its spread, control and reduce existing infestations, and rehabilitate treated areas to prevent reinfestation.

In its long history as a noxious weed, blackberry has been managed by a range of control techniques, including burning, slashing, grazing, grubbing, chemical spraying and biological control.

Blackberry management programs must be planned and sustained over a number of years to prevent the rapid return of the infestation.

Apply herbicides to healthy plants

In general, the best time to spray blackberry is during the flowering–fruiting period, but the effective spraying season can start before flowering and extend long after fruiting, into autumn.

It is easy to kill young blackberry seedlings with herbicide. However, well established blackberry thickets have a large number of root crowns of different ages, and the older and bigger ones are usually hard to kill.

If using herbicides taken up by the leaves, avoid slashing in the season before application; it can reduce the effectiveness since only the new canes will be available to take up the herbicide.

The prickly stems, known as canes, may grow up to 7 m long. The leaves are usually dark green on top with a lighter green underside.
Photo: John Hosking

Do not apply herbicides to stressed plants. Conditions such as drought or severe low or high temperatures can decrease the effectiveness of herbicide action. As a guide, look at the tips of the canes. In times of active growth (the best time to spray) these will be producing fresh new leaves, and any new growth should be healthy, not wilted.

The success of herbicide treatment can also vary between the different groups of blackberry. Some produce fewer crowns per square metre than others and fewer canes per crown. Other features such as larger leaves and canes and hairier leaf surfaces (which may reduce absorption) can also affect herbicide uptake.

Methods of herbicide application

High-volume spraying is recommended for spot spraying, particularly in dense infestations or large blackberry thickets. If using this method, spray the inside of bushes first, ensuring good coverage of stems and leaves. Then spray outside leaves, runners and tips. Take particular care with this method because it is very easy to overdose and affect off-target species or contaminate waterways. Likewise, mist blowers or air blast sprayers can be effective but allow little control over spray distribution due to spray drift. None of these methods are suitable for use near susceptible native species.

In remote areas where water for herbicide application is not available, pellets or granular herbicides can be effective. These are applied to the soil surface and the chemical is leached by rain into the root zone where the roots take it up. This method is not suitable for use near native vegetation. Results of some trials have shown that slashing before application of granular herbicide gives better results than using granules alone.

The use of a gas-powered gun has been suggested as a method which enables very accurate application of herbicide onto target plants. It can be used to control scattered blackberries to a height of 1.5 m. Knapsack units are most suitable for spraying small scattered bushes and seedlings.

For small areas of high conservation significance, the 'cut and paint' method is recommended. This involves cutting blackberry canes close to ground level and immediately painting cut stems with herbicide. However, it should be used only on small plants and retreatment is likely to be necessary.

Slashing will not kill blackberry

Although cutting blackberry plants off at ground level does not kill them, slashing can help open up dense stands for follow-up control by other methods. Regular (fortnightly or monthly) slashing or mowing forces the plant to regrow, using up root reserves and making it weaker. Slashing in summer can enhance the effect of blackberry leaf rust because regrowth stimulated by the slashing is very susceptible to the rust fungus.

Hand weeding

This is only effective in very small infestations. Even seedlings and small plants are difficult to pull out by hand. If possible, all of the root system should be removed using a mattock or shovel because blackberry will regrow from any root fragments left in the soil.

Dense infestations may require mechanical control

In dense infestations mechanised weeding with large earthmoving equipment may sometimes be necessary. Remove plants and surface soil with a bulldozer ('scalping') to ensure crowns and most of the roots are dug out. Afterwards, rake roots and leave them to dry out in the sun or collect them in piles for burning. Regrowth from crowns, root fragments and seed is inevitable, so follow-up treatment and site rehabilitation are essential.

Grazing with goats

Goats at high stocking rate can be used to control blackberry in pasture but their use must be continuous to prevent regrowth occurring.

Regrowth is inevitable after mechanical removal so follow-up treatment is necessary.
Photo: Ian Walton, DPI Vic

Weed control contacts

State / Territory	Department	Phone	Email	Website
ACT	Environment ACT	(02) 6207 9777	EnvironmentACT@act.gov.au	www.environment.act.gov.au
NSW	NSW Agriculture	1800 680 244	weeds@agric.nsw.gov.au	www.agric.nsw.gov.au
Qld	Dept of Natural Resources and Mines	(07) 3896 3111	enquiries@nrm.qld.gov.au	www.nrm.qld.gov.au
SA	Dept of Water, Land and Biodiversity Conservation	(08) 8303 9500	apc@saugov.sa.gov.au	www.dwlbc.sa.gov.au
Tas	Dept of Primary Industries, Water and Environment	1300 368 550	Weeds.Enquiries@dpiwe.tas.gov.a	www.dpiwe.tas.gov.au
Vic	Dept of Primary Industries/Dept of Sustainability and Environment	136 186	customer.service@dpi.vic.gov.au	www.dpi.vic.gov.au www.dse.vic.gov.au
WA	Dept of Agriculture	(08) 9368 3333	enquiries@agric.wa.gov.au	www.agric.wa.gov.au
Australia wide	Australian Pesticides and Veterinary Medicines Authority	(02) 6272 5852	contact@apvma.gov.au	www.apvma.gov.au

For up-to-date information on which herbicides are registered to control blackberry and the best application methods and dosages, contact your state or territory weed management agency or local council. This information varies from state to state and from time to time. Contact details are listed above, including contacts for the Australian Pesticides and Veterinary Medicines Authority, which hosts the PUBCRIS database. This database contains information on all herbicides that are registered for use on weeds in each Australian state and territory.

When using herbicides always read the label and follow instructions carefully. Particular care should be taken when using herbicides near waterways because rainfall running off the land into waterways can carry herbicides with it. Permits from state or territory Environment Protection Authorities may be required if herbicides are to be sprayed on riverbanks.

Biological control with the blackberry leaf rust

The program with the greatest likelihood of success in the foreseeable future includes biological control, particularly on large, inaccessible infestations of blackberry. The blackberry leaf rust *Phragmidium violaceum*, which attacks the leaves, is now present throughout all areas of southern Australia where blackberries are a problem. It affects the leaves and can also grow on flowers, unripe fruit and young canes. The rust is harmless to native *Rubus* species and varieties of commercial raspberry and brambleberry such as loganberry, boysenberry and youngberry. The rust alone will not eradicate blackberry but it slows its rate of spread and allows more time for control by other means.

The rust appears as purple-brown blotches, 2–3 mm in diameter, on the upper surface of the leaf. Corresponding powdery yellow or sticky black pustules of spores appear on the leaf's lower surface.

Epidemics of rust caused by summer spores initially kill leaves in summer and autumn, forcing the plants to grow new leaves, which in turn are attacked by the rust. Rust epidemics result in fewer fruit and seeds, shorter canes and fewer new plants.

This continuous attack on the leaves weakens plants by depleting root reserves. Light can start penetrating the thicket, which helps revegetation by other plants, especially in autumn and winter. Competing plants can then grow through the blackberry and in turn limit its growth by shading.

The blackberry rust has been so effective in the Gippsland region of Victoria that farmers complained about having to re-do their fencing when blackberry hedges fell down! However, the rust seems to be severe only in regions where the annual rainfall is greater than 800 mm and the average daily maximum temperature for January is close to 20ºC.

Different blackberry species vary in their susceptibility to the rust, from very susceptible to highly tolerant. The effectiveness also varies between years, according to seasonal conditions. A sufficiently high level of infection is not always present early enough to prevent seed production and tip rooting of canes. Although the rust has had a big impact on the more common and widespread blackberry strains, some less widespread groups are resistant, giving them an advantage, and resulting in their gradual takeover and a continuation of the overall blackberry problem.

Slashing can help open up dense stands of blackberry for follow-up control by other methods. Photo: Adam Whitchurch, DPI Vic

Blackberry control strategies must address all the strains present in a region. Management actions which target only some of the species will result in one strain replacing another, with no net decrease in blackberry cover. For example, while the blackberry leaf rust is successfully controlling one species in the Strzelecki Ranges of Victoria, another rust resistant group is rapidly spreading to fill the niche.

To address this issue, additional rust strains are being tested in CSIRO's quarantine facility in Canberra before their expected release throughout Australia during 2003–04. Matching virulent rust strains to susceptible blackberry species is essential for successful biological control. Just as important are suitable weather and blackberry growing conditions for development of rust disease.

Although rust epidemics can look spectacular, blackberry is a very vigorous plant and can survive repeated attacks over a number of years before its root system begins to be depleted. It can take up to five years of rust infection for large well-established blackberry infestations to open up enough to allow other plants to grow through.

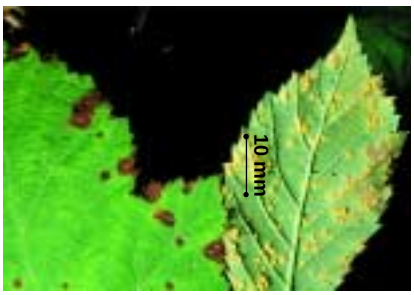
Integrated control

Blackberry should be inspected during summer–autumn and herbicide treatment planned for any infestations that are not attacked heavily by rust. Research has shown that spraying herbicides after the rust has killed some leaves gives equal or better control than application earlier in the season.

Where rust is having little impact, the use of herbicides is usually necessary since mature blackberry is able to regenerate readily from roots following burning or slashing.

Use of competitive native species

Maintaining good quality groundcover can help control blackberry seedlings. If rapid regeneration of fast-growing native species can be achieved, these can out-shade seedlings and outcompete them for water and nutrients. Blackberry roots do not develop much over winter so native seedlings able to germinate and actively grow during this period will have a definite competitive advantage.



The blackberry rust appears as purple-brown blotches on the upper leaf (*left*) and powdery yellow or sticky black pustules of spores on the lower surface (*right*).
Photo: John Hosking

Careful use of prescribed fire

This is used mainly as a follow-up to herbicide application to clear areas of dead canes and re-establish access for rehabilitation of the treated area.

Follow-up

Once an area has been treated it will be necessary to monitor it for many years and destroy new plants.

Legislation

Blackberry is declared noxious in all states and territories except the Northern Territory. Landowners are required to control it. Check with your local council or state/territory government agency about its requirements for blackberry control.

Acknowledgments

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Maps: Australian Weeds Committee.

...case study

Keeping Western Australia's Porongurup National Park blackberry free

In Western Australia's Porongurup National Park an integrated approach has been adopted to tackle blackberries, involving government departments, landholders and volunteer groups.

The aim of the program, which is targeting satellite infestations on the northeastern edge of the park, is to move the blackberry front 20 km away from the park. This involves controlling infestations both on farms (to stop them entering the park) and in the park (to stop them spreading to farmland).

Agriculture WA provides herbicide to landholders, who contribute the labour.

"While from an individual point of view, there may not be a great incentive to get rid of blackberries, the community is proud of the park, and neighbours will put pressure on each other to clear up infestations", says coordinator of the program, John Moore of Agriculture WA.

The program runs training days and equipment is available for loan. The landowners include hobby farmers with small holdings where infestations are too large to tackle using hand-held equipment.

The program includes a number of approaches, including the use of specific herbicides for large infestations, which are different from herbicides used in gardens, vineyards and other sensitive areas. Some people don't want to use herbicides at all so they may be using other techniques such as mowing, cultivation, burning or grazing with goats before seed sets.

Landholders can see the impact of blackberries and where they have been controlled in the park. For example, in some unsprayed areas tall karri (*Eucalyptus diversicolor*) trees rise through the blackberries, which dominate the undergrowth. In comparison, native grasses and understorey plants are growing in some sprayed areas where all blackberries and a small amount of native vegetation have been killed.

How to control blackberry

Quick reference guide

Prevention

Keep uninfested areas clear of blackberry and remove isolated plants before they have a chance to seed.

Herbicide control

Consult a specialist for advice on registered herbicides in your state or territory (see the contacts table on p. 4). Apply herbicide to actively growing plants – look at the tips of the canes and spray when they are producing fresh new leaves.

Physical control

Slashing can help open up dense stands for follow-up control by other methods, and in summer can enhance the effect of blackberry leaf rust.

Mechanical control is difficult and most of the root system must be removed for effective control – blackberry will regrow from any root fragments left in the soil. In dense infestations bulldozers may be used to remove plants but follow-up treatment is essential.

Biological control

Biological control offers the greatest likelihood for success in large, inaccessible infestations. The existence of at least 14 different groups or strains of blackberry in Australia makes biological control difficult as some groups are more susceptible to the blackberry leaf rust than others.

Rust fungi have established well in some high rainfall areas but have failed to have an impact elsewhere. Additional rust strains are being tested in quarantine and are expected to be released in 2003–04.

Blackberries are easily spread by birds, mammals and water.
Photo: Kate Blood

The blackberry rust is most effective during late summer and autumn in cool, moist environments such as Gippsland, Vic.
Photo: El Bruzzese, DPI Vic

Control options

Control option	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Herbicide application	✓	✓	✓	✓					✓	✓	✓	✓
Mechanical removal (incl. grazing)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Burning			✓	✓	✓	✓	✓	✓	✓	✓		
Biological control (release rust)	✓										✓	✓

✓ Optimum times for blackberry control methods

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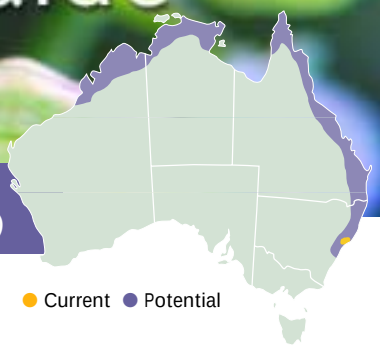
CRC Weed management

Weed Management Guide

Chinese violet
(*Asystasia gangetica* ssp. *micrantha*)



Chinese violet (*Asystasia gangetica* ssp. *micrantha*)

The problem

Asystasia gangetica subspecies (ssp.) *micrantha* is on the *Alert List for Environmental Weeds*, a list of 28 non-native plants that threaten biodiversity and cause other environmental damage. Although only in the early stages of establishment, these weeds have the potential to seriously degrade Australia's ecosystems.

A. gangetica ssp. *micrantha* is a form of Chinese violet. As an environmental weed, it smothers other ground plants and displaces vegetation, which reduces the availability of habitat for native plants and animals and therefore reduces biodiversity.

It is a major weed overseas, particularly in Malaysia, Indonesia and the Pacific islands. In these places it infests plantations, particularly oil-palm crops, and competes effectively for soil nutrients, reducing productivity and increasing crop management costs. It could also become an agricultural weed in Australia.

Another closely related species, *Asystasia gangetica* ssp. *gangetica*, has also become naturalised in the Northern Territory and Queensland.

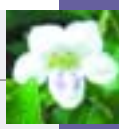
The weed

A. gangetica ssp. *micrantha* is a perennial creeper that grows rapidly, up to 0.5 m high alone but to 3 m high on supporting vegetation. It forms roots when the nodes (the joins between segments on the stem) make contact with moist soil, ultimately forming mats or a sprawling mass of stems similar to those of *Tradescantia fluminensis*, commonly known as wandering creeper.

Both the leaves and the stems have scattered hairs. Occurring in opposite pairs, the leaves are oval, sometimes nearly triangular in shape, paler on the underside, and may be up to 25-165 mm long and 5-55 mm wide. White bell-shaped flowers, 20–25 mm long, have purple blotches in two parallel lines inside. The seed capsules are about 30 mm long, club-shaped (the neck is attached to the stem) and contain four flattened seeds held in place by conspicuous hooks.

The two parallel purple stripes within the white flower are a distinctive feature of *A. gangetica* ssp. *micrantha*.
Photo: Graham Prichard, Port Stephens Council, NSW

Key points



- *Asystasia gangetica* ssp. *micrantha* is a mat-forming creeper which can smother more desirable plants.
- Prevention and early intervention are the most cost-effective forms of weed control.
- Avoid creating bare areas where *A. gangetica* ssp. *micrantha* and other weeds can invade.
- If you see a plant that may be *A. gangetica* ssp. *micrantha*, contact your local council or state or territory weed management agency. Do not attempt control on your own, as it can spread very easily from both seeds and stems.

Natural Heritage Trust
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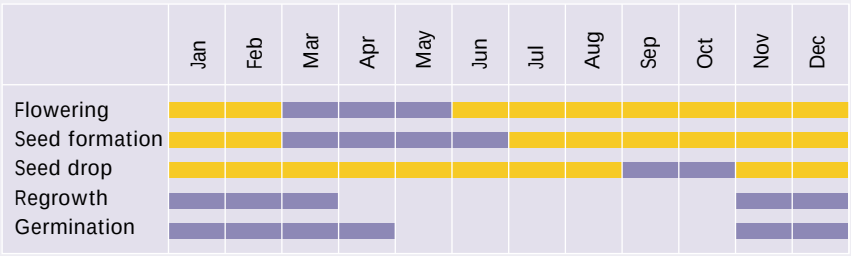
Alert List For Environmental Weeds ALERT

Growth calendar



A. gangetica ssp. *micrantha* can flower and fruit year round. In the Port Stephens area in New South Wales, it grows rapidly following germination and throughout flowering and seed capsule production. In the final stage of its life cycle, the plant dies back to ground level after most of the ripe capsules have released their seeds. Winter frosts kill the above-ground plant parts but plants regrow the following spring from basal shoots.

In tropical climates plant growth is probably continuous, especially in moist conditions or following rainfall.

The seeds are released when the seed capsules dry out.
Photo: Graham Prichard, Port Stephens Council, NSW

How it spreads

A. gangetica ssp. *micrantha* spreads by seeds, which are released explosively from drying capsules, and by trailing stems that can produce roots when nodes make contact with moist soil. The main method of dispersal over long distances is by human activities, such as mining, gardening, landscaping and roadworks. The dumping of garden waste is thought to have caused most of the outbreaks in New South Wales, although it has also spread at a great rate from garden plantings.

Where it grows

A. gangetica ssp. *micrantha* grows in tropical and subtropical areas. It is native to India, the Malay Peninsula and Africa. It was first recorded as naturalised in Australia at Boat Harbour, north of Newcastle, New South Wales, in 1999. Infestations have now been identified at nearby Anna Bay and Fern Bay. These infestations are spread over a distance of 9 km and range in size from 2 square metres to several hectares. Most of the infestations are small and occur on vacant residential land, along fencelines and in neglected garden beds. Several larger outbreaks are present along roadsides and on crown land.

In all these cases the plant is found on coastal sandy soils but it is thought to tolerate a wide range of soil types. It prefers full sun or part shade. Plants in deep shade do not thrive and become spindly, awaiting a break in the canopy. Often, plants in more exposed sites show some yellowing of the leaves, especially during winter.

A. gangetica ssp. *micrantha* was cultivated in the Darwin Botanic Gardens but it appears to have been eradicated by persistent manual removal and by allowing other plants to outcompete it in shady areas.

Most infestations north of Newcastle, NSW, occur on vacant residential land, along fencelines, and in abandoned flower beds and adjacent bushlands.
Photo: Andrew Storrie, NSW Agriculture

Why we need to be 'alert' to *A. gangetica* ssp. *micrantha*

Both subspecies of *A. gangetica* are problem weeds throughout much of South-East Asia, including Malaysia, Indonesia, Papua New Guinea and the Pacific islands. They both grow widely as weeds in rubber, oil-palm, coffee and other crops, but *A. gangetica* ssp.

Another subspecies of *Asystasia gangetica*

A. gangetica ssp. *gangetica* is less weedy and is planted widely in Australia. Its flowers are 30–40 mm long and blue–mauve in colour, whereas *A. gangetica* ssp. *micrantha* has slightly shorter flowers that are mainly white. *A. gangetica* ssp. *gangetica* is naturalised at Port Douglas in Queensland and at Bartalumba Bay and Groote Eylandt in the Northern Territory. There is also at least one Australian native species of *Asystasia* (*A. australasica*), which occurs in northern Queensland.

micrantha is particularly troublesome in oil-palm plantations. If it became established in Australia, it could potentially affect crops such as soybeans, vegetables, cut flowers and oil-teatree. Its success over a wide geographical range is due to its fast establishment, rapid growth rate, early flowering and high seed production.

As an environmental weed, it could have similarly significant effects, smothering native vegetation and destroying the habitat of many birds and animals. It has shown a tolerance to a range of subtropical and tropical climates, and could be suited to a large part of Australia's environment.

What to do about it

Prevention is better than the cure

As with all weed management, prevention is better and more cost-effective than control. The annual cost of weeds to agriculture in Australia, in terms of decreased productivity and management costs, is conservatively estimated at $4 billion. Environmental impacts are also significant and lead to a loss of biodiversity. To limit escalation of these impacts, it is vital to prevent further introduction of new weed species, such as *A. gangetica* ssp. *micrantha*, into uninfested natural ecosystems.

A. gangetica ssp. *gangetica* has purple flowers. It is naturalised across parts of northern Australia. Photo: Colin G. Wilson

Early detection and eradication are also important to prevent infestations of *A. gangetica* ssp. *micrantha*. Small infestations can be easily eradicated if they are detected early but an ongoing commitment is needed to ensure new infestations do not establish.

The Alert List for Environmental Weeds

The Federal Government's *Alert List for Environmental Weeds* was declared in 2001. It consists of 28 weed species that currently have limited distributions but potentially could cause significant damage. The following weed species are therefore targeted for eradication:

Scientific name	Common name	Scientific name	Common name
Acacia catechu var. *sundra*	cutch tree	*Koelreuteria elegans*	Chinese rain tree
Acacia karroo	Karroo thorn	*Lachenalia reflexa*	yellow soldier
Asystasia gangetica ssp. *micrantha*	Chinese violet	*Lagarosiphon major*	lagarosiphon
Barleria prionitis	barleria	*Nassella charruana*	lobed needle grass
Bassia scoparia	kochia	*Nassella hyalina*	cane needle grass
Calluna vulgaris	heather	*Pelargonium alchemilloides*	garden geranium
Chromolaena odorata	Siam weed	*Pereskia aculeata*	leaf cactus
Cynoglossum creticum	blue hound's tongue	*Piptochaetium montevidense*	Uruguayan rice grass
Cyperus teneristolon	cyperus	*Praxelis clematidea*	praxelis
Cytisus multiflorus	white Spanish broom	*Retama raetam*	white weeping broom
Dittrichia viscosa	false yellowhead	*Senecio glastifolius*	holly leaved senecio
Equisetum spp.	horsetail species	*Thunbergia laurifolia*	laurel clock vine
Gymnocoronis spilanthoides	Senegal tea plant	*Tipuana tipu*	rosewood
Hieracium aurantiacum	orange hawkweed	*Trianoptiles solitaria*	subterranean cape sedge

Weed control contacts

State / Territory	Department	Phone	Email	Website
ACT	Environment ACT	(02) 6207 9777	EnvironmentACT@act.gov.au	www.environment.act.gov.au
NSW	NSW Agriculture	1800 680 244	weeds@agric.nsw.gov.au	www.agric.nsw.gov.au
NT	Dept of Natural Resources, Environment and the Arts	(08) 8999 4567	weedinfo.nreta@nt.gov.au	www.nt.gov.au
Qld	Dept of Natural Resources and Mines	(07) 3896 3111	enquiries@nrm.qld.gov.au	www.nrm.qld.gov.au
SA	Dept of Water, Land and Biodiversity Conservation	(08) 8303 9500	apc@saugov.sa.gov.au	www.dwlbc.sa.gov.au
Tas	Dept of Primary Industries, Water and Environment	1300 368 550	Weeds.Enquiries@dpiwe.tas.gov.au	www.dpiwe.tas.gov.au
Vic	Dept of Primary Industries/Dept of Sustainability and Environment	136 186	customer.service@dpi.vic.gov.au	www.dpi.vic.gov.au www.dse.vic.gov.au
WA	Dept of Agriculture	(08) 9368 3333	enquiries@agric.wa.gov.au	www.agric.wa.gov.au

The above contacts can offer advice on weed control in your state or territory. If using herbicides always read the label and follow instructions carefully. Particular care should be taken when using herbicides near waterways because rainfall running off the land into waterways can carry herbicides with it. Permits from state or territory Environment Protection Authorities may be required if herbicides are to be sprayed on riverbanks.

Flowers, leaves, and ripe and unripe seed capsules of *A. gangetica* ssp. *micrantha*.
Photo: Graham Prichard, Port Stephens Council, NSW

Quarantine to prevent further introductions

The importation of either subspecies of *Asystasia gangetica* into Australia is not permitted because of the risk of further spread, and the potential introduction of new genetic diversity that could make future control more difficult.

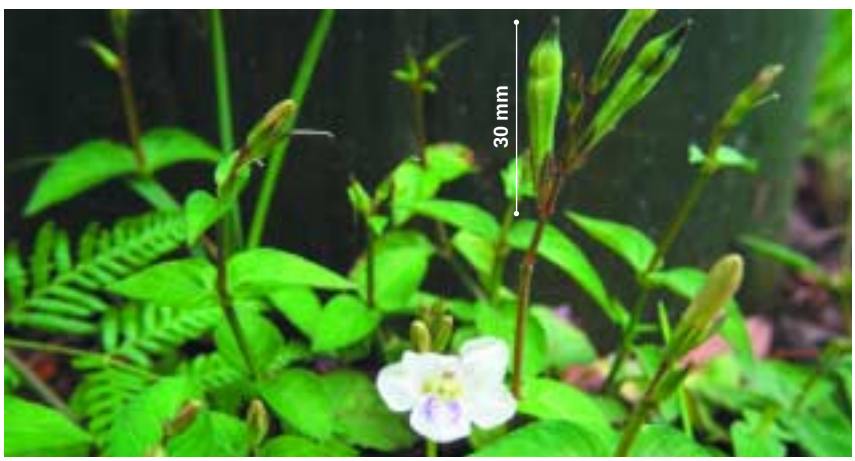
Do not buy seeds via the internet or from mail order catalogues unless you check with quarantine first and can be sure that they are free of weeds like *Asystasia gangetica* ssp. *micrantha*.
Call 1800 803 006 or see the Australian Quarantine and Inspection Service (AQIS) import conditions database <www.aqis.gov.au/icon>. Also, take care when travelling overseas that you do not choose souvenirs made from or containing seeds, or bring back seeds attached to hiking or camping equipment. Report any breaches of quarantine you see to AQIS.

Raising community awareness

Some 65% of weeds, including *A. gangetica* ssp. *micrantha*, which have recently established in Australia have escaped from plantings in gardens and parks. The detrimental impacts of these weeds far outweigh any potential horticultural benefits. The public should be made more aware of these impacts, and other issues such as how to identify *A. gangetica* ssp. *micrantha* and what to do if they find it.
A. gangetica ssp. *micrantha* is easiest to identify when in flower. It has white flowers with two parallel purple lines on raised ridges on its inside. The leaves and stems have scattered hairs, and hooks on the seeds are also distinctive.

New infestations of *A. gangetica* ssp. *micrantha*

Because there are relatively few *A. gangetica* ssp. *micrantha* infestations, and it can potentially be eradicated before it becomes established, any new outbreaks should be reported immediately to your state or territory weed management agency or local council. Do not try to control *A. gangetica* ssp. *micrantha* without their expert assistance. Control effort that is poorly performed or not followed up can actually help spread the weed and worsen the problem.



A. gangetica ssp. *micrantha* is one of many environmental weeds that have spread into bushland from initial plantings in gardens.
Photo: Graham Prichard, Port Stephens Council, NSW

Methods to control *A. gangetica* ssp. *micrantha*

Management of the soil seedbank is the key to control of established infestations of *A. gangetica* ssp. *micrantha*. This will involve persistent follow-up for several years in cooperation with your state or territory weed management agency or local council.

Hand weeding requires extreme care

Stems of *A. gangetica* ssp. *micrantha* break up easily and the plant can propagate from cuttings, so unless done carefully, hand pulling can cause infestations to spread. Because plant material may contain seeds, it is important to bag all cuttings for disposal. Hand pulling seedlings and small plants is suited to small infestations with easy access.

Seek help in disposing of plants

Much of the spread of *A. gangetica* ssp. *micrantha* has been attributed to the incorrect disposal of plant parts. Extreme care must be taken when disposing of hand-pulled plants, especially if seeds are present. Seed may also be inadvertently moved in contaminated soil. The best disposal methods which will kill seeds cheaply and easily are still being investigated. Use a conservative approach and contact your local council or state/territory weed management agency for specific advice before attempting to dispose of *A. gangetica* ssp. *micrantha*.

Herbicides are being trialled for suitability

Maintaining groundcover and competitive desirable species is important, so get advice before spraying. Trials are being carried out by the NSW Department of Agriculture to identify suitable selective herbicides for *A. gangetica* ssp. *micrantha*. Work to date indicates that it is susceptible to a wide range of selective broadleaf herbicides (those that do not kill grasses).

Infestations smother other ground vegetation: Anna Bay, north of Newcastle, NSW.
Photo: Andrew Storrie, NSW Agriculture

Herbicides to control *A. gangetica* ssp. *micrantha* are registered for 'off-label' minor use through the permit system of the Australian Pesticides and Veterinary Medicines Authority (APVMA) <www.apvma.gov.au> until October 2008. For more information, contact the APVMA (by phone: (02) 6272 5852 or email: contact@apvma.gov.au), your local council weeds officer or state or territory weed management agency.

Other control options

Slashing prior to seed set may help control *A. gangetica* ssp. *micrantha*. However, equipment must be carefully cleaned to prevent further spread. Cultivation should be avoided due to the risk of spreading plant fragments.

The effect of fire on the soil seedbank is unknown and it is not being used as a strategy to manage existing infestations.

There are no known biological control agents in Australia for this species. Biological control is a slow process and is normally intended to control a weed rather than eradicate it.

Revegetation to prevent reinfestation

Competition from other vegetation can help suppress seedling germination. Planting alternative indigenous groundcovers and avoiding bare ground wherever possible can help prevent *A. gangetica* ssp. *micrantha* taking hold.

Legislation

All subspecies of *Asystasia gangetica* have been added to the list of prohibited imports and can no longer be brought into Australia. Although *A. gangetica* ssp. *micrantha* is not declared as a noxious weed, it is marked for eradication by its inclusion on the *Alert List for Environmental Weeds*.

Acknowledgments

Information and guide revision: Graham Prichard (Port Stephens Council), John Hosking (NSW Agriculture/Weeds CRC), Barbara Waterhouse (AQIS/Weeds CRC), Andrew Storrie (NSW Agriculture/Weeds CRC), Richard Carter (NSW Agriculture/Weeds CRC), Bob Trounce (NSW Agriculture) and John Thorp (National Weeds Management Facilitator).

Maps: Data used in the compilation of actual and potential distribution maps provided by Australian herbaria via Australia's Virtual Herbarium and Sainty and Associates P/L, respectively.

If you find a plant that may be *A. gangetica* ssp. *micrantha*

Quick reference guide

Identification

You will first need to confirm its identity. Contact your state or territory weed management agency for help in identifying the plant. You will need to take note of the characteristics of the plant in order to accurately describe it. Some important features of *A. gangetica* ssp. *micrantha* are:

- white bell-shaped flowers, 20–25 mm long, with purple stripes in two parallel lines on the inside
- club-shaped seed capsules
- opposite leaves with an oval, sometimes nearly triangular, shape and up to 165 mm long. The leaves and stems have scattered hairs.

Reporting occurrences

Once identified, new occurrences of *A. gangetica* ssp. *micrantha* should be reported to the relevant state or territory weed management agency or local council, who will offer advice and assistance on its control. Because *A. gangetica* ssp. *micrantha* represents such a serious environmental and economic threat to Australia, its control should be undertaken with the appropriate expertise and adequate resources.

Follow-up work will be required

Once the initial infestation is controlled, follow-up monitoring and control will be required to ensure that reinfestation does not occur. Monitor treated areas monthly to detect and eradicate seedlings before they have a chance to produce seed.

Collecting specimens

State or territory herbaria can also identify plants from good specimens. These organisations can provide advice on how to collect and preserve specimens.

State/Territory	Postal Address	Phone	Web
Australian National Herbarium	GPO Box 1600 Canberra, ACT, 2601	(02) 6246 5108	www.anbg.gov.au/cpbr/herbarium/index.html
National Herbarium of New South Wales	Mrs Macquaries Rd Sydney, NSW, 2000	(02) 9231 8111	www.rbgsyd.nsw.gov.au
National Herbarium of Victoria	Private Bag 2000 Birdwood Avenue South Yarra, Vic, 3141	(03) 9252 2300	www.rbg.vic.gov.au/biodiversity/herbarium.html
Northern Territory Herbarium	PO Box 496 Palmerston, NT, 0831	(08) 8999 4516	http://www.nt.gov.au/ipe/pwcnt/
Queensland Herbarium	c/- Brisbane Botanic Gardens Mt Coot-tha Rd Toowong, Qld, 4066	(07) 3896 9326	www.env.qld.gov.au/environment/science/herbarium
South Australian Plant Biodiversity Centre	PO Box 2732 Kent Town, SA, 5071	(08) 8222 9311	www.flora.sa.gov.au/index.html
Tasmanian Herbarium	Private Bag 4 Hobart, Tas, 7000	(03) 6226 2635	www.tmag.tas.gov.au/Herbarium/Herbarium2.htm
Western Australian Herbarium	Locked Bag 104 Bentley DC, WA, 6983	(08) 9334 0500	http://science.calm.wa.gov.au/herbarium/

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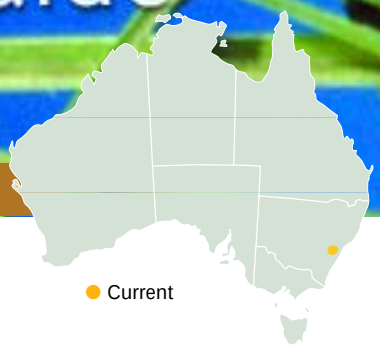
CRC Weed management

Weed Management Guide



Cyperus (*Cyperus teneristolon*)

The problem

Cyperus teneristolon is on the *Alert List for Environmental Weeds*, a list of 28 non-native plants that threaten biodiversity and cause other environmental damage. Although only in the early stages of establishment, these weeds have the potential to seriously degrade Australia's ecosystems.

There is no well-established common name for this species in Australia although 'cyperus' has been suggested. As many species share the common name cyperus, it has been decided to refer to the species here by its scientific name to prevent confusion.

C. teneristolon has become a significant weed of crops of the East African highlands, in particular Kenya. As it is a weed in overseas agricultural areas with climatic and environmental conditions similar to those that occur in Australia, it is seen as a potential threat to Australia's environment and agricultural productivity.

C. teneristolon has the potential to become a significant weed of crops in Australia. The population at Yosemite Creek, Katoomba, NSW is pictured here.
Photo: John Hosking, NSW Agriculture

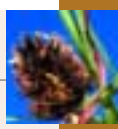
The weed

C. teneristolon is a perennial sedge which grows to 500 mm high. Sedges are evergreen plants with triangular stems that generally grow in damp areas. The species name *teneristolon* refers to the long and delicate stolons (ground-covering stems) that sprout new plants. The main flowering spike is egg-shaped, purple to black in colour, and made up of many tiny flowers (an 'inflorescence'), or spikelets, to 3 mm long with a distinctive point. The shape and colour of the inflorescence distinguishes *C. teneristolon* from all other sedge species. The fruit, produced from the mature flower, is dry, contains one seed and does not split open to release the seed when on the plant.

The leaves are 1–3 mm wide, have roughened margins and are bright green in colour. The roots are fibrous and the plant has an extensive rhizome system (underground stems) which supports its regrowth each season and helps it spread.

C. teneristolon has been observed breaking through special weedproof matting in a revegetation area alongside a creek line, suggesting the plant may potentially be an aggressive invader.

Key points



- Prevention and early intervention are the most cost-effective forms of weed control.
- *Cyperus teneristolon* is a problem overseas in environments similar to parts of Australia. For this reason it needs to be eradicated before it gets a chance to establish.
- It is capable of adapting to a variety of conditions and has the potential to invade creek systems in the Blue Mountains National Park and surrounding agricultural lands.
- *C. teneristolon* has three modes of reproduction: via rhizome, stolons and seed.

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Growth calendar

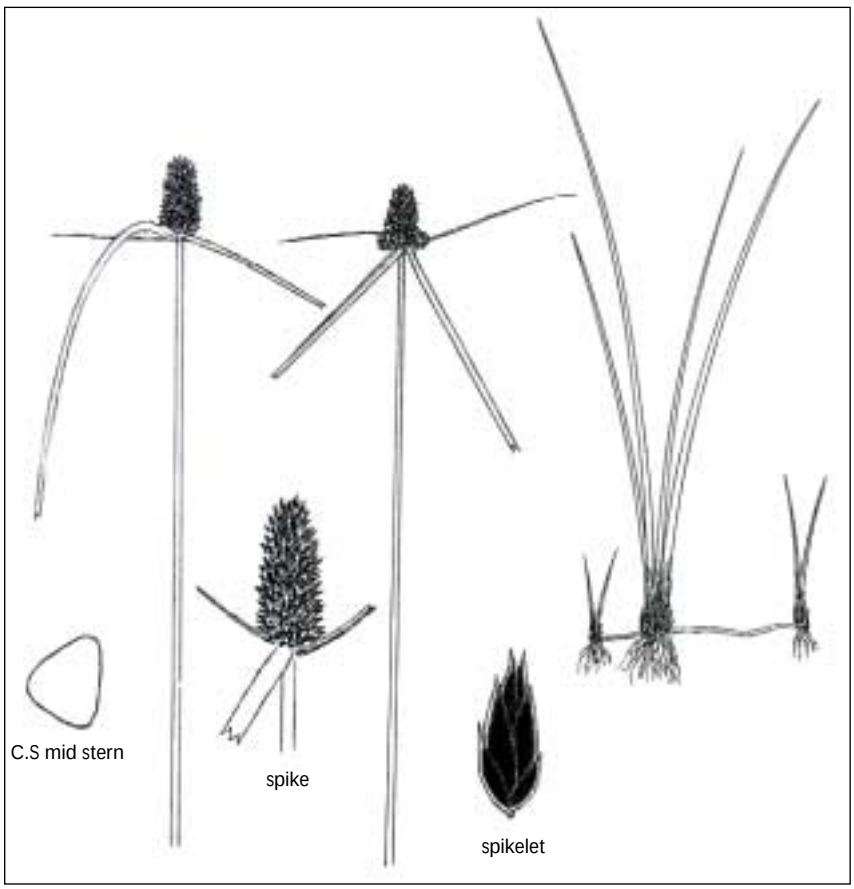
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering	■	■										■
Germination									■	■	■	
Regrowth									■	■	■	

■ General pattern of growth

Not much is known about the life cycle of *C. teneristolon* in Australia. The following information was obtained from its overseas locations, and from casual observations made in its current habitat in the Blue Mountains. Because *C. teneristolon* is a sedge, and from a tropical region, it does not go dormant during the winter, but slows its growth in cool periods. It regrows and germinates during the spring months, and flowers in the summer.

How it spreads

C. teneristolon is thought to have been introduced into the Australian natural environment by the dumping of garden plants at the Blue Mountains refuse tip. However, no source plant has ever been found. *C. teneristolon* is capable of spreading vegetatively, by its rhizome and stolon systems, and by seed. Its invasion of Yosemite Creek downstream from its source may have been via the movement of seed carried in the water. The whole spike will fall as one unit and eventually release the fruit (a nut) and the enclosed seed.



The roots of *C. teneristolon* are fibrous and the plant has an extensive rhizome system (underground stems) which supports its regrowth each season and helps it spread. Image not to scale.
Photo: Van Klaphake

The stolons spread the plant by clambering across the ground and forming new populations nearby. Rhizomes sprout new growth similarly, producing detached clumps. It is also possible for the stolons and rhizomes to break off and propagate in downstream locations, making the risk of spread even greater.

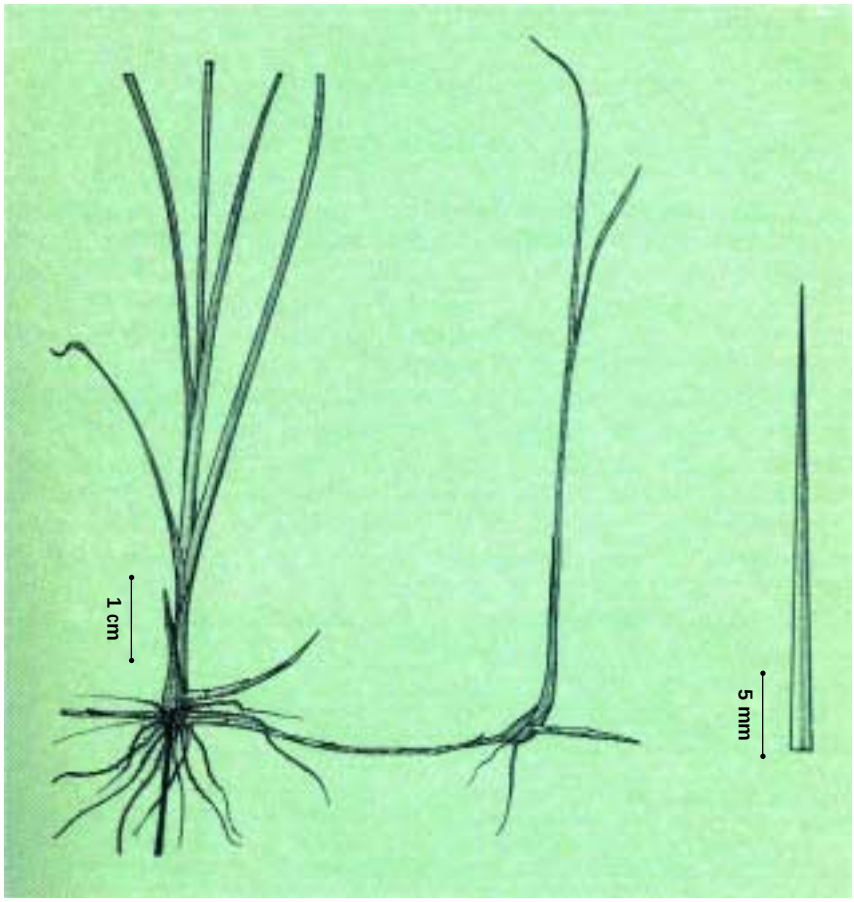
Where it grows

The only known occurrence of *C. teneristolon* in Australia invades a 2 km section of the Yosemite Creek in the Minnehaha Reserve of the Blue Mountains, New South Wales. It was first recognised as naturalised in Australia in February 2000, believed to be sourced from a refuse tip upstream of the current infestation.

C. teneristolon is native to Ethiopia and neighbouring countries, extending to South Africa. The Ethiopian climate is monsoonal, and temperatures range between approximately 20°C in the highlands and 40°C in the far eastern section of the country, where near-desert conditions exist. Most of the country is characterised by a high plateau (from 1500 m) and mountain ranges (up to 2440 m). Both native and naturalised populations of *C. teneristolon* suggest that it prefers highland areas with soils that are sandy and poor in nutrients.

C. teneristolon was able to naturalise after being dumped at a refuse tip in NSW

It has become a localised weed of crops in the semi-arid Kenyan and Tanzanian highlands, but has also invaded damp rocky outcrop areas of Natal, South Africa. The plant is therefore capable of adapting to varied environmental conditions but shows a preference for damp open areas or rock outcrops. This is very similar to its current habitat in the Blue Mountains. *C. teneristolon* grows beneath an overstorey of eucalypt along Yosemite Creek but will also grow in full-sun environments.



C. teneristolon is a perennial sedge with triangular stems that generally grows in damp areas.
Photo: Food and Agriculture Organisation of the United Nations

Why we need to be 'alert' to *C. teneristolon*

As it is a weed of both semi-arid agricultural crops and damp grasslands, the potential for its distribution in Australia is wide. *C. teneristolon* has spread 2 km from its source since approximately 1999, and may continue to threaten native ecosystems downstream if not managed. In Australia it has only been reported as occurring in relatively isolated patches. However, widespread invasion has been observed overseas. References to the weed in the report 'Kenyan Agricultural Research for Plant Protection' describe *C. teneristolon* as widespread and naturalised within the country's agricultural and natural areas, necessitating herbicide control.

The location of *C. teneristolon* in the greater Blue Mountains National Park should make it a priority for control while it is still at a manageable level. Manual removal has been undertaken in revegetation areas with some success, but its

The Alert List for Environmental Weeds

The Federal Government's *Alert List for Environmental Weeds* was declared in 2001. It consists of 28 weed species that currently have limited distributions but potentially could cause significant damage. The following weed species are therefore targeted for eradication:

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Chromolaena odorata	Siam weed	*Pereskia aculeata*	leaf cactus
Cynoglossum creticum	blue hound's tongue	*Piptochaetium montevidense*	Uruguayan rice grass
Cyperus teneristolon	cyperus	*Praxelis clematidea*	praxelis
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Dittrichia viscosa	false yellowhead	*Senecio glastifolius*	holly leaved senecio
Equisetum spp.	horsetail species	*Thunbergia laurifolia*	laurel clock vine
Gymnocoronis spilanthoides	Senegal tea plant	*Tipuana tipu*	rosewood
Hieracium aurantiacum	orange hawkweed	*Trianoptiles solitaria*	subterranean Cape sedge

Weed control contacts

State / Territory	Department	Phone	Email	Website
ACT	Environment ACT	(02) 6207 9777	EnvironmentACT@act.gov.au	www.environment.act.gov.au
NSW	NSW Agriculture	1800 680 244	weeds@agric.nsw.gov.au	www.agric.nsw.gov.au
NT	Dept of Natural Resources, Environment and the Arts	(08) 8999 4567	weedinfo.nreta@nt.gov.au	www.nt.gov.au
Qld	Dept of Natural Resources and Mines	(07) 3896 3111	enquiries@nrm.qld.gov.au	www.nrm.qld.gov.au
SA	Dept of Water, Land and Biodiversity Conservation	(08) 8303 9500	apc@saugov.sa.gov.au	www.dwlbc.sa.gov.au
Tas	Dept of Primary Industries, Water and Environment	1300 368 550	Weeds.Enquiries@dpiwe.tas.gov.au	www.dpiwe.tas.gov.au
Vic	Dept of Primary Industries/Dept of Sustainability and Environment	136 186	customer.service@dpi.vic.gov.au	www.dpi.vic.gov.au www.dse.vic.gov.au
WA	Dept of Agriculture	(08) 9368 3333	enquiries@agric.wa.gov.au	www.agric.wa.gov.au

The above contacts can offer advice on weed control in your state or territory. If using herbicides always read the label and follow instructions carefully. Particular care should be taken when using herbicides near waterways because rainfall running off the land into waterways can carry herbicides with it. Permits from state or territory Environment Protection Authorities may be required if herbicides are to be sprayed on riverbanks.

presence near a creek line does present a threat to downstream areas. Care needs to be taken to avoid any damage to native vegetation.

What to do about it

Prevention is better than the cure

As with all weed management, prevention is better and more cost-effective than control. The annual cost of weeds to agriculture in Australia, in terms of decreased productivity and management costs, is conservatively estimated at $4 billion. Environmental impacts are also significant and lead to a loss of biodiversity. To limit the escalation of these impacts, it is vital to prevent the further introduction and establishment of new weed species, such as *C. teneristolon*.

Small infestations may be eradicated if they are detected early, but an ongoing commitment is needed to ensure new infestations do not establish. In Kenya this weed has been successfully controlled using herbicides, but no herbicide is registered to control *C. teneristolon* in Australia.

The shape and colour of the flower spikelets (inflorescence) distinguishes *C. teneristolon* from all other sedge species.
Photo: John Hosking, NSW Agriculture

Quarantine to prevent further introductions

No importation of *C. teneristolon* into Australia is permitted because of the risk of further spread, and the potential introduction of new genetic diversity that could make future control more difficult.

Do not buy seeds via the internet or from mail order catalogues unless you check with quarantine first and can be sure that they are free of weeds like *C. teneristolon*. Call 1800 803 006 or see the Australian Quarantine and Inspection Service (AQIS) import conditions database <www.aqis.gov.au/icon>. Also, take care when travelling overseas that you do not choose souvenirs made from or containing seeds, or bring back seeds attached to hiking or camping equipment. Report any breaches of quarantine you see to AQIS.

Raising community awareness

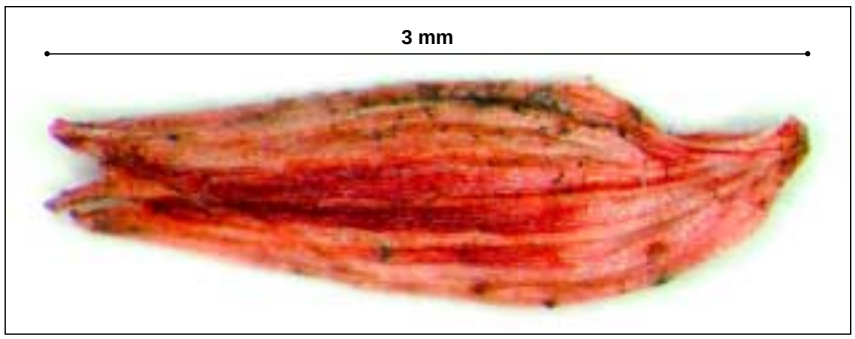
Some 65% of weeds which have recently established in Australia, including *C. teneristolon*, have escaped from plantings in gardens and parks. The detrimental impacts of these weeds far outweigh any potential horticultural benefits. The public should be made more aware of these impacts, and of other issues such as how to identify *C. teneristolon* and what to do if they find it.

C. teneristolon can be identified by its purple to black egg-shaped flower spikes that are made up of many tiny individual flower spikelets in an inflorescence. It has slender stolons that connect the individual plants together and its leaves are 1-3 mm wide. *C. teneristolon* has an extensive underground rhizome system which supports its growth each season and helps it spread.

New infestations of *C. teneristolon*

Because *C. teneristolon* has naturalised in only one known location, it can still be eradicated. Any new outbreaks should be reported immediately to your state or territory weed management agency or local council. Do not try to control *C. teneristolon* without their expert assistance. Control effort that is poorly performed or not followed up can actually help spread a weed and worsen the problem.

The flower of *C. teneristolon* is an egg-shaped purple to black-coloured spike consisting of many tiny spikelets.
Photo: NCW Beadle Herbarium, University of New England, NSW



Many of these tiny spikelets (inflorescence) make up the main flower spike of *C. teneristolon.*
Photo: NCW Beadle Herbarium, University of New England, NSW

Legislation

There is no legislation to control *C. teneristolon* but it is on the Federal Government's *Alert List for Environmental Weeds*, meaning that it is marked for eradication and should not be imported into Australia.

Acknowledgments

Information and guide revision: Tanya McLean (Bushcare Coordinator for the Blue Mountains), John Hosking (NSW Agriculture/Weeds CRC), Jeremy Bruhl (University of New England).

Map: Base data used in the compilation of distribution map provided by Australian herbaria via Australia's Virtual Herbarium.

If you find a plant that may be cyperus

Quick reference guide

Identification

If you suspect a plant to be *C. teneristolon*, you will first need to confirm its identity. Contact your state or territory weed management agency for help in identifying the plant. You will need to take note of the characteristics of the plant in order to accurately describe it. Features to aid in the identification of *C. teneristolon* include:

- purple to black egg-shaped flower heads
- slender stolons connecting the plants together
- leaves 1–3 mm wide.

Reporting occurrences

Once identified, new occurrences of *C. teneristolon* should be reported to the relevant state or territory weed management agency or local council, who can offer advice and assistance on its control. Because *C. teneristolon* represents a potentially serious environmental and economic threat to Australia, its control is a matter that should be undertaken with the appropriate expertise and adequate resources.

Follow-up work will be required

Once the initial infestation is controlled, follow-up monitoring and control may be required for some years.

Collecting specimens

State or territory herbaria can also identify plants from good specimens. These organisations can provide advice as to how to best collect and preserve specimens.

State/Territory	Postal Address	Phone	Web
Australian National Herbarium	GPO Box 1600 Canberra, ACT, 2601	(02) 6246 5108	www.anbg.gov.au/cpbr/herbarium/index.html
National Herbarium of New South Wales	Mrs Macquaries Rd Sydney, NSW, 2000	(02) 9231 8111	www.rbgsyd.nsw.gov.au
National Herbarium of Victoria	Private Bag 2000 Birdwood Avenue South Yarra, Vic, 3141	(03) 9252 2300	www.rbg.vic.gov.au/biodiversity/herbarium.html
Northern Territory Herbarium	PO Box 496 Palmerston, NT, 0831	(08) 8999 4516	http://www.nt.gov.au/ipe/pwcnt/
Queensland Herbarium	c/- Brisbane Botanic Gardens Mt Coot-tha Rd Toowong, Qld, 4066	(07) 3896 9326	www.env.qld.gov.au/environment/science/herbarium
South Australian Plant Biodiversity Centre	PO Box 2732 Kent Town, SA, 5071	(08) 8222 9311	www.flora.sa.gov.au/index.html
Tasmanian Herbarium	Private Bag 4 Hobart, Tas, 7000	(03) 6226 2635	www.tmag.tas.gov.au/Herbarium/Herbarium2.htm
Western Australian Herbarium	Locked Bag 104 Bentley DC, WA, 6983	(08) 9334 0500	http://science.calm.wa.gov.au/herbarium/

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Fireweed

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INTRODUCTION

Fireweed, or variable groundsel, is a name that refers to a number of important weed species of the genus *Senecio* within the *Asteraceae* (daisy/thistle) family.

In coastal New South Wales, the most common species of fireweed is *S.madagascariensis*, a plant native to south-eastern Africa. Recent trial work by I.J. Radford funded by the Dairy Research and Development Corporation and the Meat and Livestock Corporation has shown that *Senecio madagascariensis* in Australia and Madagascar have similar chromosome counts. However, Australian fireweed populations, using isozyme studies, were most closely related to *S.madagascariensis* from Natal and Eastern Cape than Madagascar.

Another species, *S.lautus*, does occur, but only as a minor part of the fireweed population. *S.lautus* is native to Australia, and is found mainly in bushland or undisturbed sites, and is more widely distributed throughout Australia in alpine, arid and coastal environments.

Photo: R Watson

Many thousands of hectares of pastures in coastal districts of NSW become infested with fireweed during the autumn to spring period.

Fireweed is an invasive plant, quickly colonising heavily grazed, or neglected pastures, and cultivated, or disturbed, land during the autumn to spring period. It competes strongly with existing pasture plants for light, moisture and soil nutrients, particularly phosphorus and nitrogen. This competition can lead to the further deterioration of pastures and a reduction in overall grazing area.

Fireweed can sometimes be poisonous to livestock, particularly cattle and horses.

DESCRIPTION

Fireweed, *S.madagascariensis*, has a variable growth habit and leaf structure, growing from 10–50 cm high. In coastal districts the most common form of fireweed is a low, heavily branched, short-lived perennial bush.

Although leaf shape and structure can vary, leaves are generally bright green, alternate, narrow with serrated, entire or lobed margins. The broader leaves are usually clasped around the stem and are 2–6 cm long, occasionally reaching 8–10 cm on vigorous and older plants.

Flowers are small, yellow and daisy-like, from 1–2 cm in diameter and can number from 2–200 per plant in a loose cluster at the end of the branches. Petal numbers are usually a constant 13. Plants flower mainly from April-September, with individual plants often having a wide range of flowering stages at any one time.

Seeds are small (1–3 mm long), light and slender. They are cylindrical in shape, with a downy surface and attached to a pappus of fine, silky white feathery hairs. The plant produces large quantities of seed over a long period.

Photo: JJ Dellow

Fireweed plants can have a wide range of flowering stages at any one time, but each flower always has 13 petals.

Each flower produces between 100–150 seeds. Therefore, a single large plant has the ability to produce around 25,000–30,000 seeds with a high viability.

Fireweed has a shallow, branched tap root with numerous fibrous roots, growing from 10–20 cm deep.

LIFE CYCLE

Fireweed is highly adaptable to changes in the environment. Under normal or favourable seasonal conditions, the plant can behave as a short-lived perennial. In an extremely dry season or in an arid environment however, it behaves as an annual.

In the field, many stages of development of the plant (seedlings to flowering plants) can be seen at almost any time of the year.

Germination of seed depends mostly on rainfall but is also stimulated by light and by mild-warm temperatures.

Optimum temperatures for germination of fireweed occur between 15–27°C, with greatly reduced germination at lower or higher temperatures. Most rapid germination occurs between 20–25°C.

As these temperatures indicate, fireweed can germinate over much of the year. Most seed, however, germinates from March to June, with the young plants developing rapidly. Plants can produce flowers 6–10 weeks after emergence.

Seeds can germinate immediately after they are released from the flower head. The plant is therefore able to produce several generations in one season. The seed has a germination percentage soon after maturity of around 90%.

Germination of seed is affected by soil depth, with seedling emergence not occurring below 2 cm.

It is not known how long seed will remain viable in the field, but observations of recently disturbed paddocks and subsequent infestations suggest it can be a number of years.

In most districts, fireweed ends its life cycle from spring onwards. This occurs when the top growth of most of the advanced plants, dies off during the summer. The perennial root system however remains and can produce new and rapid regrowth from the crown in the following autumn. In some situations, plants can continue to grow throughout the year.

DISTRIBUTION

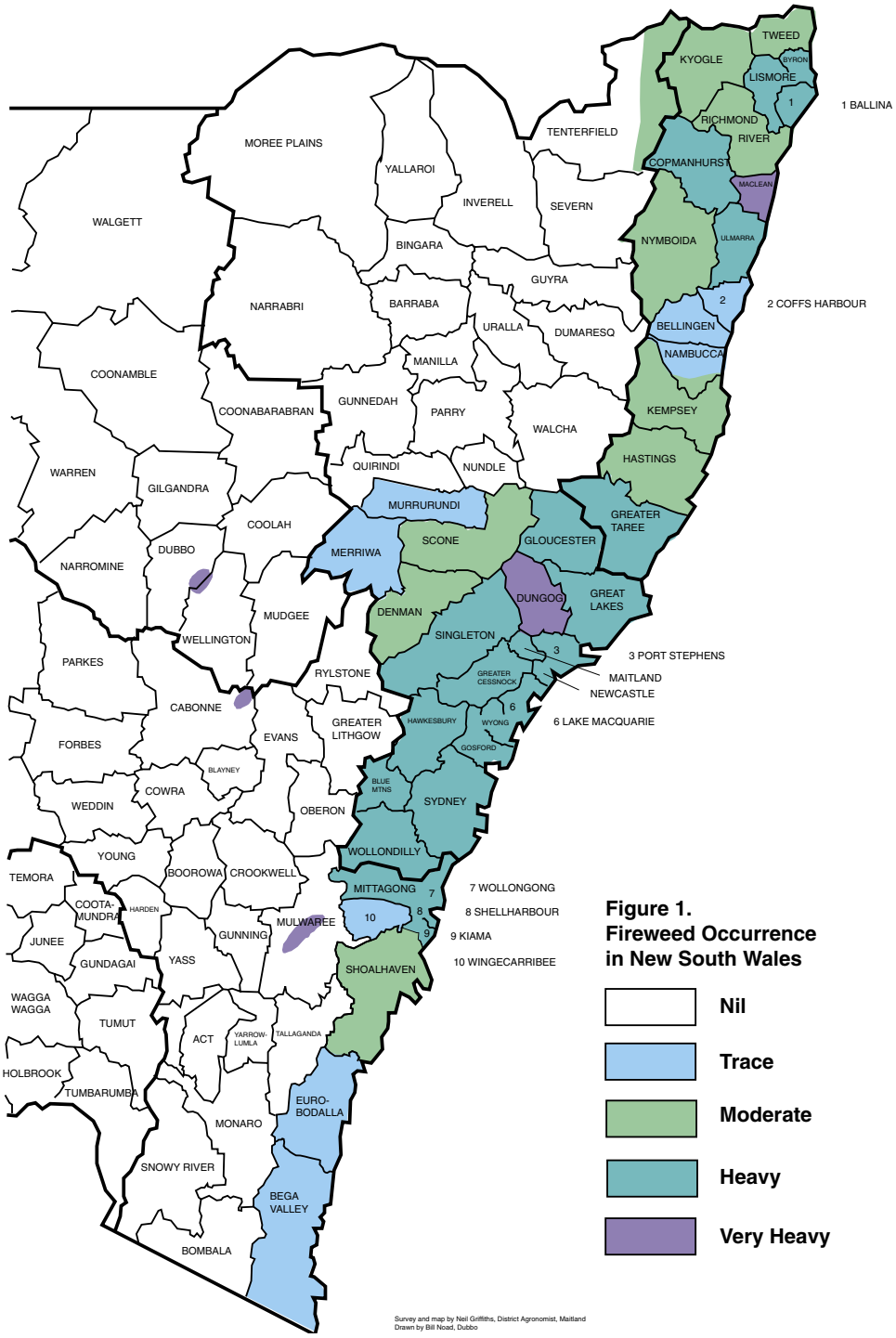
Fireweed is a serious weed of coastal pastures in New South Wales and is increasingly a problem (see Figure 1). It is especially abundant in the Richmond, Manning and Hunter valleys, in the Sydney metropolitan area, and between Wollongong and Berry on the South Coast.

Fireweed is a declared noxious weed in 16 local government areas. The weed has spread as far south as Bega and is known to occur in south-eastern Queensland. Survey work has also shown the weed can occur on the Northern and Southern Tablelands.

Fireweed grows on a wide range of soils from high fertility, self-mulching clay soils to low fertility, acid sandy soils. It is most prolific in well-drained, lighter-textured, acid soils of low-medium fertility. It will not survive in poorly drained or waterlogged situations.

SPREAD

The light, fluffy seeds are easily spread by wind. Dispersal of large amounts of seed by wind is considered to be the major factor responsible for the weed's rapid spread over large areas and long distances.



They can also be spread in hay and grain products, on clothing and vehicles, and by livestock, birds and other animals.

Fireweed also has the ability to grow vegetatively. Stems may take root at the nodes when in contact with moist soil.

FIREWEED POISONING

Fireweed is responsible for many cases of poisoning resulting in ill-thrift in livestock. This is because it contains pyrrolizidine alkaloids that are toxic. These chemicals produce a characteristic type of liver damage. All growth stages and parts of the plant contain these chemicals. Hay or silage contaminated with fireweed can be toxic, as can stands of the plant that have dried off in summer.

There are three sets of circumstances where ingestion of fireweed by livestock is difficult to avoid:

- where there is a severe shortage of other feed (often in winter on the coast when fireweed is prolific) and fireweed is the only feed available;
- where the pasture is so heavily infested with young fireweed plants that they cannot be avoided by grazing livestock;
- where a paddock with a thick stand of fireweed is slashed and then grazed by stock immediately afterwards.

Cattle and horses are most susceptible to the toxic liver damage from fireweed. Young, hungry stock are in the highest risk category. Normally, cattle and horses avoid fireweed when adequate pasture is available but may eat the weed when the quality of pasture is low.

Sheep and goats readily eat fireweed. They find the plant highly palatable and often eat fireweed in preference to other plants. Paddocks that are grazed with sheep or goats are kept relatively free of fireweed.

Sheep and goats are 20 times more tolerant of pyrrolizidine alkaloids than are either cattle or horses. This is because they have a specific bacterium in their rumen that enables them to detoxify much of the alkaloids.

Although fireweed is much less toxic to sheep and goats, it can cause some liver damage in them if large quantities are eaten over long periods, e.g. consecutive seasons or years.

Pastures contaminated with fireweed should not be baled or made into silage. A program to remove the existing fireweed plants should be carried out prior to any hay making or silage operations.

SYMPTOMS OF POISONING

Symptoms of poisoning with fireweed in cattle and horses primarily are loss of appetite and ill-thrift. Sometimes other liver related signs will include: aimless wandering, loss of muscular co-ordination, apparent blindness, photosensitisation, jaundice, abdominal straining, dullness and chronic scouring. Severe liver damage due to the pyrrolizidine alkaloids can result in death.

The most common effect attributed to fireweed in cattle is ill-thrift in young stock.

A condition in cattle on the Central Coast of New South Wales, commonly called coastal ill-thrift, is probably due to a combination of mineral deficiencies, internal parasites and fireweed toxicity. However, on fireweed-infested properties where mineral deficiencies and internal parasites are not a problem, young stock can still fail to thrive. Varying degrees of chronic liver damage are normally seen in these animals.

There is no effective treatment for fireweed poisoning. The control measure that most benefits livestock is a reduction in the quantity of fireweed in grazing pastures.

WHEN FIREWEED IS A PROBLEM

Losses of up to 62% in pasture productivity have been recorded in fireweed infested pastures monitored from August-September.

A combination of unfavourable pastoral and seasonal conditions such as drought, overgrazing or poor pasture management enables fireweed to take over run-down pastures.

While it grows in all types of pasture and on all aspects, fireweed density is influenced by the quality of ground cover and competition provided by pasture plants.

Fireweed is also encouraged by pastures that have been trampled by stock such as in stock camps, holding paddocks, or through heavy stocking rates.

Areas that have been cultivated or disturbed are also vulnerable. Fireweed is generally not a problem in irrigated pastures, which are normally intensively managed with more vigorous growth and better cover.

Fireweed seed is readily dispersed by wind. Therefore the potential for reinfestation is always present in fireweed districts.

CONTROL

An integrated approach is the best means to control fireweed in pastures. This approach includes grazing strategies, such as not overgrazing pastures and using sheep and goats with other livestock to control fireweed. Other strategies include: fertiliser application at appropriate times, upgrading pastures via direct drilling or oversowing, and strategic herbicide applications.

Effective control of fireweed in every situation is not always economic or practical. Any effective control program though must be thorough and systematic. It is also preferable to manage a small area correctly, than to poorly manage a large area. Follow-up control methods and management will also be essential if initial control is to be successful.

Control methods

Early removal. Isolated plants can be pulled out by hand or spot-sprayed before they set seed. Uprooted plants should then be placed in a large plastic bag, such as an old fertiliser bag, and burnt. If left in the paddock, these uprooted plants can still produce viable seeds and propagate from cut or broken stems in contact with the soil.

Pasture improvement and management. A vigorous permanent pasture provides the best control of fireweed. This can be achieved by sowing suitable competitive pasture species, appropriate grazing management and fertiliser applications. A dense autumn-winter cover will reduce fireweed populations. This can be achieved by: sowing winter pasture species, allowing standover of summer pasture feed, or combinations of winter/summer pastures.

Suitable summer-growing species include kikuyu, paspalum, setaria and Rhodes grass. These summer pastures can be 'locked up' over the period February-April to develop a thick sward that will compete directly against germinating fireweed seedlings.

Establishing these pastures requires good management, (see Agfact P2.2.6 *Eight steps to successful pasture establishment*).

Research conducted at Taree has shown that Setaria/white clover pastures can effectively control fireweed over winter-spring. Appropriate establishment methods were important to gain maximum pasture plant density and ground cover (see Table 1), however, a fully prepared seedbed can encourage germination of fireweed seeds. Where cultivation may encourage fireweed germination or on non-arable country, pasture establishment in badly infested paddocks can be strategically achieved by broadcasting the pasture seed onto a chemical seedbed.

Table 1. Establishment methods for *Setaria*, Taree district, as a competitor for fireweed

Establishment method	Ground cover %	
	(after 1 year)	(after 2 years)
Broadcast	0	0
Aerator	0.4	11
Chisel plough	2	26
Herbicide only	13	49
Herbicide + mulch	9	44
Herbicide + aerator	6	42
Herbicide + direct drill	10	40
Seedbed (chisel plough)	24	64
Seedbed (rotary hoe)	25	58

NB. Excellent coverage of all plots by white clover kept fireweed under control throughout winter and spring.

In suitable areas, winter-spring growing pasture species such as phalaris, fescue, ryegrass, white clover and subterranean clover will also compete directly with fireweed over winter.

Phalaris and fescue with Haifa white clover and subterranean clover is an ideal permanent pasture to compete against fireweed south of the Hunter Valley.

It is relatively slow to establish and may require bromoxynil herbicide treatment in the initial stages of development to control fireweed infestations. The phalaris and fescue develop into large, tussocky plants that provide direct competition for fireweed.

Perennial ryegrasses, including Kangaroo Valley and Victorian ryegrasses, also provide direct competition to fireweed. Very vigorous annual and biennial ryegrasses like Concord, Surrey, Flanker and Eclipse provide even greater competition. These can be direct drilled, broadcast or mulch-sown into semi-dormant paspalum, couch and kikuyu pastures for greater winter feed and fireweed control with outstanding results.

Incorporating pasture, management and, where necessary, herbicides, are essential for controlling fireweed. A pasture should be vigorously growing

before spraying with a herbicide. This will guarantee competition for the next generation of fireweed plants that will germinate when the larger weeds have been killed.

Maintaining soil fertility and correcting soil problems such as acidity are important in establishing and maintaining a permanent competitive pasture. Paddocks that have had a heavy fireweed infestation, and which are then heavily fertilised without pasture improvement, are especially prone to further invasion. It is therefore very important that fertiliser is only applied to improved or competitive pasture species. Ryegrass and phalaris are competitive against fireweed as well as barley grass which has the same growth habit as fireweed and provides good competition in winter and spring.

Careful grazing management to maintain pasture density and a moderate body of pasture litter, will reduce fireweed seed germination and suppress seedling growth and development. Lenient grazing management is very important for native and unimproved pasture to ensure the pasture has a sufficient groundcover and a competitive advantage. Where pasture vigour declines because of drought or over-grazing, a reinfestation of fireweed is likely.

When pasture becomes less vigorous it is important to correct the cause of the decline before upgrading or resowing the pasture. Problems of soil fertility, and possibly, acidity should be examined and overcome to ensure that a competitive permanent pasture can be established and maintained.

Applications of superphosphate fertilisers can encourage fireweed in the short-term, particularly if the area is disturbed by pasture renovation and establishment practices. Topdressing, however is necessary for the build-up of soil fertility and helps to establish and maintain productive permanent pasture. This type of pasture must be the aim for long-term control of fireweed.

Soil phosphorus levels are critical to maintain a vigorous pasture on the coast. Annual applications of 125–250 kg/ha of single superphosphate or the application of 20 cubic metres/ha of broiler manure every second or third year will give excellent results. Annual single applications of 125–250 kg/ha superphosphate will result in more productive pastures than heavier applications made less frequently.

Maintaining other soil components, including nitrogen, potassium, pH and a correct cation balance are also important. For many coastal soils which tend to be acidic, and particularly where

Photo: H Allan

Direct drilled Tetila and Concord ryegrass competing against a dense establishment of fireweed.

pH sensitive species are sown, liming may be necessary to maintain an optimum pH for pasture growth.

Consult your local district agronomist for specific advice on the most appropriate pasture and fertiliser recommendations and pasture establishment techniques for your situation.

Cultivation. A large proportion of fireweed-infested areas are non-arable due to slope and/or soil type. For arable areas however, cultivation followed by a cropping program and/or pasture improvement can be effective. Cultivation also allows effective lime incorporation. Lime topdressed onto existing pastures is slow to penetrate into the top 10 cm of soil and is generally far less effective than incorporated lime.

Cultivation in February-March is ideal as it usually stimulates a massive germination of seed. While a number of cultivations can be necessary to reduce fireweed soil seed reserves, it must be remembered that overcultivation can damage soil structure. It is important to have rain after each cultivation to get as many seeds to germinate as possible.

The initial cultivation should be at least 15 cm deep to completely bury any seed deposits. After pasture has been sown, strategic applications of herbicides may be necessary to kill fireweed seedlings.

Chemical control. (Also refer to the NSW DPI publication *Noxious and environmental weed control handbook 2004–2005*). There are currently a number of registered herbicides that are effective on fireweed. Before spraying, check paddocks during early autumn-winter for fireweed seedlings and regrowth, particularly after a good fall of rain.

Spray fireweed with registered herbicides during the small seedling-early flowering stages of growth. Early autumn-winter is best when fireweed plants are young and actively growing. At this

stage, lower rates of herbicide are sufficient to kill seedlings. Isolated plants that survive can be pulled out by hand or spot sprayed. Follow-up treatment can also be necessary to deal with regrowth and seedlings that appear after spraying.

Selective herbicides (see NSW DPI publication *Noxious and environmental weed control handbook 2004–2005*) are effective when used in conjunction with good management practices. For example, improved winter pastures of ryegrass and clover can be sprayed in May to kill small fireweed seedlings before they flower and set seed. This reduces reserves of fireweed seed in the ground. Also at this stage, the lower rates of the selective herbicide will give an excellent kill of fireweed.

Subsequently, topdressing these ryegrass pastures with nitrogen fertilisers produces a flush of growth that inhibits further fireweed growth over winter.

Weed wiping equipment using appropriate herbicides has also given excellent results in trials at Taree where fireweed had been taller than pasture in trials. The trial area was initially grazed by cattle. One pass of a ropewick applicator produced a 70% kill while two passes in different directions resulted in a 95% kill. Most fireweed plants died within three weeks of treatment.

Generally, multi-rope, carpet wipers or rotary wipers are more effective than simple ropewick applicators. One pass of these applicators usually produces similar results to two passes of a simple ropewick applicator.

Slashing/mulching. Slashing or mulching a fireweed paddock from mid-September onwards to control fireweed has proven effective on the Central Coast in paspalum/kikuyu paddocks. By mid-September, when fireweed has developed into a large plant, slashing or mulching can damage plants sufficiently to allow the summer growing pasture to out compete fireweed. This control method is not recommended for summer growing pastures over autumn and winter because fireweed can recover more quickly than the pasture.

Slashing or mulching ryegrass pastures that have been grazed in autumn, winter and spring at six-weekly intervals and topdressed with nitrogen will reduce fireweed growth and seedling establishment. However, fireweed is generally not a problem in these situations.

A danger of slashed or mulched fireweed is that it wilts and can become more attractive to stock, with a greater concentration of plant toxin. Slashing is therefore less desirable than mulching as it leaves a windrow which stock can readily graze. Mulching, however, cuts plants into smaller pieces that are spread more evenly over the paddock, minimising the poisoning risk.

After slashing or mulching, fireweed-infested paddocks should not be grazed for at least two weeks.

Biological control. Various naturally occurring diseases and insects have been found attacking, and sometimes destroying fireweed plants. The most damaging insects are the chrysomelid beetle, *Chalcolampra* sp., larvae and adults of which defoliate plants, and two native moths, magpie moth, *Nyctemera amica*, which may defoliate plants and blue stem borer, *Patagoniodes farinaria*, which may ringbark plants causing plant death. These insects tend to damage plants late in the season after many seeds have matured.

Other insects which can be reared from plants but do not appear to cause a lot of damage are a stem mining fly, *Melanagromyza seneciophila*, a leaf mining fly, *Chromatomyia syngenesiae* (commonly known as cineraria leafminer), two gall forming fly species, *Sphenella ruficeps*, which form galls in flower heads and *Trupanea prolata* which forms galls in stems and flower heads, and two seed head feeding bugs, *Nysius clevelandensis* (commonly known as grey cluster bug) and *Nysius vinitor* (commonly known as Rutherglen bug).

In wet conditions the rust, *Puccinia lagenophorae*, may damage or destroy plants. Another disease, *Albugo tragopogonis*, sometimes forms blisters on fireweed.

All these insects and diseases are also present on the closely related native *Senecio lautus* complex.

Biological control of fireweed using introduced insects from Madagascar has been attempted but all insects tested to date have fed on the native *Senecio lautus* complex. This means that these insects are unlikely to be approved for release.

Grazing. Experience and observations in a number of districts indicate that sheep and goats will graze fireweed, sometimes in preference to other plants. In appropriate situations, they can provide an effective level of control. In the Upper Hunter and many inland districts where sheep enterprises are more common, fireweed invasion has been prevented and infestations totally controlled as a result of integrating sheep grazing of pasture. This has proved to be a simple, cheap and effective control program.

Paddocks stocked with sheep and goats are usually free of fireweed. However, once sheep and goats are removed, fireweed can reinvade. Cattle and horses, by avoiding the weed, actually encourage it.

In the Gippsland area of Victoria, many dairy farmers carry some sheep, usually crossbred wethers, for the sole purpose of controlling ragwort (*Senecio jacobaea*), a weed very closely related to fireweed.

Sheep and goats, by eating fireweed seedlings and large plants, prevent further seeding and therefore reduce the problem. They are also less affected by fireweed toxins, unless they eat the plant in large quantities or over two or more successive seasons. Flock composition should be altered regularly to avoid poisoning of animals. Sheep used for fireweed control should be replaced. Only sheep destined for slaughter, or wool cutting wethers, should be used, not breeding stock. Crossbred or British bred sheep are considered more suitable for the coastal environment. Blood tests for liver function can be carried out on a few representative animals to determine the need for replacement.

Problems associated with this control method do exist. For example, running sheep under coastal conditions can lead to an increased incidence of parasites and diseases. Ticks can also be a problem for sheep and goats in many coastal areas.

Improved and additional fencing or yards may also be required to successfully run sheep or goats. Wild dogs can be a problem in many districts and may require measures to limit their impact.

Stocking rates should also be carefully managed in order to suppress fireweed, but not overgraze pastures.

FURTHER INFORMATION

For further information on identification and control of fireweed, contact your nearest NSW DPI district agronomist. For further information on fireweed poisoning, contact your Rural Lands Protection Board District Veterinarian.

ACKNOWLEDGEMENT

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Disclaimer

The information contained in this publication is based on knowledge and understanding at the time of writing (February 2001). However, because of advances in knowledge, users are reminded of the need to ensure that information upon which they rely is up-to-date and to check currency of the information with the appropriate officer of New South Wales Department of Primary Industries or the user's independent adviser.

Always read the label

Users of agricultural (or veterinary) chemical products must always read the label and any Permit, before using the product, and strictly comply with the directions on the label and the conditions of any Permit. Users are not absolved from compliance with the directions on the label or the conditions of the Permit by reason of any statement made or omitted to be made in this publication.

Pasture improvement

Pasture improvement may be associated with an increase in the incidence of certain livestock health disorders. Livestock and production losses from some disorders are possible. Management may need to be modified to minimise risk. Consult your veterinarian or adviser when planning pasture improvement.

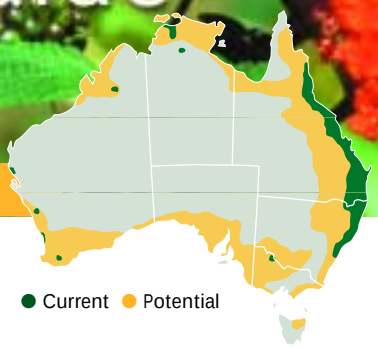
The *Native Vegetation Act 2003* restricts some pasture improvement practices where existing pasture contains native species. Inquire through your office of the Department of Natural Resources for further details.

ISSN 1832-6668

Job No 6333

Weed Management Guide

Lantana – *Lantana camara*



Lantana (*Lantana camara*)

The problem

Lantana is a *Weed of National Significance*. It is regarded as one of the worst weeds in Australia because of its invasiveness, potential for spread, and economic and environmental impacts.

Lantana forms dense, impenetrable thickets that take over native bushland and pastures on the east coast of Australia. It competes for resources with, and reduces the productivity of, pastures and forestry plantations. It adds fuel to fires, and is toxic to stock.

Lantana is a serious threat to biodiversity in several World Heritage-listed areas including the Wet Tropics of northern Queensland, Fraser Island and the Greater Blue Mountains. Numerous plant and animal species of conservation significance are threatened. It is listed as the most significant environmental weed by the South-East Queensland Environmental Weeds Management Group.

It is a problem in gardens because it can cross-pollinate with weedy varieties to create new, more resilient forms.

The weed

There are two main forms of lantana in Australia: a cultivated form planted in gardens and a weedy variety found in bushland and pastures. The cultivated form of lantana is non-thorny, produces few seeds and is compact in shape. The weedy form is a prolific seeder with straggly, thorny stems. Both forms include many varieties, which differ from each other in shape, flower colour, prickliness, response to enemies and toxicity.

Lantana is a significant weed of woodlands and pastures east of the Great Dividing Range.
Photo: Qld DNRM

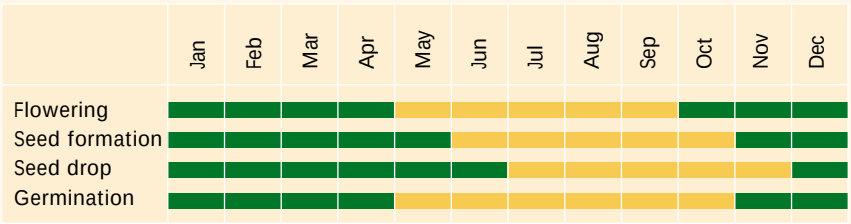
Weedy lantana is a much branched, thicket-forming shrub, 2–4 m tall. The woody stems are square in cross-section and hairy when young but become cylindrical and up to 150 mm thick with age. The ovate (ie tear-shaped) leaves (20–100 mm long) occur in opposing pairs along the stem. The leaves are rough and finely hairy and emit a pungent odour when crushed. Each flower head is made up of 20–40 flowers, ranging in colour from white, cream or yellow to orange, pink, purple and red. The fruit has many berries, which ripen from green to shiny purple-black and contain a single pale seed. Lantana has a short taproot and a mat of many shallow side roots.

Key points

- Lantana is a thicket-forming shrub that has spread from gardens into pastures, woodlands and rainforests on the east coast.
- It typically invades disturbed land and river margins, extending its range in response to rainfall.
- It threatens agriculture and pastoral production, forestry and biodiversity of conservation areas, and may be toxic to stock.
- The highest priority for lantana control is preventing its spread into northern Australia and west of the Great Dividing Range.
- Integrated control should combine fire, mechanical, chemical and biological methods, and revegetation.

Natural Heritage Trust
Helping Communities Helping Australia
An Australian Government Initiative

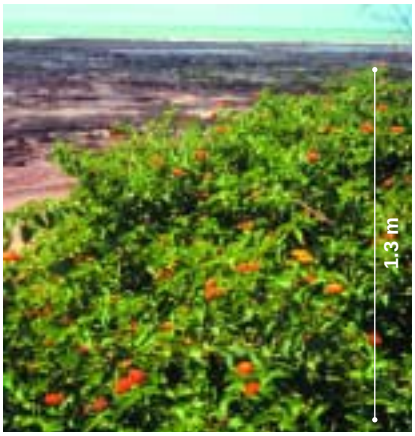
Growth calendar



Lantana flowers whenever the soil is moist and the air is warm and humid. For much of its range along the Queensland and New South Wales coasts, this results in almost continuous flowering and fruiting. Further inland, peak flowering occurs several weeks after soaking rain (25 mm or more) and is usually accompanied by good fruit set.

Germination most frequently occurs following the first summer storms, but may occur at any time of the year when sufficient moisture is present. Initial seedling growth is slow until the roots become established, after which close stems intertwine and begin to form thickets. Flowering does not usually commence until early in the following summer and then continues until March or April.

Lantana can resprout from the base if the shoot dies, extending the life of individual plants.



Flowering lantana infestation in Darwin, NT, in December.
Photo: Colin G. Wilson

How it spreads

Lantana spreads in two ways. Layering is a form of vegetative reproduction where stems send roots into the soil, allowing it to quickly form very dense stands and spread short distances. Also, birds and other animals such as foxes consume and pass the seed in their droppings, potentially spreading it over quite large distances. The germination rate of fresh seed is generally low, but improves after being digested.

Butterflies, bees and other insects are attracted by the nectar and pollinate lantana flowers. About half of the flowers produce seeds, typically 1–20 seeds on each flower head. Mature plants can produce up to 12,000 seeds every year. Seeds are thought to remain viable for several years under natural conditions.

Lantana is allelopathic and can release chemicals into the surrounding soil which prevent germination and competition from some other plant species.

First recorded in the Adelaide Botanic Gardens in 1841, lantana spread to east coast gardens and was recorded as a weed in Brisbane and Sydney in the early 1860s. It is now found across four million hectares of land east of the Great Dividing Range, from Mount Dromedary in southern New South Wales to Cape Melville in northern Queensland. Isolated infestations exist in the Top End of the Northern Territory, around Perth in Western Australia, and on Lord Howe and Norfolk Islands. Although present Australia wide as a garden ornamental, it has not naturalised to any serious extent elsewhere.

When ripe, birds and animals consume fruit and spread seed.
Photo: Colin G. Wilson

Where it grows

Lantana can grow in high-rainfall areas with tropical, subtropical and temperate climates. It does not tolerate salty or dry soils, waterlogging or low temperatures (<5ºC). It thrives on rich, organic soils but also grows on well-drained clay and basalt soils. Sandy soils tend to dry out too rapidly for lantana unless soil moisture is continually replenished. It has been reported at altitudes up to 1000 m in Queensland.

Lantana invades disturbed sites, especially open sunny areas, such as roadsides, cultivated pastures and fencelines. From there it can invade the edges of forests, but it does not fare as well under a heavy canopy as it is not very shade tolerant. Therefore, it is not a problem in intact tropical rainforest but can quickly spread there if the canopy opens out.

Lantana occurs naturally in Mexico, the Caribbean and tropical and subtropical Central and South America. It is considered a weed in nearly 50 countries.

Another weedy species of lantana

Another species of lantana is a popular ornamental that is considered a weed when present in natural ecosystems. Creeping lantana (*Lantana montevidensis*) occurs in coastal and subcoastal Queensland and as far south as Sydney. It is fairly similar to *Lantana camara* but does not have thorns, has mainly pink or purple flowers and trails along the ground, only growing to a height of half a metre. It is also toxic and readily displaces native vegetation.

Creeping lantana (*Lantana montevidensis*) is naturalised in coastal and subcoastal Qld and only grows to a height of half a metre. It is toxic and readily displaces native vegetation. Photo: John Swarbrick

Potential distribution

Lantana may be able to spread west of the Great Dividing Range, and could expand its range throughout southern Victoria, South Australia and southwestern Western Australia.

What to do about it

Lantana is extremely widespread and abundant. Because it is so well established on the east coast, and prevention of spread is the most cost-effective weed management tool, the highest priority for lantana management is to prevent its spread into uninfested areas. This will require three main actions.

1. Restricting further importation of lantana into Australia. Any new varieties brought in could escape cultivation and naturalise, or could cross-breed with naturalised varieties, leading to hardier new varieties more resistant to control.
2. Restricting the sale and use of lantana in gardens as these are potential sources of new infestation and new varieties. There are native and less weedy exotic ornamental alternative species.
3. Strategically controlling infestations that threaten areas where lantana is not yet a weed. Control methods are outlined below.

Integrated management

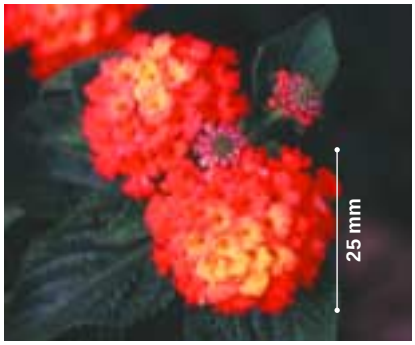
An integrated approach that uses a variety of control methods gives best results when dealing with lantana. A range of methods including herbicides, mechanical removal, fire, biological control and revegetation should be used. Best results are obtained by working from areas of light infestation towards heavier infestation, and long-term follow-up control is required after initial attempts. Minimise both disturbance to land and excessive use of fire to retain vigorous native vegetation and reduce the opportunity for lantana to become established.

Herbicide control – effective but expensive

There are many herbicides registered for lantana control and three main application techniques. Spraying the entire plant (foliar spraying) usually kills plants that are less than 2 m high. Herbicides applied to the lower bark of the stems (the basal bark technique) or immediately painted onto a freshly cut stump (the cut-stump technique) are useful for larger plants. Both of these techniques are time consuming because they require treatment of each stem, which can be difficult to access in large stands of lantana. High costs make herbicide control uneconomical for large infestations, except when there are no other options (eg on steep slopes, where helicopter spraying may be required).

For best results, integrate fire, mechanical, chemical and biological control and revegetation

Herbicides, especially those that are foliar applied, are most effective when plants are actively growing. With lantana, best results are obtained six weeks after good rains (at least 35 mm) when minimum temperatures exceed 15ºC. In Queensland the spraying season generally lasts from early summer to autumn, but earlier control will potentially allow follow-up in the same growing season.



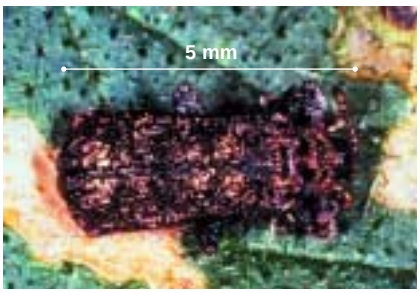
Lantana flowers can be one colour (*left*), or a mix of two (*centre*) or more colours (*right*). Photos: Kate Blood (left and middle). Colin G. Wilson (right)

Weed control contacts

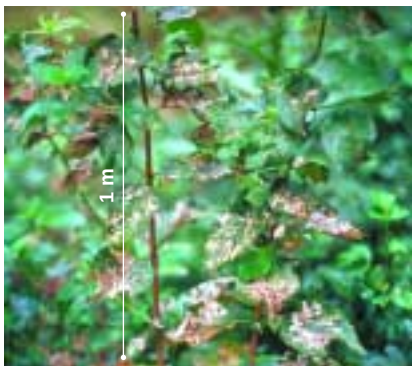
State / Territory	Department	Phone	Email	Website
ACT	Environment ACT	(02) 6207 9777	EnvironmentACT@act.gov.au	www.environment.act.gov.au
NSW	NSW Agriculture	1800 680 244	weeds@agric.nsw.gov.au	www.agric.nsw.gov.au
NT	Dept of Natural Resources, Environment and the Arts	(08) 8999 4567	weedinfo.nreta@nt.gov.au	www.nt.gov.au
Qld	Dept of Natural Resources and Mines	(07) 3896 3111	enquiries@nrm.qld.gov.au	www.nrm.qld.gov.au
SA	Dept of Water, Land and Biodiversity Conservation	(08) 8303 9500	apc@saugov.sa.gov.au	www.dwlbc.sa.gov.au
Tas	Dept of Primary Industries, Water and Environment	1300 368 550	Weeds.Enquiries@dpiwe.tas.gov.au	www.dpiwe.gov.au
Vic	Dept of Primary Industries/Dept of Sustainability and Environment	136 186	customer.service@dpi.vic.gov.au	www.dpi.vic.gov.au www.dse.vic.gov.au
WA	Dept of Agriculture	(08) 9368 3333	enquiries@agric.wa.gov.au	www.agric.wa.gov.au
Australia wide	Australian Pesticides and Veterinary Medicines Authority	(02) 6272 5852	contact@apvma.gov.au	www.apvma.gov.au

Note that herbicides vary in their effectiveness on different lantana varieties. The red flowered varieties are normally the least susceptible to herbicides while the pink forms are the easiest controlled. Consult your local council or state/territory weed management agency about which herbicides and applications are most suitable for your infestation of lantana. State and territory contact details are listed above, including contacts for the Australian Pesticides and Veterinary Medicines Authority, which hosts the PUBCRIS database. This database contains information on all herbicides that are registered for use on weeds in each Australian state and territory.

When using herbicides always read the label and follow instructions carefully. Particular care should be taken when using herbicides near waterways because rainfall running off the land into waterways can carry herbicides with it. Permits from state or territory Environment Protection Authorities may be required if herbicides are to be sprayed on riverbanks.



Both adults (*above*) and larvae of the leaf-mining beetle *Octotoma scabripennis* feed on lantana leaves. It is present in most lantana infestations, particularly where it is shady and wet in subtropical, coastal areas.
Photo: J. Wright, Qld DNRM



Damage to lantana leaves caused by the leaf-mining beetle *Octotoma scabripennis*.
Photo: Michael Day, Qld DNRM

Mechanical and physical control – suitable for small infestations

Lantana can be removed mechanically or physically in several ways, including stickraking, bulldozing, ploughing and grubbing. These techniques are mainly suited to medium-sized infestations and require extensive follow-up, as they invariably lead to regrowth if the rootstock is not removed, or seedling germination when heavy machinery disturbs the soil. Any soil disturbance should be avoided on steep inclines or in gullies. A permit may be required if native plants are to be affected by mechanical control – check with your local council or state/territory weed management agency.

Fire – inexpensive but caution must be exercised

Fire is often used prior to mechanical or herbicide control to improve their effectiveness, or as a follow-up to such methods. It can also provide some control when used on its own under the right conditions. It is most effective when fires are hot and the lantana is actively growing. In southeastern Queensland best results from fire are achieved during early summer. In New South Wales controlled burns are used opportunistically, mainly in late winter and spring before conditions become too dry and fires could escape control.

Fire is relatively inexpensive and well suited to dense infestations, but the risks to people and property must be carefully managed. Burning is not recommended in rainforest and vine thickets because they are highly sensitive to fire. Disturbance in these habitats may actually promote lantana if the canopy is opened up. A permit may be required to burn – check with your local council or state/territory weed management agency.

Biological control

In 1902 the first attempt at biological control of a weed targeted lantana in Hawaii. In Australia biological control agents were first introduced in 1914; so far, 30 species have been introduced. Research into biological control is ongoing, and several agents are currently being examined for suitability of release.

Of the 16 species that have established, four insects have had a major impact on lantana. They are:

- a sap-sucking bug (*Teleonemia scrupulosa*) (Sydney to northern Queensland).
- a leaf-mining beetle (*Uroplata girardi*) (northern Queensland to Sydney).
- a leaf-mining beetle (*Octotoma scabripennis*) (Sydney to south of Rockhampton).
- a seed-feeding fly (*Ophiomyia lantanae*) (southern New South Wales to northern Queensland).

The biological control agents vary in their effectiveness against the many different types of lantana. For example, lantana can drop its leaves when stressed, depriving some agents of their food.

Revegetation – useful in pastures and forests

Revegetation of a treated site is a key component of a lantana management program. Revegetation helps to reduce erosion, adds fuel for future burning in pastures and is vital in limiting the re-establishment of lantana and other weeds. Sowing an improved pasture that outcompetes and smothers lantana seedlings is assisted by withholding grazing for the first six months, and only allowing light grazing for the next 12–18 months. In forested areas either planting trees or encouraging naturally occurring seedlings will help to shade out lantana in the longer term. Check with your local council or state/territory weed management agency about appropriate species for revegetating pastures or forests in your area.

Follow-up

Follow-up control after an initial effort may include any or all of the above methods. Established pastures can be burnt to control significant lantana regrowth, and any small patches can be spot sprayed with a registered herbicide or grubbed out. In forested areas herbicides are recommended to control regrowth, typically requiring three follow-up sprays after the initial control effort.

Legislation

Landholders are required to reduce lantana infestations throughout some regions of Queensland, New South Wales and the Northern Territory. The sale of lantana in Queensland was banned in late 2003. Lantana importation is prohibited in Western Australia. Check with your local council or state/territory weed management agency for relevant details.

Acknowledgments

Information and guide revision: Michael Day (Qld DNRM/Weeds CRC), Tony Grice (CSIRO/Weeds CRC), Richard Carter (NSW Dept of Agriculture/Weeds CRC), Andrew Clarke (Qld DNRM), Georgina Eldershaw (NSW NPWS), Jim Sloane (Sutherland Shire Environment Centre) and John Thorp (National Weeds Management Facilitator).

Maps: Australian Weeds Committee.

...case study

Lantana control at Towra Point, Botany Bay, New South Wales

Towra Point Nature Reserve in Botany Bay contains habitats of high conservation status, including wetlands of international importance and open woodlands that are unique in the Sydney region. A coastal rainforest in the region was recently listed as an endangered ecological community under the New South Wales *Threatened Species Conservation Act 1995*. It includes the magenta brush cherry (*Syzygium paniculatum*), a vulnerable tree species.

By the 1990s, lantana made up almost 75% of the vegetation cover in some parts of the reserve and was limiting the regeneration of native species, particularly around a freshwater wetland called Weedy Pond. The Friends of Towra, a volunteer group, commenced weed control in the Weedy Pond rainforest in 1996. In 1998 the Sutherland Shire Environment Centre, working in conjunction with the National Parks and Wildlife Service, gained Coastcare funding to supplement the volunteer program.

Beginning in March 1998, weed control focused on a corridor connecting the rainforest and a casuarina/banksia forest, following up on previous control and initiating new efforts. Lantana was controlled by a combination of cut-stump herbicide application and manual removal of smaller plants. Other weeds were also controlled when they were encountered.

Work was undertaken about every two months throughout 1998 by volunteers and members of local community groups. Follow-up hand weeding and spot spraying, and further control of primary lantana infestations, were also undertaken throughout 1999. This work involved international backpackers, unemployed people from Green Corps 2000, students and personnel from private enterprise, all of whom volunteered their time. The total area cleared of lantana and other weeds was approximately 75 m wide and 100 m long.

In May 2000 the cleared areas were planted with native vegetation by local Cub Scouts and Venturers and members of the Friends of Towra. Approximately 200 banksias were planted. The training of volunteers and community groups on such issues as weed control techniques, bush regeneration and plant identification was another significant outcome.

At each quarterly follow-up visit to the site, approximately 24 man-hours are required to keep on top of any reshooting and newly germinated lantana, and encourage regeneration of native species. It is expected that lantana will become disadvantaged as canopy cover and shade increases, and less work will be required in the future.

How to control lantana

Quick reference guide

Lantana – *Lantana camara*

Minimise spread and future impacts

Although lantana is widespread on the east coast of Australia, it is still absent from parts of its potential range. These areas should be protected by:

- preventing the importation of further varieties and species of lantana
- stopping more planting of lantana in gardens
- strategically controlling infestations which threaten uninfested areas.

A control program for dense infestations in pastures

The Queensland Department of Natural Resources and Mines has produced a pest series fact sheet on lantana (PP#34). They advise that herbicides are too expensive to treat large lantana infestations.

A combination of fire and mechanical control makes spot treatment of small patches with herbicides more cost-effective. The following suggested control program for dense infestations in pastures is based on the fact sheet:

1. Exclude stock to allow a fuel load to build up.
2. Bulldoze, stickrake or plough the infestation to add to the fuel load.
3. Burn the infestation after obtaining a permit. Summer burns are more effective than winter burns.
4. Sow an improved pasture. Seek advice of local council or state/territory government agencies for selection of non-weedy pasture species.
5. Continue stock exclusion until pasture has established and set seed.
6. Burn the infestation again after obtaining a permit.
7. Spot spray or grub out any regrowth or seedlings. Spraying is most effective between summer and autumn.
8. Follow-up burning, spraying and/or grubbing will be required for several years.

Lantana can escape from garden plantings into surrounding bushland.
Photo: Tim Schultz

Control options

Type of infestation	Physical	Mechanical	Chemical	Fire	Biological
Small (few plants, small area)	Hand grubbing only suitable for seedlings. Wear gloves for protection from thorns.	Not suitable.	Spot spray plants less than 2 m in height between summer and autumn with a registered herbicide.	Not suitable.	There are four useful biological control agents. They are already distributed throughout their potential range.
Medium (medium density, medium total area)		Bulldoze, plough, stick-rake or slash infestations. Soil disturbance will lead to mass seed germination, so follow up with further controls. Do not use mechanical control in areas susceptible to erosion. A permit may be required.	Spraying is uneconomical for medium or large infestations. Helicopter spraying is used when there is no access for mechanical control, eg very steep slopes.	Under permit, burn in summer with good fuel load of grass and/or mechanically cleared lantana. Also use as follow-up. Do not burn in rainforests.	
Large (many plants, many ha)					

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CRC Weed management

Annex F

Audit Checklists

FERN BAY SEASIDE VILLAGE CONSTRUCTION AUDIT CHECKLIST		
Date of Inspection:		
Inspected by:		
	Yes / No	**Comments / Action**
INDUCTIONS		
Site induction training for all personnel undertaken. Documented evidence kept and maintained of inductions.	☐ **Yes** ☐ **No**	
SEDIMENT CONTROLS		
Erosion and sediment control measures installed and maintained.	☐ **Yes** ☐ **No**	
Site checked for erosion.	☐ **Yes** ☐ **No**	
Topsoil / excess soil stockpiles separated in designated area and sediment control devices installed (eg diversion drains, silt fencing). Stockpiles compacted to reduce erosion and where stockpiling exceeds four months, stockpile is seeded to encourage vegetative growth.	☐ **Yes** ☐ **No**	
Disturbed areas re-seeded with a fast growing cover crop immediately following completion of earthworks.	☐ **Yes** ☐ **No**	
WATER QUALITY AND QUANTITY		
Drainage and sediment controls in place and in good order.	☐ **Yes** ☐ **No**	
Fuel or oil spills reported and cleaned up.	☐ **Yes** ☐ **No**	
Fuels / chemicals stored in bunded areas.	☐ **Yes** ☐ **No**	
AIR QUALITY		
Construction machinery not emitting excessive, visible smoke / fumes (for more than 10 seconds).	☐ **Yes** ☐ **No**	
On site dust suppression undertaken as required.	☐ **Yes** ☐ **No**	
All loads covered entering and leaving site.	☐ **Yes** ☐ **No**	
NOISE		
Plant and equipment maintained and kept in good working order	☐ **Yes** ☐ **No**	
Where practical, machines operated at low speed or power and switched off when not being used and not left idling for prolonged periods.	☐ **Yes** ☐ **No**	
Machines producing excessive noise (in comparison to industry standards) removed from the site or stood down until repairs / modifications made.	☐ **Yes** ☐ **No**	

Avoiding any coincidence of noisy plant working together in close proximity simultaneously near to sensitive receivers.	☐ Yes ☐ No	
Maximise the offset distance between noisy plant items and nearby noise sensitive receivers, orienting noisy plant or equipment away from sensitive areas.	☐ Yes ☐ No	
All work conducted within prescribed operating hours.	☐ Yes ☐ No	
FLORA AND FAUNA		
Clearing activities restricted to only those areas nominated on construction plans for each stage.	☐ Yes ☐ No	
Cleared vegetation chipped / mulched on site and reused in landscaping.	☐ Yes ☐ No	
Vehicle movements in uncleared areas restricted.	☐ Yes ☐ No	
Weed control undertaken as required to control spread of weeds on or off site.	☐ Yes ☐ No	
Ensure conservation areas adjacent to construction activities are protected with polyweb fencing or similar before commencing vegetation clearing. Maintain fencing during works to keep vehicles out of designated areas.	☐ Yes ☐ No	
Tree protection fencing installed around trees to be retained, including protection of tree root zone.	☐ Yes ☐ No	
Hollow bearing trees identified and marked in field prior to clearing.	☐ Yes ☐ No	
Inspection of tree hollows prior to clearing to determine use by fauna.	☐ Yes ☐ No	
Removal and release (nearby, on site) of fauna from hollows by experienced and licensed fauna expert.	☐ Yes ☐ No	
All felling of hollow bearing trees supervised by qualified fauna ecologist and in accordance with tree clearing protocol.	☐ Yes ☐ No	
Any injured wildlife reported to a fauna rescue organisation for rescue and care.	☐ Yes ☐ No	
Relocation of dead wood and dead mature trees to conservation areas and reserves on site (consistent with requirements of the Bush Fire hazard Assessment Report).	☐ Yes ☐ No	
REHABILITATION		
Rehabilitation undertaken immediately following completion of construction.	☐ Yes ☐ No	
Rehabilitated areas in good condition.	☐ Yes ☐ No	
WEEDS		
Weed control undertaken as required to control spread of weeds on or off site. Follow up control undertaken as required.	☐ Yes ☐ No	

Tyres of trucks entering and leaving the site are checked for weed seeds to limit spread of weeds.	☐ Yes ☐ No	
HERITAGE		
Stop work if Aboriginal sites located and consultation with DECC – NPWS undertaken as required.	☐ Yes ☐ No	
Aboriginal community consulted with during ground disturbing works.	☐ Yes ☐ No	
WASTE MANAGEMENT		
During clearing, vegetation will be stockpiled for mulching and use in landscaping on-site.	☐ Yes ☐ No	
Topsoil and excess fill will be reused on site wherever possible.	☐ Yes ☐ No	
Waste materials will be reused on site wherever possible prior to recycling or disposal and removed by licensed contractors.	☐ Yes ☐ No	
Provide an area for the segregation, storage and recycling of waste.	☐ Yes ☐ No	
No waste is buried on site.	☐ Yes ☐ No	
Fuels / waste oils stored in bunded area.	☐ Yes ☐ No	
ROADS AND TRANSPORT		
Ensure all vehicles access construction site via defined ingress and egress only.	☐ Yes ☐ No	
Machinery storage in designated area (within development footprint)	☐ Yes ☐ No	
COMPLAINTS AND INCIDENTS		
Complaints register maintained and complaints responded to.	☐ Yes ☐ No	
Incident register maintained and incidents responded to.	☐ Yes ☐ No	

FERN BAY SEASIDE VILLAGE - SHORT TERM MONITORING CHECKLIST

To be used:

1 week following revegetation works; and

6 months following weed control works (or prior to weeds setting seed)

Report is to be submitted to Community Association within one week of inspection.

Date of Inspection:		
Inspected by:		
	Yes / No	**Comments / Action**
REVEGETATION		
Plants in good condition?	☐ Yes ☐ No	
Mulch / woodchip in place?	☐ Yes ☐ No	
Stakes / tree guards in place?	☐ Yes ☐ No	
Is additional watering required?	☐ Yes ☐ No	
Any additional works required?	☐ Yes ☐ No	
Any plants that require replacing?	☐ Yes ☐ No	
WEED CONTROL		
Has previous weed control works been effective?	☐ Yes ☐ No	
Is follow up weed control works required? (including additional hand removal of seedlings, spraying, brush cutting etc)	☐ Yes ☐ No	
Follow Up Actions Required **(list actions identified above)**	**Timing** **(identify required timing of works)**	**Date of Next Inspection** **(insert date of next follow up inspection)**