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PACIFIC PINES ESTATE

Hairy Joint Grass Management Strategy

12 March 2008
Job No. 7296-21

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Document Control

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1	12 March 2008	Monica Campbell		John Delaney	

PACIFIC PINES ESTATE

HAIRY JOINT GRASS MANAGEMENT STRATEGY

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1. INTRODUCTION

This Management Strategy (MS) has been prepared to facilitate the management of populations of the threatened grass species *Arthraxon hispidus* (Hairy Joint Grass) that have been recorded at the Pacific Pines Estate, Lennox Head, northern New South Wales ("the site").

The majority of the site, which is comprised of Lot 234 on DP1104071, is zoned 2(b) – Village Zone under the *Ballina Local Environmental Plan 1987*, with a small portion of the site along the south-western boundary zoned as 7 (a) Environment Protection – Wetland Zone.

In 2003 a Master Plan was submitted for approval under the provisions of the NSW Government's State Environmental Planning Policy No. 71 (SEPP 71). This Master Plan was adopted by the State Government in 2006 and currently three planning approvals, issued by Ballina Shire Council, exist for a range of specific works on the site. Petrac are currently seeking an Approval from the NSW Government under the provisions of Part 3A of the *Environmental and Planning Assessment Act 1979* for a Concept Plan for urban development of the site. This Concept Plan provides for:

- a subdivision providing approximately 630 residential allotments including medium density housing sites and 167 retirement lots;
- a neighbourhood centre/facilities;
- sporting facilities; and
- approximately 13 ha of Open Space Reserve.

The NSW Department of Planning (DoP) issued the Director General's Environmental Assessment Requirements (DGRs) for assessment of Petrac's current Concept Plan application on the 18 May 2007. As part of the DGRs, the DoP required an updated ecological assessment be undertaken in accordance with the draft Guideline for Threatened Species Assessment. Ballina Council advised that, as part of that updated assessment, targeted surveys should be undertaken for Hairy Joint Grass. Such a survey was undertaken by GeoLINK and populations of the species were detected around a freshwater spring in the central portion of the site and also in a low-lying area in the north-western sector.

A copy of the current Concept Plan in relation to populations of Hairy Joint Grass recorded on the site is provided as Appendix A. With reference to this Appendix, the proposed urban development of the site will necessitate the displacement of Hairy Joint Grass populations that occur within the north-western and central portions of the site. As such, the primary objective of this MS is to provide details concerning the management actions that will be implemented in order to compensate for the loss of, or any adverse effects on, Hairy Joint Grass populations resulting from urban development of the site.

2. DESCRIPTION OF THE SITE AND SPECIES

2.1 Site Description

The site has a westerly aspect, with land occurring at elevations of around 50m AHD in the southern, eastern and north-eastern sectors, around 20m AHD in the far north-western corner and less than 5m AHD in the central and north-western portions. The elevated areas have a moderate slope of between 10-15%, while lower-lying sections of the site are generally flat.

Major vegetation communities existing on the site have been mapped by GeoLINK and a copy of this mapping is provided as Appendix B. With reference to this Appendix, the majority of the site has been subject to extensive vegetation clearance and currently supports degraded paddocks used for livestock grazing. There are a number of rainforest species scattered across the balance of the site, namely Rough-shelled bush nut (*Macadamia tetraphylla*), White laceflower (*Archidendron hendersonii*), Red lilipilly (*Syzygium hodgkinsoniae*), Moreton Bay Fig (*Ficus macrophylla*), Tuckeroo (*Cupaniopsis anarcaroides*), Guioa (*Guioa semiglauca*), Quassia sp. Moonee Creek, Arrow head vine (*Tinospora tinosporoides*) and Pinkheart (*Medicosma cunninghamii*). Three remnants of the pre-existing native vegetation communities have also been identified on the site, namely:

- Swamp oak floodplain forest;
- Swamp sclerophyll forest on coastal floodplain; and
- Littoral rainforest in the NSW North Coast bioregion.

These three communities are recognised as Endangered Ecological Communities pursuant to the NSW *Threatened Species Conservation Act 1995*.

The low-lying area in the central portion of the site supports a freshwater spring. This spring is in a degraded state owing to the history of native vegetation clearance and livestock grazing. There is also a large constructed water quality treatment pond along the south-western boundary of the site and a modified natural channel that traverses the north-western corner of the site. The modified natural channel and existing spring drain into North Creek and associated wetlands to the south-west of the site.

2.2 Species Description

Hairy Joint Grass is a slender, creeping grass with branching to semi-erect purplish stems that form roots at the node. The species is distinguished by a hispid (having bristly hairs) leaf sheath 1 – 3 cm long and leaf margins that are fringed with long, white hairs. While generally considered to be a perennial, the species life-cycle can be comparable to an annual plant, where individuals arise from seed during spring, flower in autumn and die off in winter. Hairy Joint Grass is typically described as a moisture and shade-loving species often associated with the edge of rainforest, wet sclerophyll forest, creeks and swamps. However, at present there is dearth of published knowledge concerning the species biology and ecology. Information that is currently available has been reviewed and is summarised in the 'Species Profile' prepared by Cardno (QLD) Pty Ltd, provided as Appendix C.

Hairy Joint Grass is currently listed as 'Vulnerable' pursuant to both the Commonwealth's *Environment Protection and Biodiversity Act 1999* and the New South Wales *Threatened Species Conservation Act 1995*. Currently there are no State or Commonwealth based Recovery Plans in place, or being developed, for Hairy Joint Grass.

3. MANAGEMENT STRATEGY OBJECTIVES, ACTIONS AND RECOMMENDATIONS

3.1 Overall Objectives

The overall objective of this MS is to contribute to the preservation of Hairy Joint Grass in the Lennox Head locality by:

- compensating for the displacement of Hairy Joint Grass populations that will result from urban development of the site; and
- advancing the current understanding of the species biology and ecology.

This overall objective will be achieved through the implementation of the following Management Actions:

1) on-site population retention and enhancement within the proposed Open Space Reserve;
2) off-site population retention and enhancement of Hairy Joint Grass populations within the proposed Open Space Reserve linkage to the west and north-west of the site; and
3) regional surveying and mapping of known and potential Hairy Joint Grass habitat.

Each of these Management Actions is discussed in more detail in the following sections.

3.2 On-site Population Retention and Enhancement

The on-site retention and enhancement of Hairy Joint Grass populations will achieve four main objectives:

1) retention of populations within suitable areas of the proposed Open Space Reserve network;
2) compensation for displacement of populations elsewhere on the site;
3) monitoring and research to increase the current understanding of the species biology, ecology and appropriate management; and
4) development of source populations for seed and/or seedling translocation trials to be conducted on and off the site.

3.2.1 Recommendations for Population Retention

Successful retention of Hairy Joint Grass populations on-site will require appropriate management of the Open Space Reserve during the Detailed Design Phase, Construction Phase and Occupational Phase of development of the Pacific Pines Estate. In this regard, the recommendations pertaining to management during each of these phases of development are outlined below.

Detailed Design Phase

Hairy Joint Grass populations that will be retained on-site occur within the area of Open Space Reserve in the central eastern portion of the site which also supports a remnant patch of Swamp sclerophyll forest and a spring-fed drainage line.

As a priority the boundaries of the Open Space Reserve that will support retained Hairy Joint Grass populations should be clearly marked in the field. Access to these areas will be restricted.

Trials involving the translocation of seed and seedlings within retained populations will be carried out in order to enhance the retained population.

The Open Space Reserve that supports retained populations of Hairy Joint Grass will be privately owned and managed by the Retirement Community. As such, an Open Space Management Plan (OSMP), with specific reference to retained Hairy Joint Grass habitat, will be developed and provide management specifications relating to:

- delineation of the proposed Open Space Reserve network;
- protection measures for retained vegetation;
- weed removal and control;
- revegetation and landscaping within the Open Space Reserve system;
- ongoing monitoring and maintenance; and
- the provision of suitable access to facilitate management of Open Space Reserve areas.

Construction Phase

Areas of the Open Space Reserve that support retained Hairy Joint Grass populations will be protected with highly visible fencing for the duration of works.

Prior to the commencement of any operational works on the site a Construction Environmental Management Plan (CEMP) will be prepared that clearly states the restrictions associated with the presence of Hairy Joint Grass within the Open Space Reserve, and the penalties that will be enforced should construction activities result in any unauthorised disturbance to retained populations.

The CEMP should specify that the clearance, removal or disturbance of Hairy Joint Grass within the Open Space Reserve is prohibited as are any of the following activities:

- storage and mixing of materials;
- vehicle parking;
- liquid disposal;
- machinery repairs and/or refuelling;
- construction property office or shed;
- combustion of any material;
- stockpiling of soil, rubble or debris;
- any filling or excavation including trenchline, topsoil skimming and/or surface excavation, unless otherwise approved by the relevant authority; and
- unauthorised pesticide, herbicide or chemical applications.

All contractors who undertake works within or adjacent to the Open Space Reserve must be made aware of these restrictions and associated penalties.

The Concept Plan provides for staged development of the site, with the first stage of development affecting Hairy Joint Grass populations in the central portion. In this regard, construction works within Hairy Joint Grass habitat affected by Stage 1 will be timed in a manner that does not interfere with components of the Hairy Joint Grass life-cycle that involve the production of seed and emergence of seedlings. More specifically, construction works within Hairy Joint Grass habitat during Stage 1 will be delayed until July 2008 to allow for:

- sufficient numbers of seedlings to emerge during spring 2007;
- the translocation of seedling cohorts of an appropriate age (i.e. spring 2007 – summer 2008); and
- remaining seedlings in the field to mature into adults and produce seed for collection (i.e. spring 2007 – winter 2008).

Securing sufficient number of seeds and seedlings from populations that will eventually be displaced by urban development of the site will be critical to the success of population enhancement trials as described in Section 3.2.2.

Occupational Phase

A public awareness campaign will be undertaken that educates future land owners/occupants of the threatened status of Hairy Joint Grass and the penalties that may be applied under the *EPBC Act* and *TSC Act* should any unlawful disturbance of the Hairy Joint Grass populations occur.

Appropriate management of the population will be undertaken throughout the life of the development to ensure the long-term viability of Hairy Joint Grass within the Open Space Reserve. Details and specifications pertaining to maintenance, landscaping, access and monitoring of Open Space Reserve that supports Hairy Joint Grass populations will be provided in the OSMP prepared during the Detailed Design Phase.

3.2.2 Recommendations for Population Enhancement

Population enhancement refers to the process of increasing the number of individuals in a population through manipulation of the environment and/or translocation of individuals. This MS proposes to enhance populations of Hairy Joint Grass that will be retained on the site (refer Section 3.2.1) and also populations that occur off the site (refer Section 3.3).

It is proposed to enhance populations of Hairy Joint Grass through the translocation of seeds and seedlings. In this regard, two issues will be addressed:

1) is there a difference in the efficiency and effectiveness of directly seeding areas of suitable habitat in comparison to germinating seeds and raising seedlings in an artificial environment (i.e. nursery); and
2) is there a difference in the efficiency and effectiveness of translocating seedlings between areas of suitable habitat in comparison to growing seedlings in a nursery for part of their life-cycle prior to translocation in the field.

Seeds and seedlings will be sourced from populations in areas of the site that will be subject to displacement during the initial stages of development. Transplanting trials conducted in the field will occur within the fenced Open Space Reserve that will support retained populations of Hairy Joint Grass.

Other studies have demonstrated an increase in seedling emergence in the field after slashing and removal of mulch. Such manipulations will be used in small areas of known Hairy Joint Grass habitat to encourage a greater number of seedlings to be available for translocation and enhancement trials.

The Department of Environment and Climate Change (DECC) have identified "*Maintain populations ex situ at suitable botanic gardens, regional gardens or nurseries*" as a Priority Action in the recovery of Hairy Joint Grass. With the implementation of this management action the potential exists for Petrac to contribute Hairy Joint Grass seeds and seedlings to Seed Banking projects and Botanic Gardens in the region.

3.2.3 Recommendations for Long-term Management of Retained Populations

The need to "*develop and implement site management plans for some of the known populations*" has been identified by DECC as a Priority Action in the recovery of Hairy Joint Grass. As part of this MS, research and/or monitoring of retained and enhanced populations of Hairy Joint Grass will be carried out to contribute to the development of management protocols that can be applied at a wider scale.

Areas of known Hairy Joint Grass occurrence within and adjacent to the site will be surveyed during the active growing season of the species (i.e. late spring – early winter), to establish habitat parameters that may be essential to its growth and survival. More specifically, it is proposed that the following environmental conditions will be assessed:

- aspect;
- soil type and structural characteristics;
- soil moisture content;
- groundwater depth;
- elevation; and
- vegetative cover and composition.

Detailed assessment of these parameters will discern if any environmental conditions are driving species distribution and abundance. Furthermore, this knowledge will assist in the identification of suitable habitat for establishment of populations within and adjacent to the site.

Information concerning the response of populations to varying disturbance regimes is essential to establishing effective management strategies that ensure long-term population viability. Currently cattle are assumed to be facilitating the survival of on-site populations through the grazing and control of competing grasses. A key aim of this MS is to establish self-sustaining Hairy Joint Grass populations that require minimal intervention. As such, trials will be conducted to examine the effectiveness of the following potential management measures:

- slashing the area with a brush-cutter;
- intermittent grazing;
- mechanical disturbance of soil (i.e. ripping or raking); and
- no interference.

Monitoring of retained and enhanced Hairy Joint Grass populations will be implemented prior to the commencement of works and it is envisaged that monitoring of populations would continue until they have reached a stable and self-sustaining state.

3.3 Off-site Population Retention and Enhancement

This Management Action aims to establish an off-site Reserve system to achieve the following:

- establishment of a self-sustaining system that reflects pre-existing vegetation types and ecotones that are considered to constitute natural Hairy Joint Grass habitat;
- creation of a habitat linkage between areas of protected vegetation that occur to the west and north of the site; and

- restoration of biodiversity values that have been lost in the locality through past land management practices.

An aerial photograph of the site and surrounding locality is provided as Appendix D. With reference to this Appendix, land to the north and west of the site has been subject to broad-scale vegetation clearance in the past and currently supports a mosaic of pasture paddocks, sugar cane crops and urban development. Consequently, native vegetation to the north of the site has been reduced to remnant patches that are physically isolated from larger tracts of intact vegetation held within the Ballina Nature Reserve. In this regard, the proposed off-site Reserve system will provide a vegetated linkage between Hairy Joint Grass populations identified on a parcel of Council owned land to the west of the site and Hairy Joint Grass habitat associated with the SEPP 14 Wetland within the northern section of the adjoining Henderson Farm. The potential also exists for the proposed Reserve to include, or provide linkage to, a small remnant of SEPP 26 Littoral Rainforest adjoining the north-western corner of the site.

It is envisaged that Hairy Joint Grass habitat on the Council-owned land will eventually be dedicated to the State Government as an addition to the adjoining Ballina Nature Reserve. In this regard, it is noted that a Specific Management Objective pursuant to the Ballina Nature Reserve Plan of Management is to "*enhance the viability of habitats by encouraging vegetation corridors off the Reserve where possible*". The development of the off-site Reserve in general accordance with this MS will therefore contribute to broader biodiversity conservation measures and the ecological value of the adjoining Ballina Nature Reserve.

A key factor in the development of the off-site Reserve is the emphasis on restoring a self-sustaining system that reflects the natural ecological values and features of the area. While the retention and enhancement of Hairy Joint Grass populations will be accommodated within the Reserve the overall objective is to increase biodiversity values and functions in the area. This objective will be achieved through the following measures.

1. In the first instance, it will be necessary to define the extent of the off-site Reserve and securing control and management of land to be included in the Reserve system. This will require communication and cooperation between Petrac and Ballina Shire Council, and in the future, owners of land to be included in the off-site Reserve system.
2. A species-specific survey will be undertaken to identify and map the location and extent of Hairy Joint Grass populations within the proposed off-site Reserve system. This will involve a systematic survey that includes assessment of the environmental conditions discussed in Section 3.2.3.
3. Once populations and areas of suitable habitat have been identified within the proposed off-site Reserve system the potential exists for the enhancement of existing populations or the establishment of new populations using seeds and seedlings collected from on-site Hairy Joint Grass populations that will be displaced by urban development of the site (refer 3.2.2).
4. Prior to the restoration of wooded vegetation in the off-site Reserve system, it will be necessary to discern the impact of shading on the growth and survival Hairy Joint Grass. Data collected during the detailed surveys described in Section 3.2.3 should provide sufficient information concerning any shade-induced limitations on Hairy Joint Grass abundance and distribution.
5. A Restoration Concept Plan (RCP) will be prepared for the off-site Reserve prior to any revegetation and restoration works being implemented within the off-site Reserve system. This RCP will depict the nature and extent of vegetation

communities that will be restored within the Reserve. It is envisaged that in order to achieve a balance between Hairy Joint Grass conservation and the establishment of a broader habitat linkage, a mosaic of vegetation communities will be planted. The detailed design of the RCP will be determined after relevant data pertaining to Hairy Joint Grass growth, survival and habitat requirements has been collected, including:

- specific environmental conditions that may be required by Hairy Joint Grass;
- the degree of shading that is tolerated by Hairy Joint Grass;
- the success of seed and seedling translocation; and
- any specific management strategies that may need to be implemented, including weed control strategies.

3.4 Regional Habitat and Mapping

The cryptic and seasonal nature of Hairy Joint Grass renders it difficult to identify in the field without targeted searches. As such, published records of the species occurrence may not provide an accurate representation of the actual distribution and abundance. In this regard, data obtained from monitoring and survey exercises described in Sections 3.2 and 3.3 will be used to:

- update and confirm current information concerning the distribution of the species in the Lennox Head area;
- increase the knowledge of the species range of occurrence and the land tenures it occupies;
- clarify the understanding of the species conservation status and the threats that may be operating within its range of occupancy; and
- create predictive GIS models based on essential habitat parameters (i.e. aspect, topography, soil characteristics etc).

It is relevant to note that DECC have identified the need to "*map extent of known populations and survey areas of potential habitat near known occurrence for additional populations*" as a Priority Action in the recovery of Hairy Joint Grass.

4. IMPLEMENTATION

The long-term development and implementation of this MS will involve collaboration between a number of relevant parties. Petrac have commissioned Cardno (QLD) Pty Ltd and GeoLINK to play a principal role in development of the MS. However, continuing discussions with Ballina Shire Council, DECC, adjoining land owners, local environment groups and other relevant persons will be critical to the evolution and success of the MS and its overall objectives. In this regard, Table 1 provides an initial schedule of the timing and parties responsible for the implementation of the Management Actions presented within this MS.

Table 1 Proposed Timing and Responsibility for Implementation of Management Actions

Management Action	Responsibility for implementation	Timing
On-site Population Retention and Enhancement		
Detailed Design Phase		
Identification and demarcation of populations to be retained on site. Restricted access to retained populations.	Cardno GeoLINK	2008
Manipulation of populations to enhance seedling emergence	GeoLINK	2008
Translocation of seedlings – *in situ* vs *ex situ* comparisons	GeoLINK	2008
Collection of seed	Cardno GeoLINK	2008
Germination trials – *in situ* vs *ex situ* comparisons	GeoLINK	2008
Construction Phase		
Fencing around populations identified for retention	Contractor	2008 - 2013
Preparation of Construction Environmental Plan (CEMP)	Cardno	2008
Staging of works in known areas of Hairy Joint Grass to coincide with the completion of key life-cycle events (i.e. seedling emergence, seed production).	Cardno GeoLINK Contractor	2008 - 2013
Occupational Phase		
Development and implementation of a low-intensity management regime to sustain populations on-site in Private Open Space	Retirement Community	TBA
Education and awareness of future owner/occupants of the estate about the grass and its importance.	TBA	TBA

Management Action	Responsibility for implementation	Timing
Establishment of Off-site Reserve System		
Negotiation management of land to be included in the habitat linkage	Petrac GeoLINK Ballina Shire Council	2008
Translocation of Hairy Joint Grass seeds and seedlings	GeoLINK Contractor	2008
Implementation of shading trials	Cardno GeoLINK	2008
Development of revegetation plan	Cardno GeoLINK	2008-2009
Implementation of revegetation works	GeoLINK Contractor	2009
Mapping and Habitat Assessment		
Consolidating data concerning known populations of Hairy Joint Grass	Cardno GeoLINK	2008
Identifying and surveying potential habitat for Hairy Joint Grass	Cardno GeoLINK	2008

5. CONCLUSION

This Management Strategy (MS) has been prepared to facilitate the management of the threatened grass species, *Arthraxon hispidus* (Hairy Joint Grass) that has been recorded within the site.

The information presented in this MS is to be incorporated into:

- the detailed design and construction phases of site development;
- an Open Space Management Plan;
- a Construction Environmental Management Plan for the site and immediate surrounds which is to be prepared in support of any relevant Operational Works application submitted for the site; and
- a Restoration Concept Plan that will be developed in relation to the proposed off-site Reserve system.

The information presented in this MS demonstrates that Petrac will provide compensation for adverse impacts on Hairy Joint Grass populations that will occur as a result of urban development of the site through:

- the retention and enhancement of Hairy Joint Grass populations within the proposed Open Space Reserve network on the site;
- the establishment of an off-site Reserve system that will retain and conserve Hairy Joint Grass populations as well as providing broader ecological benefits to the locality (i.e. an increase in biodiversity values and functions and a habitat linkage); and
- monitoring and research into effective management of Hairy Joint Grass populations; and
- contributions to a number of Priority Actions for the recovery of Hairy Joint Grass as identified by DECC.

APPENDIX A

Current Concept Plan

PACIFIC PINES ESTATE
LENNOX HEAD

PETRAC

TESD ECOLOGICALLY SUSTAINABLE DESIGN

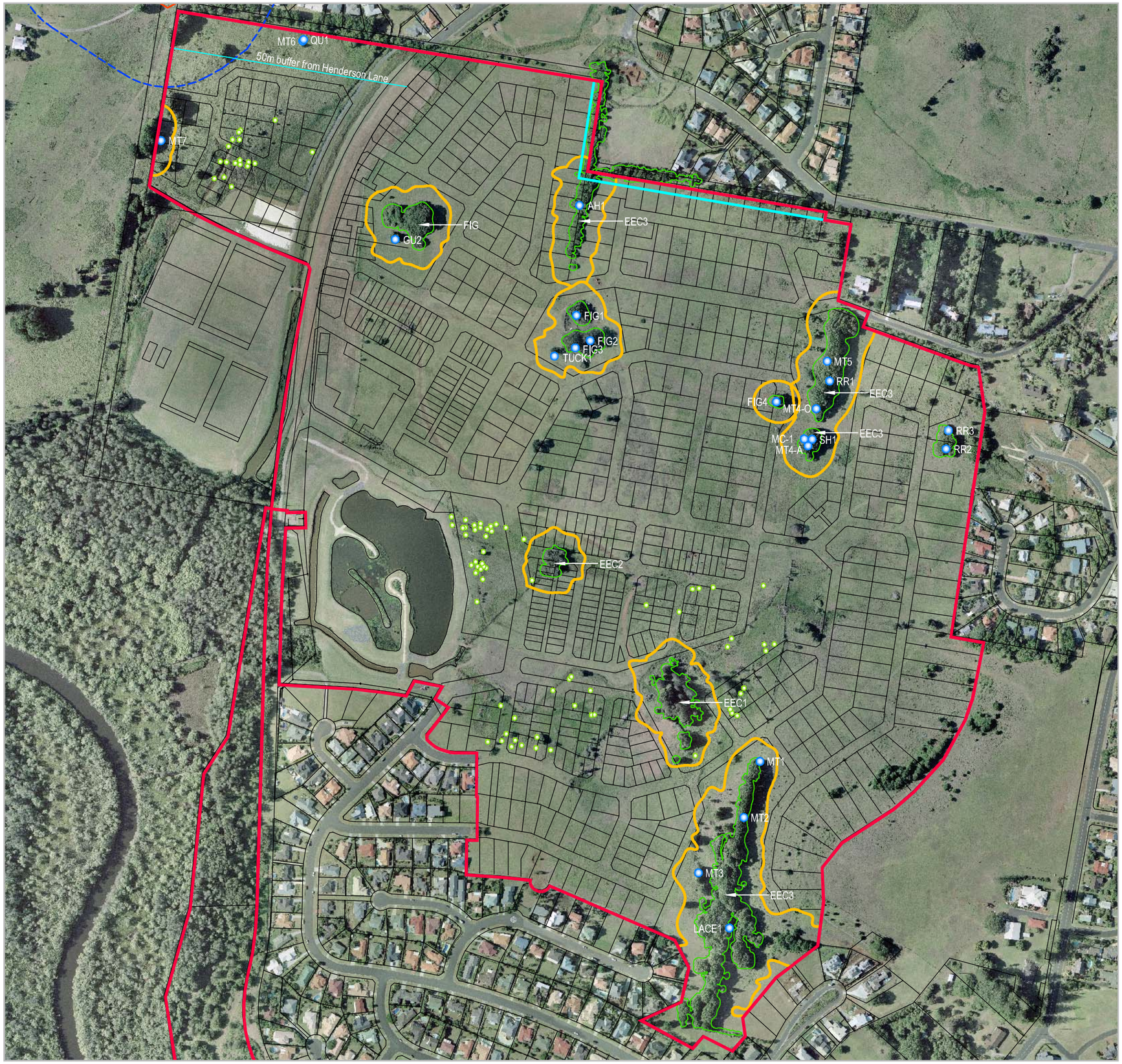
Deicke Richards

Architecture
Urban Design
Community Design

CONCEPT PLAN 06115 - PAP_A 26 JULY 07 1:5000 @ A3

APPENDIX B

GeoLINK Illustration 2.c – Ecological Constraints



Source: GeoLINK Date: June 2007

LEGEND

MT - Rough- shelled Bush Nut
(Macadamia tetraphylla)

RR - Scrub Turpentine
(Rhodamnia rubescens)

LACE - White Laceflower
(Archidendron hendersonii)

SH - Red Lily Pilly
(Syzygium hodgkinsoniae)

FIG - Moreton Bay Fig
(Ficus macrophylla)

TUCK - Tuckeroo
(Cupaniopsis anarcaroides)

GU - Guioa
(Guioa semiglauca)

QU - *Quassia* sp. 'Moonee Creek'

AH - Arrow head Vine
(Tinospora tinosporoides)

MC- Pinkheart
(*Medicosma cunninghamii)*

EEC1 - Swamp oak floodplain forest

EEC2 - Swamp sclerophyll forest on coastal floodplain

EEC3 - Littoral rainforest in the NSW North Coast bioregion

Site boundary

100m SEPP 26 buffer

20m vegetation buffer

10m boundary buffer

Hairy Joint Grass records

North

0 100

GeoLINK environmental management and design

Petrac Pacific Pines
0955045

Ecological Constraints

Illustration 2.c
-With Hairy Joint Grass records

APPENDIX C

Species Profile *Arthraxon hispidus* prepared by Cardno (QLD) Pty Ltd

SPECIES PROFILE

Arthraxon hispidus (Thunb.) Makino – Hairy joint grass

This species profile has been prepared by Cardno (QLD) Pty Ltd on behalf of Petrac in relation to a parcel of land known as Pacific Pines Estate located in Lennox Head, New South Wales ("the site"). The site has been approved for urban development, however populations of the threatened grass species *Arthraxon hispidus* ("*Arthraxon"* hereafter, unless specified otherwise) have recently been discovered on the site. This Species Profile details:

- in Section 1, a taxonomic description of *Arthraxon*;
- in Section 2, details of the national, state and local distribution of *Arthraxon*;
- in Section 3, a review of the current ecological knowledge of *Arthraxon*;
- in Section 4, a review of the conservation status of *Arthraxon* pursuant to Commonwealth and NSW legislation;
- in Section 5, an analysis of the populations on the site in relation to attributes recognised by Commonwealth and NSW legislation; and
- in Section 6, conservation measures that may be adopted by Petrac to mitigate against adverse impacts on populations of *Arthraxon* that may occur as result of development of the site.

1. Species Description

Taken from Wheeler *et al*. 1990, Harden 1993 and Benwell 2203.

*Arthraxon i*s a slender, creeping grass with branching, erect to semi-erect purplish stems that form roots at the node. Leaves have a sheath approximately 1 – 3 cm long that is mostly hispid (having bristly hairs) and slightly inflated in appearance. Leaf-blades are ovate to ovate-lanceolate, 2 – 6cm long, broad at the base and tapering abruptly to a short point. Long white hairs fringe the leaf margins. The ligule (or leaf collar) is short, membranous and torn and/or slightly hairy. Inflorescences consist of 2 – 5 racemes that are greenish to purple and bare at the base. Spikelets are solitary, 4 – 5 mm with the pedicel of the reduced pedicillate spikelet, present and reduced, or absent. Lower glumes are purplish, with around 9-nerves, scabrous with rows of fine, antrorse (i.e turned towards the apex) tubercles (wart-like growths) on the nerves. The upper glume is strongly compressed and keeled, the keel is rough and greenish. Lemmas (the bracts enclosing the flowers) are approximately 65% the length of the glumes, the lower entire, nerveless, the upper Lemma is bilobed with a long awn to a length of 9mm, geniculate (bent like a knee) and twisted. Flowers appear from summer to autumn. The species is generally considered to be a perennial, but some authors report that the grass has an annual life-cycle where individuals arise from seed during spring, flower and seed in autumn and die off in winter (i.e. Wheeler *et al* .1990; Benwell 2003).

2. Distribution

2.1 Introduction

Arthraxon is a genus consisting of around 20 species world wide from tropical and subtropical regions, and is particularly common in Asia. *Arthraxon hispidus* is the only species native to Australia and has a wide spread distribution covering the Northern Tablelands, the north coast of New South Wales, south-east Queensland and a disjunct occurrence in far north Queensland (refer Appendix A – Illustration 1.0). However, the species has never been reported as common within its known distribution.

Published records of the species occurrence may not provide an accurate representation of the actual distribution and abundance. The cryptic nature of the grass can make it difficult to identify and if surveys are conducted during winter when above ground biomass is not present, there is the potential for the plant to not be recorded. In addition, the species is very similar in appearance to grass species such as *Oplismenus imbecillis*, *O. aemulus*, *Entolasia stricta* and the trailing herb *Commelina cyanea* (Native wandering jew) that often occur sympatrically with *Arthraxon*, making identification in the field difficult and further complicating the issue of accurate documentation of species occurrence.

2.2 Queensland distribution

Records from the Queensland Herbarium indicate a concentration of *Arthraxon* populations in coastal areas of south-eastern Queensland (refer Appendix A – Illustration 2.0). However, populations have also been recorded as far north as the Daintree and west as Carnarvon Gorge. The species is commonly associated with wetlands and springs fed by the Great Artesian Basin, but populations have also been recorded on Fraser and North Stradbroke Islands.

2.3 New South Wales distribution

Records of the species occurrence in New South Wales show a concentration of the species around the north coast of NSW and the Northern Tablelands (refer Appendix A – Illustration 3.0). Information supplied by GeoLINK indicates that additional 'verbal' records of populations have been provided by Andrew Benwell for Boambee, Southern Cross University - Lismore, Duck Creek - Alstonville, Billinudgel and Koala Beach, although these records have not as of yet been included within databases such as the NSW Department of Environment and Climate Change (DEC) Wildlife Atlas.

The DEC Threatened Species website provides further information concerning the regional distribution of the species on the basis of Catchment Management Authority (CMA) regions. This information is detailed in Table 1.

Table 1. Distribution within the Border Rivers/Gwydir Region and the Northern Rivers Region.

CMA Region	Known or Predicted to occur	Vegetation Types
Border Rivers/Gwydir region		**Dry sclerophyll forests (shrubby sub-formation)** • Southern escarpment wet sclerophyll forests **Freshwater wetlands** • Montane bogs and fens • Montane lakes **Grassy woodlands** • New England grassy woodlands • Tableland clay grassy woodlands **Wet sclerophyll forests (grassy (sub-formation)** • Northern escarpment wet sclerophyll forests
Deepwater downs	Predicted	
Northeast forest lands	Predicted	
Tenterfield plateau	Known	
Northern Rivers region		
Cataract	Predicted	**Dry sclerophyll forests (shrubby sub-formation)** • Southern escarpment wet sclerophyll forests
Chaelundi	Known	
Clarence lowlands	Predicted	
Coffs coast and escarpment	Known	
Dalmorton	Predicted	

CMA Region	Known or Predicted to occur	Vegetation Types
Ebor basalts	Predicted	**Rainforests** • Cool temperate rainforests • Dry rainforests • Littoral rainforests • Northern warm temperate rainforests • Subtropical rainforests • Western vine thickets **Wet sclerophyll forests (grassy (sub-formation)** • Northern hinterland wet sclerophyll forests • Northern escarpment wet sclerophyll forests **Wet sclerophyll forests (shrubby sub-formation)** • North coast wet sclerophyll forests • Northern escarpment wet sclerophyll forests
Guy fawkes	Predicted	
Murwillumbah (QLD southeast hills and ranges)	Known	
Nightcap	Predicted	
Mortheast forest lands	Known	
Richmond – Tweed (QLD – Scenic rim Part A)	Known	
Richmond – Tweed (QLD – Scenic rim Part B)	Predicted	
Rocky River gorge	Predicted	
Round mountain	Predicted	
Stanthorpe plateau	Predicted	
Washpool	Predicted	
Wongwibinda	Predicted	
Woodenbong	Predicted	
Yuraygir	Predicted	

2.4 Lennox Head distribution

At present there an increasing number of populations of *Arthraxon* being recorded in the Lennox Head locality (refer Appendix A – Illustration 4.0), which may coincide with an increase in search effort and targeted survey work during the active growing season (i.e. spring to autumn) for *Arthraxon*. The distribution of *Arthraxon* in the Lennox Head locality appears to be coupled to the availability of ground water, an issue which is further discussed in the following section.

3. Ecology

3.1 Habitat

Arthraxon is typically described as moisture and shade-loving grass often associated with the edges of ranforest, wet sclerophyll forest, creeks and swamps (DEC). With regard to Table 1, the NSW Threatened Species website indicates that in the Border Rivers/Gwydir region essential habitat for *Arthraxon* consists of moist grassland or swampy areas, while in the Northern Rivers Region essential habitat for the species is identified as moist sites on edges of rainforest or in wet sclerophyll forest.

There is growing evidence from the north coast of NSW, that the species persistence and survival is driven more by a dependence on groundwater than a preference for the prevailing vegetation type (Kooyman 2005). More specifically, populations of the species are being recorded in degraded, weed-infested cow paddocks that support ground-fed springs, wetlands and swamps (Benwell 2003; Kooyman 2005; Parker 2006). It is predicted that these environments at some stage represented the ecotone between Littoral rainforest and *Melaleuca* swamps along the north coast of NSW.

3.2 Life-cycle and population dynamics

At present, the life-cycle and population dynamics of *Arthraxon* is poorly understood. Plant population dynamics can be interpreted in terms of plant life-stages (i.e. adults, seeds seedlings, juveniles) and the flux of individuals between them (i.e. seed dispersal, germination and emergence). This information can provide a useful framework for the development of management strategies for plant species by identifying key demographic processes and components of the plant life-cycle that are critical to population persistence under varying disturbance regimes and changes to environmental conditions. In this regard, the majority of available information on the life-cycle and population dynamics of *Arthraxon* has come from monitoring and research conducted at Koala

Beach (Benwell 2003). The major finding of this research is presented below and complemented with additional sources of information where indicated.

Adults

Observations from populations at Koala Beach indicated that adults of *Arthraxon* die off in winter, and do not regenerate vegetatively during the following growing season (i.e. spring).

Adults plants form roots at the lower nodes, but there is also no evidence of vegetative proliferation through this mechanism.

Adults are low-growing, but have the potential to grow stems up taller tussock grasses (i.e. *Setaria*), a mechanism that has potentially enabled the species to persist in a highly competitive environment (i.e. amongst greater number of exotic grasses).

Seeds and seed dispersal

The seeds of most grasses are shed from the plant enclosed within the lemma and palea. The lemma in *Arthraxon* bears a long twisted awn with a knee-like bend. In many species awns of this structure, twist and untwist in response to changes in humidity enabling the lemma to penetrate soil or the hides of grazing animals (Wheeler et al. 1990).

Monitoring of the Koala Beach population revealed that *Arthraxon* seeds are poorly dispersed as plants were generally restricted to points where adults were recorded in the previous year. Furthermore, no dormant seed bank was detected in areas that did not support adult plants.

Seed bank and seedling emergence

Data collected from the Koala Beach population indicates that seeds have the ability to remain viable in the soil for at least one season. Seed bank longevity has been estimated at several years in an *Arthraxon* population at Boambee, south of Coffs Harbour (Benwell 2003).

Germination and emergence of seedling from the soil seed bank was improved by slashing and removal of mulch in the Koala Beach population. There was also evidence that *Arthraxon* seeds are not able to germinate through mulch greater than 3 cm thick.

In the absence of disturbance, seedlings have been reported to germinate and emerge in gaps between *Setaria* tussocks.

Seedling survival

Seedlings of *Arthraxon* have demonstrated an ability to compete and survive with large numbers of introduced grass species and various herbaceous plants that arise after disturbance (i.e slashing and mulch removal).

The longer-term growth and survival of *Arthraxon* seedlings may be facilitated by the shading and suppression of competing species by *Setaria* regrowth.

Seedlings were successfully transplanted from the Koala Beach populations into pots, raised under glasshouse conditions for approximately two months and then replanted in the field, with an 80 - 90% survival rate.

Key demographic processes

Arthraxon adults lack a vegetative regeneration mechanism and as such, the restoration of populations following disturbance and the annual die-off is reliant on seedling germination and survival. The annual production of seed by mature adults *in situ* is therefore critical to population persistence given that:

- the soil seed bank appears to be relatively short-lived; and
- it is unlikely that seeds have the capacity to disperse into an area form *ex situ* populations.

Two key demographic processes that should therefore be considered in any management program include:

- the creation or provision of conditions that enhance the germination and emergence of *Arthraxon* (i.e. slashing and removal of mulch cf. Benwell 2003) to ensure a supply of potential adult plants for reproduction each season; and
- the maintenance of adult populations during the flowering and fruiting season (i.e. late spring to late autumn) to ensure the provision of viable seed source for population regeneration following disturbance and the annual die-off (i.e. during winter).

4. Conservation Status

Arthraxon is currently listed as 'Vulnerable' plant species pursuant to Commonwealth, New South Wales and Queensland legislation. However, as the Pacific Pines Estate is located in Lennox Head NSW, this section will address issues associated with the Commonwealth and New South Wales legislation.

4.1 *Environment Protection and Biodiversity Conservation Act 1999*

The *Environment Protection and Biodiversity Conservation Act 1999* ("*EPBC Act"*) protects the environment, particularly matters of National Environmental Significance (Protected matters), including threatened species.

Arthraxon was listed as a *Vulnerable* species pursuant to the *EPBC Act* on the 16th of July 2000.

Pursuant to Section 179 of the *EBPC Act* a native wildlife species is eligible to be included in the *Vulnerable* category if:

a) it is not critically endangered or endangered; and

b) it is facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with the prescribed criteria.

The criteria for listing a species as *Vulnerable* under the *EPBC Act* and its associated *Environment Protection and Biodiversity Conservation Regulation 2000* are detailed as follows.

Criterion 1: It has undergone, is suspected to have undergone or is likely to undergo in the immediate future: a substantial reduction in numbers.

Criterion 2: Its geographic distribution is precarious for the survival of the species and is: limited (area of occupancy estimated to be less than <2, 000 km^2).

Criterion 3: The estimated total number of mature individuals is: limited and either (a) or (b) is true:

(a) evidence suggests that the number will continue to decline at: a substantial rate (10% in 10 years or 3 generations up to 100 years, which ever is longer); or
(b) the number is likely to continue to decline and its geographic distribution is: precarious for its survival.

Criterion 4: The estimated total number of mature individuals is: low (<1,000).

Criterion 5: The probability of its extinction in the wild is at least: 10% in the medium-term future (within 100 years).

At present there is no 'Recovery Plan' that has been adopted or implemented for *Arthraxon* under Commonwealth legislation.

4.2 *Threatened Species Conservation Act 1995* (New South Wales)

The NSW *Threatened Species Conservation Act 1995* ("TSC Act") identifies and protects native plants and animals in danger of becoming extinct. The Act also provides for species recovery and threat abatement programs.

Arthraxon was listed as '*Vulnerable'* species pursuant to the *TSC Act* prior to the establishment of the NSW Scientific Committee in 1996. The decision to list the species occurred after revision of:

a) the Rare or Threatened Australian Plants (ROTAP) list; and

b) a draft threatened plant list for NSW, developed by the National Parks and Wildlife Service (NPWS) using standardized risk assessment criteria.

With regard to the above, *Arthraxon* is listed as a category 3VC-+ ROTAP. The 'V' in the ROTAP code indicates that *Arthraxon* has a 'Vulnerable' conservation status, which is defined as 'a *taxon not presently Endangered, but at risk over a longer period (20 – 50 years) of disappearing from the wild through continued depletion, or which occurs on land whose future use is likely to change and threaten its survival'*.

Pursuant to the *TSC Act*, a *Vulnerable species is likely to become endangered unless the circumstances and factors threatening it's survival or evolutionary development cease to operate*.

Currently, a Recovery Plan pursuant to the *TSC Act* has not been prepared or adopted for *Arthraxon* in NSW.

5. Pacific Pines Population Analysis

The location and extent of *Arthraxon* populations on the site is indicated in Appendix A – Illustration 5.0. With reference to this illustration, *Arthraxon* is restricted to two main areas in the north-western corner and the central section of the site to the east of the Water Quality Control Ponds. Information provided by GeoLINK, indicates that the species is specifically associated with damp areas that would be subject to periods of brief inundation, amongst Swamp ricegrass (*Leersia hexandra*) and Swamp foxtail (*Pennisetum alopecuroides*).

The ecological attributes of the *Arthraxon* populations on the site, as recognised by Commonwealth and State legislation are presented below.

5.1 Attributes recognised by the *EPBC Act*

An important aspect of the EPBC significant impact criteria for a *Vulnerable* species is the concept of an "important population" which is defined as:

An 'important population' is a population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, and/or that are:

- *key source populations either for breeding or dispersal;*
- *populations that are necessary for maintaining genetic diversity; and/or*
- *populations that are near the limit of the species range.*

Based on available information concerning the distribution and ecology of *Arthraxon*, it is considered that *Arthraxon* populations on the site do not constitute an 'important population' for the purposes of the *EPBC Act*, due to the following.

1. The potential for *Arthraxon* populations on the site to "interact" with surrounding populations is limited owing to:
    a) their spatial isolation by tracts of cleared agricultural land and existing residential development; and
    b) poor seed dispersal that generally results in a concentration of the seed bank around the base of existing parental plants (refer Benwell 2003).
2. The small size and isolation of the populations on site limit the probability of gene transfer to occur and it is doubtful that they would have a genetic diversity that is superior to that of larger populations in the locality (i.e. the Newton property population, refer Annexure A – Illustration 4.0).
3. The Pacific Pines populations not at the edge of this species geographic distribution given that populations have been recorded further south (i.e. Boambee), north (Queensland) and to the West (New England Tablelands).

It is also relevant to note that the site and surrounding locality is not identified by the Commonwealth's Department of Environment and Water Resources (DEWR) 'Register of Critical Habitat'.

5.2 Attributes recognised by the *TSC* Act

No areas of declared 'Critical Habitat' pursuant to the *TSC Act* occur within or adjacent to the site.

The *Arthraxon* populations on the site are not listed or recognised as 'endangered' populations pursuant to the *TSC Act*.

6. Contribution to Conservation Strategies

6.1 Recognised threats

The New South Wales DEC have recognised a number of threats to the survival and persistence of *Arthraxon* populations, namely:

- clearing of habitat for agriculture and development;
- inappropriate fire regimes;
- over-grazing by domestic stock;
- competition from introduced grasses such as *Paspalum* and *Kikuyu*; and
- slashing or mowing of habitat.

There is also increasing evidence that the species distribution is more closely tied to availability of ground water than the prevailing vegetation. As such, any land use or disturbance that has impact on the hydrology or flow regime of a spring, wetland or swamp that supports populations of *Arthraxon* should also be considered as a threat to the species survival and persistence. It is relevant to note that 'Alteration to the natural flow regimes of rivers streams, floodplains and wetlands' is recognised as a Key Threatening Process (KTP) pursuant to the *TSC Act*.

Other KTPs that are of relevance to *Arthraxon* include Lantana and Bitou Bush invasion (DEC).

6.2 Mitigation measures

The potential exists for Petrac to provide or contribute to conservation measures and/or recovery strategies in order to mitigate against any loss of adverse effect on *Arthraxon* populations that may result from development of the site. In this regard, a total of nine strategies have been identified by DEC to assist in the recovery of *Arthraxon* populations. The strategies that are of most relevance to the site are detailed as follows.

Develop and implement protocols and guidelines (Medium priority). Develop and implement site management plans for some of the known populations.

Habitat management: Weed control (Medium priority). Assess weed threats to populations, manage as necessary. Implement Medium Bitou bush control as described in the approved Threat Abatement Plan.

Monitoring (Medium priority). Establish monitoring sites to determine trends in habitat condition and Low population size.

Research (Medium priority). Observations suggest that *Arthraxon hispidus* is an annual but literature suggest it's a perennial species; this needs to be resolved through biological research.

Survey/Mapping and habitat assessment (Medium priority). Map extent of known populations and survey areas of potential habitat near known occurrences for additional populations.

Captive husbandry or ex-situ collection/propagation (Low priority). Maintain populations *ex situ* at suitable botanic gardens, regional gardens or nurseries.

Petrac could contribute to any of the above mentioned recovery strategies through one or more of the following:

- the retention and appropriate management of *Arthraxon* habitat located within the proposed on-site Public Open Space Reserve and conduct of site based monitoring and/or research to contribute to the development of management strategies that can be applied on a wider scale;
- conduct or contribute to trials on the capacity for the species to be translocated (either as adults, seedlings or seeds) to suitable areas of on-site Public Open Space Reserves and off-site Public Open Space Reserves ;
- the provision of monetary contributions to external bodies to conduct research on *Arthraxon* populations external to the site;
- the provision monetary contributions towards surveying and mapping programs within the Lennox Head area; and
- the provision of seeds collected from populations on the site to Botanical gardens for *ex situ* preservation of the species.

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