



**BHP Billiton Mitsui Coal Pty Ltd**

**EPBC 2014/7272**

**Mulgrave Pit Expansion Project  
South Walker Creek Mine**

**Offset Area Management Plan  
“Zamia Creek (North Section)”**

30 June 2015

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# Introduction

The purpose of this management plan is to identify the management objectives and outcomes, and the actions necessary to fulfil a statutory requirement for the provision of an offset under the *Queensland Environmental Offsets Policy (2014)* or the *Environment Protection & Biodiversity Conservation Act 1999*.

The plan template is composed of 3 components:

## Part 1 – Summary Information

This section must be completed by all offset proposals and lists all of the following information:

1. Departmental reference details
2. Legislative triggers and impacts requiring an offset
3. Offset area details
4. Ecological Equivalence Assessment
5. Description of the values impacted on the clearing area and the values located on the offset area

## Part 2 – Management Plan

This section contains the management plan details that must be completed based on the offsets triggered and requires at minimum the following information:

1. The offset area management objectives and outcomes
2. Any restrictions imposed on the use of the offset area
3. The activities that will be undertaken to achieve the objectives and outcomes
4. Monitoring requirements
5. An analysis of the risks to achieve the management objectives and outcomes
6. A map that shows spatially the areas subject to the management plan
7. A reporting program
8. Consent between the landowner and the delegate

## Part 3 - Appendices

- A. Detailed Mapping
- B. Baseline data
  - 1) Ecological equivalence assessment of offset area
  - 2) Weed and pest species
- C. Land Manager's Monitoring Guide

Parts 1, 2 and 3 must be completed to fulfil the management plan requirements

# 1. Summary Information

## 1.1. Departmental Reference Details

Departmental Reference Details for application that triggers offset	
Departmental Reference Number and Case Name:	EPBC Reference 2014/7272
Offset reference number (if applicable):	
Tenure: Land Lease – Mining Lease 4750 (ML4750) Environmental Authority MIN 100552107	Primary Local Government Area: Isaac Regional Council

Offset Triggers and Values	
Offset Trigger	Values requiring to be offset
<input type="checkbox"/> Regional Vegetation Management Code <input type="checkbox"/> Part P <input type="checkbox"/> Part S <input type="checkbox"/> Part Xa <input type="checkbox"/> Part Xb <input type="checkbox"/> Material Change of Use / Reconfiguration of a lot Policies (Table F1) <input checked="" type="checkbox"/> <i>Environment Protection and Biodiversity Conservation Act 1999</i> (Cth)	<input checked="" type="checkbox"/> EPBC TEC and/or Protected Spp. <input type="checkbox"/> Assessable vegetation adjacent to a wetland, significant wetland <input type="checkbox"/> Assessable vegetation adjacent to a watercourse <input type="checkbox"/> Connectivity <input type="checkbox"/> Endangered regional ecosystem <input type="checkbox"/> Of concern regional ecosystem <input type="checkbox"/> Threshold regional ecosystem <input type="checkbox"/> Critically limited regional ecosystem <input type="checkbox"/> Essential habitat <input type="checkbox"/> Essential habitat for koalas in SEQ <input type="checkbox"/> Values within a highly vegetated bioregion

## 1.2. Offset Area Details

Landholder Details	
Register Owner/s on Title: Woorabinda Aboriginal Shire Council	
Lessee:	Trustee:
Business/Company name: Woorabinda Aboriginal Shire Council	
ABN/ACN: <b>16 133 571 041</b>	
Phone number: (07) 4925-9800	Mobile phone:
Facsimile number:	Contact person (if required): CEO
Email: ceo@woorabinda.qld.gov.au	
Postal Address: c/- Post Office, Woorabinda QLD 4713	

Property Details	
Property name: Zamia Creek (North Section)	
Real property description (lot on Plan/s): Lot 9 BH194	
Tenure: Freehold	Primary Local Government Area: Woorabinda Aboriginal Council
Planning Scheme Zone: Rural	Property area (ha): 2,794.76    Offset Area (ha): 24.8
Landzone / geology	Landzone 4 - Tertiary-early Quaternary clay deposits, usually forming level to gently undulating plains not related to recent Quaternary alluvial systems.
Soils	Mainly Vertosols, Deep cracking black clay with gilgai present
Pre-clear regional ecosystem (V.)	11.4.8/11.4.9
Existing vegetation	Regrowth 11.4.8 and 11.4.9
Estimated age of vegetation	Regrowth – minimum of 8 years

Is there a PMAV currently over all or part of the property, Please detail	Yes – PMAV – 2005/109907
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Legally Binding Mechanism	
<input checked="" type="checkbox"/> Voluntary Declaration ( <i>Vegetation Management Act 1999</i> )	<input type="checkbox"/> Covenant ( <i>Land Act 1994/ Land Title Act 1994</i> )
Reference Number:	Reference Number:
<input type="checkbox"/> Nature Refuge ( <i>Nature Conservation Act 1992</i> )	<input type="checkbox"/> Other
Reference Number:	Reference Number:

### 1.3. Description of MNES clearing and offset values

Table 1 identifies the MNES impacted on and captured under the *Environmental Protection and Biodiversity Conservation Act 1999* – in the Mulgrave Pit Expansion Project clearing area for which an offset is provided in the Offset Area. These values are illustrated in Figure 4-11 in *Threatened Terrestrial Fauna Species Assessment Report for Mulgrave Pit Expansion Project South Walker Creek Mine, June 2013, Footprints Environmental Consultants*.

**Table 1. Clearing area and offset area values**

Attribute	Value	Rationale/Assumption
Impact Area	17.5 ha	Despite the species not being recorded in the Project Area during targeted fauna surveys consistent with Commonwealth (SEWPaC 2011a; SEWPaC 2011b) and State (DSITIA 2012) survey guidelines, the preferred habitat is present.
Quality	5/10	<p><b>Site Condition = 6</b></p> <p>Dominated by low, closed woodland of brigalow on deep cracking grey clays with well-developed gilgai formations. In areas where gilgai were less well-developed to absent, yellow wood formed a dense understorey to the brigalow. Ground cover was dominated by native grass species, with patches of blackcurrant bush scattered throughout. Fallen timber and leaf litter was common to abundant, though trees with decorticating bark were not. Bog marsh and other floating aquatic emergents were common in those gilgai that supported surface water, indicating that these gilgai had supported surface water for extended periods of time.</p> <p><b>Site context = 5</b></p> <p>The Project area has large areas of essentially monotypic vegetation on deeply-weathered sand plains, dominated by poplar gum and poplar box woodlands which are unsuited to the ornamental snake. The 17.5ha of ornamental snake habitat identified was fragmented and located in three disconnected patches (see Figure 4-11 in the <i>Threatened Terrestrial Fauna Species Assessment Report for Mulgrave Pit Expansion Project South Walker Creek Mine, June 2013, Footprints Environmental Consultants</i>). These patches have no connectivity to remnant areas.</p> <p>The two gilgai patches identified in the northern Project area have been significantly impacted upon by pastoral land management practices (e.g., clearing and grazing). The gilgai patch in the southern section has a relatively intact canopy, with fallen timber and leaf litter common.</p> <p><b>Species stocking rate = 5</b></p> <p>Surveys within the brigalow gilgai communities recorded several reptile species, but none of the targeted species, specifically ornamental snake. Of particular note was the lack of frog species, the primary food source for ornamental snakes, from all developmental stages, i.e., tadpoles, metamorphs, juveniles, sub-adults or adults within the gilgai areas.</p>

## 2. Management Plan

### 1. Management area objectives and outcomes

The management area objectives and outcomes identified below are estimated to be achieved within 15 years, or by 2030. It is recognised that the timeframes are subject to natural conditions and unexpected events, and the risks identified in section 4, Risk Analysis.

The management area objectives and outcomes for the Offset Area are for the enhancement of the condition of the MNES of ornamental snake habitat that are in a degraded condition within the offset area.

#### 2.1.1 Management area objectives

##### EPBC Act

The management area objectives are to protect and to improve the habitat conditions for the listed threatened species *Denisonia maculata* (ornamental snake). Management actions will enable the natural regeneration of the habitat via weed control, fire management, management of livestock, pest animal management and restrictions on access within the Offset Areas to meet the offset requirements of the Approval Conditions EPBC 2014/7272 for the Mulgrave Pit Expansion Project, South Walker Creek Mine.

A legally binding mechanism, in the form of a Voluntary Declaration under the *Vegetation Management Act 1999 (Qld)* will protect this vegetation and associated habitat from clearing and require the actions within this management plan to be implemented. The areas will be actively managed until 30 June 2030.

#### 2.1.2 Offset Area Outcomes

- (a) **Site Condition:** The offset management area is managed to improve the condition of the habitat through appropriate restoration and management actions as detailed in **Table 5**. These actions include the exclusion of any forestry and/or timber harvesting operations therefore allowing the natural regeneration of canopy and sub canopy species, weed control, and fire management as per the guidelines provided in the Queensland Herbarium Regional Ecosystems Descriptions Database (REDD) for the protected regional ecosystem comprising the offset.
- (b) **Offset Start Condition** scores as shown in **Table 2** align with the scores recorded as the baseline condition at the monitoring and reporting locations as detailed in **section 6** and **section 7** and **Appendix A4** of this management plan. The EPBC Offset Assessment Tool outputs are provided at **Appendix D** of this management plan.
- (c) **Site Context:** the Offset Area is managed to enable the natural regeneration process of the TEC and associated habitat to occur and to therefore achieve enhanced connectivity to the adjacent offset areas, Zamia Creek Conservation Park and the Zamia Creek watercourse.

**Table 2: *Denisonia maculata* (Ornamental snake) - Offset Area EPBC Calculator Input (start) and offset area future quality (outcome) scores**

Offset Calculator Step	Score attributed	Comments
Step 8 – Time horizon	20 years	Time over which loss is averted: the value selected for time over which loss is averted was the maximum of 20 years for the offset site.
Time until ecological benefit	10 years	As noted in the <i>Conservation of Biodiversity in Brigalow Landscapes (University of Queensland, 2011)</i> , regrowth with an age of 16-30 years begins to have the characteristics of older regrowth with density of stems beginning to thin due to competition for resources and a reduction in grasscover. The improvements from herein are related to stem size and the accumulation of leaf litter and fallen woody debris which is augmented by the exclusion of fire in the area. As the regrowth area is already circa eight years of age, a time of ten years to achieve an intermediate stage is reasonable. During this time, gilgai and associated ecological function will be enhanced, due to the exclusion of mechanical control of the brigalow regrowth. Grazing is restricted to fuel reduction purposes only during the dry season, thus reducing associated impact on the gilgai when moisture is present.

Offset Calculator Step	Score attributed	Comments
<p>Step 9 – Start area and quality</p>	<p>20 ha of core ornamental snake habitat</p> <p>Score - 4</p>	<p>Targeted surveys positively identified the species on-site, both adult and sub-adult.</p> <p>There were a diverse range of gilgai habitats supported on-site in terms of depth and sizes of depressions and heights and sizes of mounds, and extensive evidence of long term water holding (presence of dense aquatic growth including bogmarsh and sedges).</p> <p>Positive identification of sub-adult animals on-site indicates that site supports suitable breeding habitat for the species.</p> <p>Identification of 13 species of frogs in abundance of different age classes on-site, which included “preferred” prey species (<i>Andrew Veary pers. obs and Steve Wilson pers. comm.</i>).</p> <p>However, due to historic land management practices and the abundant presence of cane toads on the site, a ‘Start Quality’ score of ‘4’ has been given for the ornamental snake habitat present on-site.</p>
<p>Step 10 – Future area and quality without offset</p> <p>Risk of loss (%) Without Offset</p>	<p>2.0 ha</p> <p>Score - 1</p> <p>90%</p>	<p>Historically, the Zamia Creek (North Section) property has been subjected to various land management techniques including vegetation clearing and pulling, blade ploughing and inappropriate fire regimes. In addition, active cattle grazing and unfettered access to gilgai areas, particularly during wet environmental conditions, significantly reduces the habitat values of the site. In association with cattle grazing and associated impacts, cane toad populations also have an impact on ornamental snake populations and thus the value of the site. Typically, increased cane toad densities are linked to increasing grazing pressure. Without the offset and the subsequent inability to eliminate these three primary threatening impacts, it is considered highly likely that the habitat values for the ornamental snake will most likely continue to decline which may result in the loss of this species from this property. Therefore, a ‘Future Quality without Offset’ score of ‘1’ has been given.</p>
<p>Step 11 – Future area and quality with offset</p> <p>Risk of loss (%)With Offset</p>	<p>18.0 ha</p> <p>Score - 7</p> <p>10%</p>	<p>This Offset Area Management Plan and accompanying Offset Delivery Plan outlines a number of planned management actions that will be implemented to enable the quality of the habitat on site for the ornamental snake to improve.</p> <p>For example, cattle will be excluded from the gilgai areas of the site (i.e., greater than the offset area) with the exception of controlled grazing activities during dry periods to reduce grass fuel loads. The removal of cattle when there is any evidence of moisture in the gulgais will enable the swelling and cracking nature of the soil to increase the depth of the gulgais over time, as well as to enable the cracks in the soil to stay intact (further assisted by exclusion of mechanical control), which will improve the extent of time that moisture is present in the gulgais, thus enabling a longer period for use of these areas by frogs, as the primary food source for the ornamental snake. These improvements will primarily result in increases to longevity of the existing population and breeding success which will lead to more successful recruitment of the site and local area. The values of the gilgai (i.e., the depth of the depressions and the height of the mounds formed through the process of the clay shrinking and swelling) will improve over time, but will be dependent on rainfall events (and the removal of mechanical disturbance), both in terms of occurrence and intensity. The exclusion of chemical control methods for regrowth control (both pelleted and foliar spray) is expected to have a positive effect on the native frog population, again enabling a greater food source for the ornamental snake.</p> <p>Further, the risk of mechanical and chemical control of the brigalow community, which provides key habitat attributes for the species, will be removed and frequent/high intensity fire shall not be part of management activity, to allow the accumulation of leaf litter and fallen woody debris.</p>



Offset Calculator Step	Score attributed	Comments
		<p>The management actions proposed align will counter the existing threats to this species as identified in DotE's approved <i>Conservation Advice for Denisonia maculata (Ornamental Snake) (approved 29 April 2014)</i>, being:</p> <ul style="list-style-type: none"> <li>• continued legacy of past broadscale land clearing – refer forestry operations and grazing management actions in <b>Table 5</b>.</li> <li>• habitat degradation – refer grazing management actions in <b>Table 5</b>.</li> <li>• modification of habitat through agricultural land and urban development – refer forestry operations and grazing management actions in <b>Table 5</b>.</li> <li>• destruction of wetland habitat by feral pigs – refer pest (pest animals) management actions in <i>Table 5</i>.</li> <li>• destruction of frog habitat (being the key prey source) refer forestry operations and grazing management actions in <b>Table 5</b>.</li> <li>• direct competition for food sources – refer pests (pest animals) management actions in <b>Table 5</b>.</li> </ul> <p>The conservation advice for the ornamental snake also identifies a potential threat of poisoning resulting from the ingestion of cane toads. As outlined in <b>Table 5</b>, there is difficulty in in-field control of cane toads (e.g., as chemical control poses further threats for a range of native species). Research into effective control measures is in its infancy, particularly with regard to control methods in an extended area, such as the Zamia Creek (North Section) offset area.</p> <p>Provided that these key strategies are effectively employed, the habitat values of the offset will improve. The predicted "Future Quality with Offset" score of '7' has been applied within the calculator based upon the effective implementation of a management plan.</p>
Step 12 – Start quality and future quality without offset	Score – 4 Score - 1	See commentary in Step 9 and 10 respectively
Step 13 – Future quality (with offset)	Score – 7	See commentary Step 11
Step 14 – Calculating adjusted gain using confidence in result (%) Confidence in Result	12.0 ha 4.5 75%	Automatic Calculator Outputs  75% confidence based on habitat surveys of the site and proven management measures.
Step 15 – Net present value (adjusted hectares)	8.95 ha	Automatic Calculator Outputs
Step 16 – Percentage of impact offset	102.32%	Automatic Calculator Outputs

## 2. Detailed Offset Area Mapping

The figures in **Appendix A** demonstrate the Offset Areas within the region and the Zamia Creek (North Section) property being the BMC MRA Offset Management Area including the Location Map (**Appendix A1**), the BMC Ornamental Snake Offset Area Map (**Appendix A2**), the Offset Area Monitoring Points Map (**Appendix A3**), and the Co-located Offsets Map including Zamia Creek Conservation Park (**Appendix A4**).

### 3. Restrictions imposed on the use of the offset area<sup>i</sup>

The restrictions below (**Table 3**) will be implemented within the Offset Area Management Plan.

#### Cultural Values and Practices

It is noted and agreed that nothing in **Table 3** or this Offset Area Management Plan limits the traditional Indigenous owners of the property from carrying out hunting and fishing within the Offset Area.

**Table 3 Offset Area Restrictions**

Restriction	Details
<b>Vegetation clearing</b>	<p>1. Vegetation clearing on the Offset Area is restricted to:</p> <ol style="list-style-type: none"> <li>that necessary for the removal of non-native weeds or declared pests</li> <li>ensure public safety</li> <li>maintenance of existing roads, fence lines, water pipelines and firebreaks.</li> </ol> <p>Where vegetation clearing is sought for any other purpose, the landowner must contact the relevant department administering the <i>Vegetation Management Act 1999 (Qld)</i>.</p> <p>2. Vegetation clearing is restricted to the use of non-mechanical means.</p> <p>3. Native forest practice (harvesting of timber for forestry purposes) <u>is not</u> allowed under this Offset Area management plan.</p> <p><b>Note:</b> Any vegetation clearing must be undertaken in accordance with:</p> <ul style="list-style-type: none"> <li>best practice management methods; and</li> <li>any applicable legislative requirements. For example, the clearing of endangered, vulnerable or near-threatened plant species or the tampering with animal breeding places under <i>Nature Conservation Act 1992 (Qld)</i>.</li> </ul>
<b>Grazing</b>	<p>1. Grazing of domestic livestock may occur in the Offset Area for fuel reduction purposes under the following arrangements:</p> <ol style="list-style-type: none"> <li>only during periods when water is absent from gilgai, and</li> <li>at stocking rates that will not reduce total grass cover to below 30% at the end of the dry season. The ground cover is to be determined as per <b>Appendix 3: Land Manager's Monitoring Guide</b>, and</li> <li>the grazing regime should allow native grasses to flower and set seed at least every two years (6-8 week period during the wet/summer season).</li> </ol>
<b>Fire</b>	<p>1. Fire is to be, where possible, excluded from the Offset Area except for ecological burns by:</p> <ol style="list-style-type: none"> <li>maintaining firebreaks relative to the Offset Area;</li> <li>using a low intensity fire &gt; 20 years in a mosaic pattern</li> <li>co-locating firebreaks with roads and fence lines on the property where possible; and</li> <li>not using fire as a tool for regrowth management in the Offset Area.</li> </ol>
<b>Pest animals and weeds</b>	<p><b>Animal</b> Minimise the introduction of pest animals and control of existing populations of pest animals within the Offset Area in accordance with <i>the Land Protection (Pest and Stock Route Management) Act 2002</i>.</p> <ol style="list-style-type: none"> <li>Increase the current pest animal control effort with regards wild pigs, dogs and cats</li> <li>Investigate any realistic methods of cane toad control/management <a href="http://sydney.edu.au/science/biology/shine/canetoad_research/scientific-publications-cane-toad-control.shtml">http://sydney.edu.au/science/biology/shine/canetoad_research/scientific-publications-cane-toad-control.shtml</a></li> </ol> <p><b>Weeds</b></p>

<sup>i</sup> Restrictions may relate to achieving the management area objectives and outcomes e.g. mapped remnant status, or are a means of managing threatening processes for identified flora and fauna species, or are simply best practice management.

Restriction	Details
	<ol style="list-style-type: none"> <li>1. Keep the introduction; establishment and spread of non-native weeds including Declared Pest Plants listed under the <i>Land Protection (Pest and Stock Route Management) Act 2002 (Qld)</i> to no more than 10% total weed cover over the Offset Area.</li> <li>2. Control any existing infestations of non-native weeds including Declared Pest Plants under the <i>Land Protection (Pest and Stock Route Management) Act 2002 (Qld)</i> to ensure that the non-native weeds do not cover more than 10% of the Offset Area, e.g., parthenium.</li> <li>3. Minimise the spread of any non-native pasture species within the Offset Area in accordance with <b>Table 5: Management Actions</b>.</li> </ol> <p><b>Note:</b> existing weed control efforts on this property are effective (i.e. the current levels of weed infestation are low). Any weed control required will be undertaken as early as practicable within the natural regeneration process throughout the Offset Area and then periodically as required to treat the weeds at the optimum time in their life cycles to control and minimise the spread of the existing weed species.</p>

#### 4. Analysis of Risks to Achieving Management Objectives and Outcomes

The following risk assessment (Table 4) has considered:

- any real or potential risks associated with achieving the management objectives and outcomes;
- the actions taken to minimise those risks and;
- any remedial action that will be undertaken if any of the risks occur

**Table 4: Risk Analysis**

Number	Risk	Level of Risk if not mitigated (Extreme, High, Moderate or Low)	Proposed Actions to Minimise Risk	Proposed Remedial Actions if Risk Occurs
1	Fire	High	<p>Maintaining firebreaks at appropriate widths to enable fires on adjoining properties to be prevented from impacting on the offset area.</p> <p>Manage fuel loads through controlled grazing.</p> <p><i>Force Majeure</i> events are acknowledged being separate from general fire use practices.</p> <p>Fire control lines to be checked annually for condition and adequacy.</p>	<p>Fire to be excluded wherever possible from the offset area with low intensity fires &gt;20year intervals.</p> <p><b>Remedial action:</b> Destock the offset area, re-establish fire breaks and control lines and if appropriate, widen fire control lines and reassess fuel load reduction practices.</p>
2	Forestry	High	<p>Forestry and Native Timber Harvesting are <b>excluded</b> from the offset area.</p> <p>Signs at entrance points to the property with regards that it is an offset area and that any harvesting of timber is prohibited.</p>	<p>No clearing of native trees are to occur within the offset area.</p> <p><b>Remedial action:</b> Reassess access protocols for any lessees etc., signage and general access.</p>
3	Grazing	Low	<p>Grazing of domestic livestock may occur on the Zamia Creek (North Section) property (including the Offset Area) during the dry season for fuel reduction purposes with a minimum of 30% grass cover to be present at the end of the dry season.</p> <p>Boundary fencing to be checked</p>	<p>Grazing is determined by the amount of dry matter available and is used conservatively for that necessary for fuel reduction purposes only</p> <p><b>Remedial action:</b> Any entry points due to fencing breaks etc. to be repaired to a stock proof condition within a 30 day</p>

Number	Risk	Level of Risk if not mitigated (Extreme, High, Moderate or Low)	Proposed Actions to Minimise Risk	Proposed Remedial Actions if Risk Occurs
			annually and maintained in a stock proof condition.	period.
4	Erosion	<b>Low</b>	Maintaining grass cover at a minimum of 30% at the end of the dry season. This, in conjunction with other forms of groundcover (fallen woody debris, organic matter etc.), will minimise the risk of erosion.	<b>Remedial action:</b> Further reduction of grazing levels and checking on the cause of any point source erosion (such as illegal vehicle access) and rectifying access if this is the cause.
5	Drought	<b>Low</b> The risk incurred by drought would be an increase in the likelihood of fire due to the dry conditions and accumulated fuel loads.	Maintain fire control lines as detailed above and manage grazing levels according to the amount of dry matter available for grazing.	<b>Remedial action:</b> Allow Offset Area to recover post drought/fire, particularly through the control of weeds. Maintain a minimum of 30% grass cover at the end of the dry season.
6	Pests  Animals          Weeds	<b>Low</b>          <b>Low</b>	Maintain annual baiting program on the property.          Maintain current weed control program, and control buffel via the use of grazing during the dry season and by allowing an increase in tree canopy cover.	If an increase in pig or wild dog activity is noted during regular landholder inspections of the offset area, then a programme of baiting and or pig trapping is to be instigated until the population and occurrence of these pests is reduced. This will have a greater impact if control measures are integrated with neighbouring properties.          The level of weed infestation is low in the observed areas and spot spraying of small outbreaks observed during routine property inspections should suffice.

## 5. Management actions

The following table (Table 5) identifies the actions which will be undertaken for the offset area, by whom, when and more specific information relating to the action.

**Table 5. Schedule of management actions**

Management action	How the action will be carried out	Where the action will be carried out	When the action will be carried out	Who will be carrying out the action	Progress/ measurable outcomes	Comments/ corrective actions
<b>Forestry Operations, Native Timber Harvesting and general Vegetation clearing</b>	<p>Vegetation clearing on the Offset Area is restricted to:</p> <ol style="list-style-type: none"> <li>that necessary for the removal of non-native weeds or declared pests;</li> <li>establishing and maintaining fencing around the boundary of the declared area;</li> <li>establishing and maintaining fire breaks; and</li> <li>ensure public safety</li> </ol> <p>Vegetation clearing for any other purpose <b>is not</b> permitted within the offset area.</p>	<p>Only in those areas subject to non-native weed control, fire control lines and fences.</p>	<p>As required and identified in the quarterly inspections of the fences and collocated fire control lines.</p>	<p>Landowner or suitable qualified person appointed by the Landowner.</p>	<p>No evidence of recent forestry or timber harvesting activities are evident during term of the offset management plan.</p> <p>Any illegal clearing to be recorded in the landholder records and identified during the monitoring and reporting program.</p>	<p>Any evidence of clearing apart from weeds is to be noted in the Annual Landholder reports.</p> <p>If evidence of recent timber harvesting is noted during inspections, the landholder is to reassess access protocols for any lessees etc., signage and general access.</p>
<b>Fire</b>	<p>Fire is to be, excluded from the Offset Area except for low intensity ecological burns by:</p> <ol style="list-style-type: none"> <li>Maintaining firebreaks relative to the Offset Area;</li> <li>Using a low intensity fire &gt;20 years interval; and</li> <li>Firebreaks are to be co-located with roads and fence lines on the property where possible.</li> </ol> <p><b>Note:</b> Fire is not to be used as a tool for regrowth management on the Offset Area.</p>	<p>Throughout the Offset Area.</p>	<p>Fire Control lines are to be inspected weekly and maintenance undertaken as required but at an interval of at least each 2 years.</p> <p>If fire is used at all, it is to be at a low intensity fire at &gt;20 years interval.</p>	<p>Caretaker will undertake weekly inspections, Pastoral Manager monthly inspections. Grading of the fire breaks is to be undertaken by a suitable qualified person appointed by</p>	<p>No evidence of fire is observed during the term of the offset management plan, except for prescribed mosaic &gt;20 year burns.</p> <p>Any incidence of wild fire or illegal burning (Force Majeure) is to be identified during weekly inspections and documented within the monitoring and reporting</p>	<p>Any occurrence of fire in the Offset Area is to be noted during weekly inspections of the property and recorded in the Annual Landholder reports.</p> <p><b>Corrective action:</b> Check and repair all fire control management lines. Destock the offset area, re-establish fire breaks and control lines and if appropriate, widen fire control lines and reassess fuel load reduction practices.</p> <p>Fire and grazing excluded until the</p>

Management action	How the action will be carried out	Where the action will be carried out	When the action will be carried out	Who will be carrying out the action	Progress/ measurable outcomes	Comments/ corrective actions
				the Pastoral Manager or council CEO.	program.	grasscover has increased to 50% using the methodology in the Land Manager's Monitoring Guide as attached.
<b>Grazing</b>	<p>There is no set stocking rates as this region is subject to significant changes in grass cover with seasonal conditions.</p> <p>It is recognised that competition from non-native pasture species can have a negative effect on the establishment of brigalow communities. Grazing is therefore restricted as per these management actions to reduce the risk of high-intensity fires and to manage the levels of ground cover of the non-native pastures.</p>	<p>A new fence is to be established to exclude cattle from the Zamia Creek watercourse and another fence is to be established along the eastern boundary of the combined 490ha offset area, which includes this offset area.</p> <p>Stock will be grazed in the Offset Area for fuel reduction purposes only during the dry season.</p>	<p>As required when grass fuel loads exceed 50%. During the dry season.</p> <p>Establish the new fence by December 2016.</p> <p>The dry season is normally between April and October; however, if unseasonal rainfall should occur, then grazing is to be allowed only if there is no evidence of moisture in the bottom of the gilgai to ensure that no "pugging" of the soil occurs by livestock.</p>	Pastoral Manager	<p>The Landowner, at their discretion, may graze stock during the dry season, at rates and times necessary to reduce the fuel load in the Offset Area without lowering the grass cover to below 30% at the end of the dry season.</p> <p>No evidence of "pugging" is to occur.</p>	<p>The property Caretaker will undertake twice weekly inspections when stock are grazing the offset area. The Pastoral Manager will undertake monthly inspections of the property to ensure that cattle are not present when there is any evidence of moisture in the gilgai formations, thus preventing the risk of "pugging". Fence lines are to be inspected weekly during grazing periods and along with Photo point and Terrestrial Habitat Quality Assessment results of grass cover and groundcover, grazing instances, stocking rates, timeframes and rainfall records are to be incorporated into the Annual Landholder Reports and the Compliance reports to BMC and the regulator/s.</p> <p><b>Corrective action:</b> grazing excluded until grass cover has increased to 50% using the methodology in the Land Manager's Monitoring Guide as attached. If cattle are in the offset area when rainfall occurs, (e.g. unscheduled or unauthorised incursion by cattle), or there is moisture in the gilgai, they are to be removed within 24 hours and fencelines inspected to ensure security of the offset area.</p>

Management action	How the action will be carried out	Where the action will be carried out	When the action will be carried out	Who will be carrying out the action	Progress/ measurable outcomes	Comments/ corrective actions
<p><b>Pests</b></p>	<p><b>Pest Animal Management</b>  Minimise the introduction of pest animals and control of existing populations of pest animals (wild pigs) within the Offset Area in accordance with the <i>Land Protection (Pest and Stock Route Management) Act 2002 (Qld)</i>.</p> <p>There is currently no incidence of foxes on the property. Wild pig and dog populations are transient and are infrequent and of short duration and impact due to the small numbers that occur.</p> <p>Current control of pigs and wild dogs is undertaken via an annual baiting programme on the property. Additional to this measure, the caretaker, during weekly inspections of the offset area is to shoot any wild pigs or wild dogs that are seen. If an increase in pig or dog activity is noted, an additional trapping and shooting programme is to be instigated until the increased activity has ceased.</p> <p>Research into methods of cane toad control/management is in its infancy. Cockatoo Coal has adjacent offset areas and will be exploring partnership opportunities with the University of Sydney with regards to commercial scale implementation. This would involve training of the local indigenous community and hence the Department of Aboriginal and Torres Strait Islander and Multicultural Affairs for training.</p> <p><a href="http://sydney.edu.au/science/biology/shine/canetoad_research/scientific-publications-cane-toad-control.shtml">http://sydney.edu.au/science/biology/shine/canetoad_research/scientific-publications-cane-toad-control.shtml</a></p>	<p>Throughout the Offset Area.</p>	<p>As required.</p>	<p>Pastoral Manager, caretaker or suitable qualified person appointed by the Landowner.</p>	<p>Scrappings, wallow holes, tracks and visual incidents along with control measures are to be noted in the Annual Landholders Reports after weekly inspections by the caretaker and monthly inspections by the Pastoral Manager. This evidence is to be collected quarterly and included in the Monitoring and Reporting to the Regulator.</p>	<p><b>Corrective action:</b> if an increase in pig or wild dog numbers is observed, the landholder will implement a pest animal management programme to control the feral animal population.</p> <p>If an increase in pig or wild dog activity is noted during regular landholder inspections of the offset area, then a programme of baiting and or pig trapping is to be instigated until the population and occurrence of these pests is reduced. This will have a greater impact if control measures are integrated with neighbouring properties.</p> <p>Potential cane toad management investigations to be incorporated into the first Annual Report and if a pragmatic training and scaled approach can be identified, incorporated into the Pest Animal Control Programme (led by Cockatoo Coal).</p>

Management action	How the action will be carried out	Where the action will be carried out	When the action will be carried out	Who will be carrying out the action	Progress/ measurable outcomes	Comments/ corrective actions
	<p><b>Weeds</b></p> <ol style="list-style-type: none"> <li>1. Keep the introduction, establishment and spread of non-native weeds including <i>Declared Pest Plants listed under the Land Protection (Pest and Stock Route Management) Act 2002 (Qld)</i> to less than 10% weed cover over the Offset Area.</li> <li>2. Control existing infestations of non-native weeds including Declared Pest Plants under the <i>Land Protection (Pest and Stock Route Management) Act 2002 (Qld)</i> to ensure that the non-native weeds cover is less than 10% of the Offset Area. e.g., Parthenium, mother of millions, and velvety tree pear.</li> <li>3. Buffel in this instance is recognised as being a threat to the ecological community/habitat however is not referred to as a weed. Control of buffel is best managed via grazing during the dry season and by increasing tree canopy cover. The dry season is normally between April and October; however, if unseasonal rainfall should occur, then grazing is to be allowed only if there is no evidence of moisture in the bottom of the gilgais to ensure that no “pugging” of the soil occurs.</li> <li>4. The use of broadscale herbicide is not recommended due to the potential impact on frog species in the creek and gilgai formations. This impact would lead to a negative impact on the ornamental snake population via the loss of frog species and population on which it is reliant.</li> <li>5. Spot spraying of patches of Parthenium and mother of millions is allowed as required.</li> <li>6. The rare occurrences of tree pear are to be treated as per the recommended advice at the time of treatment.</li> </ol>	Throughout the Offset Area.	Any weed control required will be undertaken as early as practicable within the natural regeneration process throughout the Offset Area and then periodically as required to treat the weeds at the optimum time in their life cycles to control and minimise the spread of the existing weed species.	Pastoral Manager, caretaker or suitable qualified person appointed by the Landowner.	Observations during routine property inspections by the caretaker (weekly) or by the Pastoral Manager (monthly). Incidence, observations and resultant control measures are to be recorded via photos and additionally by the photo point and Terrestrial Habitat Quality Assessment results of grass cover and non-native groundcover to be incorporated into the Annual Landholder Reports and the Compliance reports to BMC and the regulator.	<p><b>Corrective action:</b></p> <p>The level of weed infestation is low in the observed areas and spot spraying of small outbreaks observed during routine property inspections should suffice.</p> <p>Broadscale chemical spraying is NOT supported due to the potential negative effect on the native frog population thus impacting on the ornamental snake population due to ingestion of the chemicals and the reduction in the frog population.</p>



## 6. Monitoring requirements<sup>ii</sup>

Monitoring of the offset area will occur in accordance with Table 6:

**Table 6. Offset area monitoring**

Monitoring	Attributes monitored	Frequency	Method	Location/s
<b>Surveys undertaken by Ecologists</b>				
<b>Baseline monitoring</b>	Ecological Condition attributes (refer below in this table)	At commencement of Plan (year 0)	Field observations, vegetation assessment as per Queensland Terrestrial Habitat Quality Assessment methodology (using former BioCondition methodology).	BioCondition Site 1 and observation sites 23, 24 as listed at <b>Table 7</b> below.
<b>Ecological condition</b>	Recruitment of woody perennial species in EDL Native plant species richness - trees Native plant species richness - shrubs Native plant species richness - grasses Native plant species richness - forbs Tree canopy height Tree canopy cover Shrub canopy cover Native perennial grass cover Organic litter Large trees Coarse woody debris Non-native plant cover	<u>BioCondition site 1</u> At commencement (year 0) and then every 5 years to (and including) year 2030; reported every 5 years	Field observations, vegetation assessment as per Queensland Terrestrial Habitat Quality Assessment methodology.  Data for each of the ecological condition attributes monitored (BioCondition methodology) will be collected at each site listed in <b>Table 7</b> and reported on and presented in a sequential manner (including previous data collected) to quantify change from the benchmark collected in 2015. This will record the change in each attribute measured and hence the condition of the ecological community and the ornamental snake habitat, thus enabling a statistical comparison to	BioCondition Site 1 and observation sites 23, 24 as listed at <b>Table 7</b> below.

<sup>ii</sup> The objectives and outcomes should link with the monitoring requirements identified in section 6. Monitoring requirements.

Monitoring	Attributes monitored	Frequency	Method	Location/s
			previous years' data and the progression of the offset site condition and EPBC Offset Assessment Guide Calculator inputs.	
<b>Landholder Records</b>				
<b>Photo Points</b>	Visual record of the change in the structure and composition of the ecological community over time.	Reported annually in April/May for the first 5 years and then every 5 years to (and including) year 2030	A sequence of photos taken annually from the same location (refer <b>Table 7</b> ) and at the same time of year will record changes in ground cover, woody plant populations, and illustrate the long-term effects of management as well as short-term changes caused by seasonal conditions and the effects of grazing management thus enabling a direct comparison to previous years' photos and the progression of the offset site condition.	BioCondition Site 1 and observation sites 23, 24 as listed at <i>Table 7</i> below.
<b>Grazing</b>	Stocking rates and timing, incidence and extent		Pastoral Manager/landholder representative will undertake inspections of the offset area to observe and record grass cover levels, weed occurrence and any evidence of pest animal incursion. These records are to be collated and reported every year for the first 5 years. Subsequently, they are to be included in the five yearly reports along with the Terrestrial Habitat Quality Assessment reports.	Within Offset Area
<b>Fire</b>	Occurrence, control measures, timing and result of the control measures			
<b>Weeds</b>	Occurrence, control measures adopted, timing of the control measures and the result			
<b>Pest animals</b>	Occurrence, control measures adopted, timing of control measures and the result.			

**Table 7: BioCondition Sites**

Bio-Condition Site Number	Related Observation Site Number	Centre Point Easting	Centre Point Northing
1	23	740775	7276052
	24	740735	7276073
	25	740817	7276019

## 7. Reporting.

BMC Pty Ltd, its successors or assigns, will prepare Offset Area monitoring reports and submit the reports to the administering authority every year for the first 5 years for the life of this plan and thereafter each 5 years for the life of this plan (i.e., until 2030).

Ongoing monitoring is required to ensure the Management Plan achieves the outcomes identified. Non-compliance with the Management Plan will be evidenced during the collation of the data as detailed in **Table 6** and reported as per **Table 8**. Any non-compliance will be noted in the reports to the regulator, and the landholder will be advised accordingly and advised to implement the relevant corrective actions.

The frequency of monitoring has been determined based on the remnant status and established regrowth within the area and the likely rate of improvement. As remnant and an established regrowth community the expected rate of change is likely to be moderate, with high opportunities for improvement and, with good management, a low risk of decline. Accordingly, monitoring frequency has been established on an initial yearly photo point monitoring cycle followed by a 5 year BioCondition monitoring cycle (**Table 8**).

Each year's photo point reporting will incorporate all previous years' photos, thus enabling a direct comparison to previous years and illustrating the progression of the offset site condition.

The five year BioCondition monitoring will measure 13 attributes for ecological condition. Data for each of the attributes monitored will be collected at each site and reported on and presented in a sequential manner (including previous data collected) to quantify change from the benchmark collected in 2015. This will record the change in each attribute measured and hence the condition of the ecological community and the ornamental snake habitat, thus enabling a statistical comparison to previous years' data and the progression of the offset site condition and EPBC Offset Assessment Guide Calculator inputs.

**Table 8. Reporting Schedule**

Offset Year	Report Details	Date to be submitted
1	Offset Area Annual Report including Photopoint and Landholder records collated and reported to the administering authority	1 <sup>st</sup> anniversary of offset being secured (2016)
2	Offset Area Annual Report including Photopoint and Landholder records collated and reported to the administering authority	2 <sup>nd</sup> anniversary of offset being secured (2017)
3	Offset Area Annual Report including Photopoint and Landholder records collated and reported to the administering authority	3 <sup>rd</sup> anniversary of offset being secured (2018)

Offset Year	Report Details	Date to be submitted
4	Offset Area Annual Report including Photopoint and Landholder records collated and reported to the administrating authority	4 <sup>th</sup> anniversary of offset being secured (2019)
5	Offset Area Report summarising all monitoring defined in <b>Table 6</b> for the first 5 years of the offset	5 <sup>th</sup> anniversary of offset being secured (2020)
10	Offset Area Report summarising all monitoring defined in <b>Table 6</b> for years 6 to 10 of the offset	10 <sup>th</sup> anniversary of offset being secured (2025)
15	Offset Area Report summarising all monitoring defined in <b>Table 6</b> for years 11 to 15 of the offset	15 <sup>th</sup> anniversary of offset being secured (2030)

### 3. Consent

#### Administering authority

**SIGNED** by the <insert name, position> to indicate approval of the offset area management plan.

Name:..... Signature:.....

Witness name:..... Signature:.....

Date.....

#### Landholder

The landowner agrees:

1. Any non-compliance with the requirements of this offset area management plan shall constitute a breach of the terms and conditions of the legally binding mechanism entered into.
2. To notify the State in writing of an Event, or the likelihood of the occurrence of an Event.  
Event means any agreement or understanding entered into or accepted by and or circumstance permitted or suffered by the landholder which effects a change of ownership, control or use of the offset area, the exercise of power of sale under any Mortgage, the granting of a Mortgage, the appointment of a receiver, the death of a landholder or any other circumstance which may allow or permit a person, other than the Landholder to own, control or use the offset area.  
In notifying the State of an Event, the landholder will notify the State of the nature of the change, or potential change of ownership, control or use result from the Event, and the name and address of any person who may own, control or use the offset area as a result of the Event.
3. That if, at the time of execution of this offset area management plan, there exists a Property Map of Assessable Vegetation (PMAV) over the offset area or a part of it, the landholder hereby agrees, where the management plan area is identified as Category X on the PMAV, to the replacement of the PMAV by the State to reflect the offset area as Category A.
4. To take all necessary steps as may be required to accomplish the obligations contained in this offset area management plan.

The landowner acknowledges:

5. That before the State will agree to the release this offset area management plan the State must be satisfied that the objectives and activities contained in the offset area management plan have been achieved.

The landowner notes:

6. All reports, notices or requests for amendment in relation to this offset area management plan must be in writing and delivered to the administering authority at the following address:  
<Insert departmental name>  
<Insert postal address and telephone number>

**SIGNED** by Woorabinda Aboriginal Council being the current owner/s of the abovementioned property to indicate that the terms of this offset area management plan including responsibilities under the offset area management plan, have been read, understood and accepted.

Name:..... Signature:.....

Witness name:..... Signature:.....

Date.....

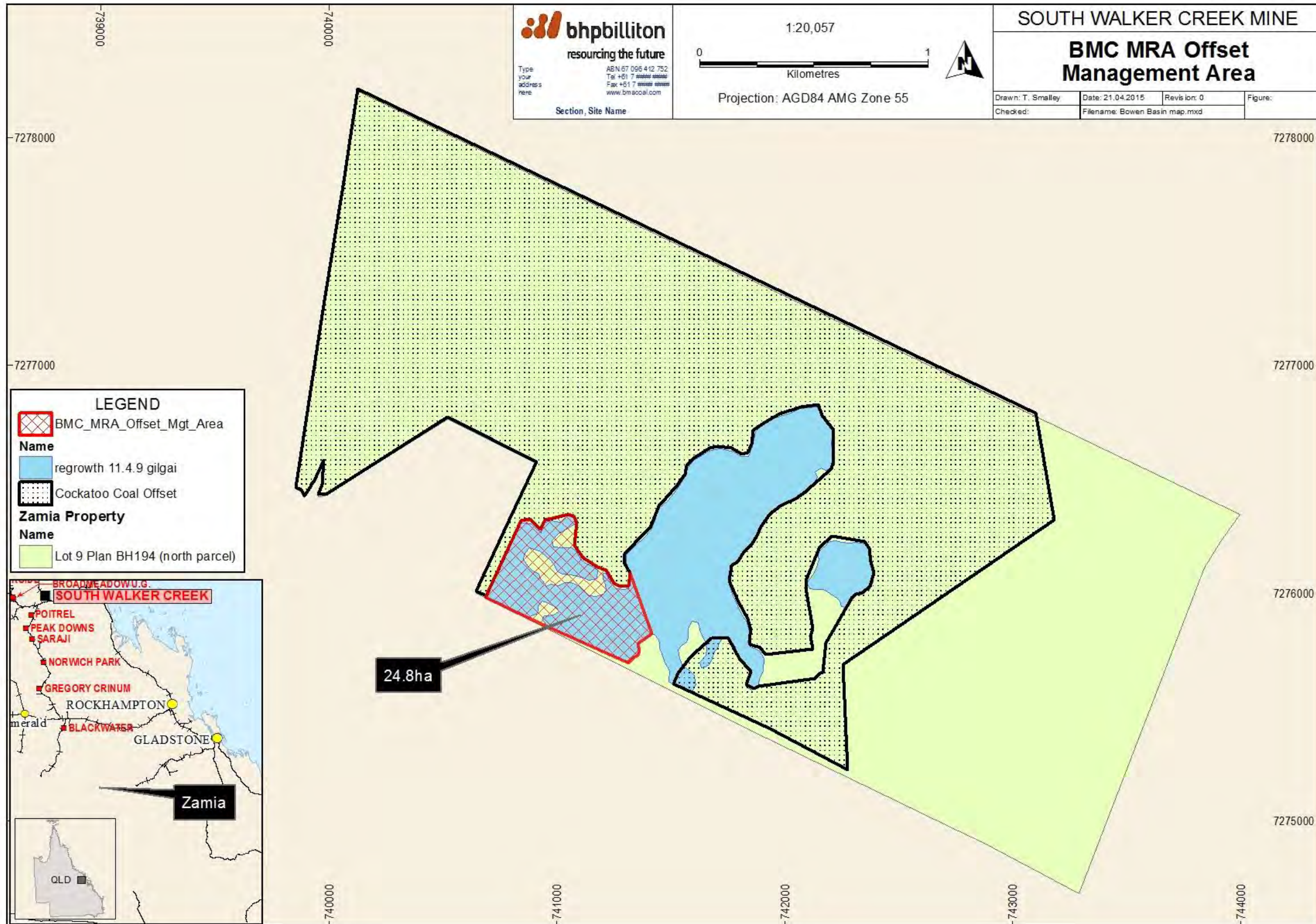
Name:..... Signature:.....

Witness name:..... Signature:.....

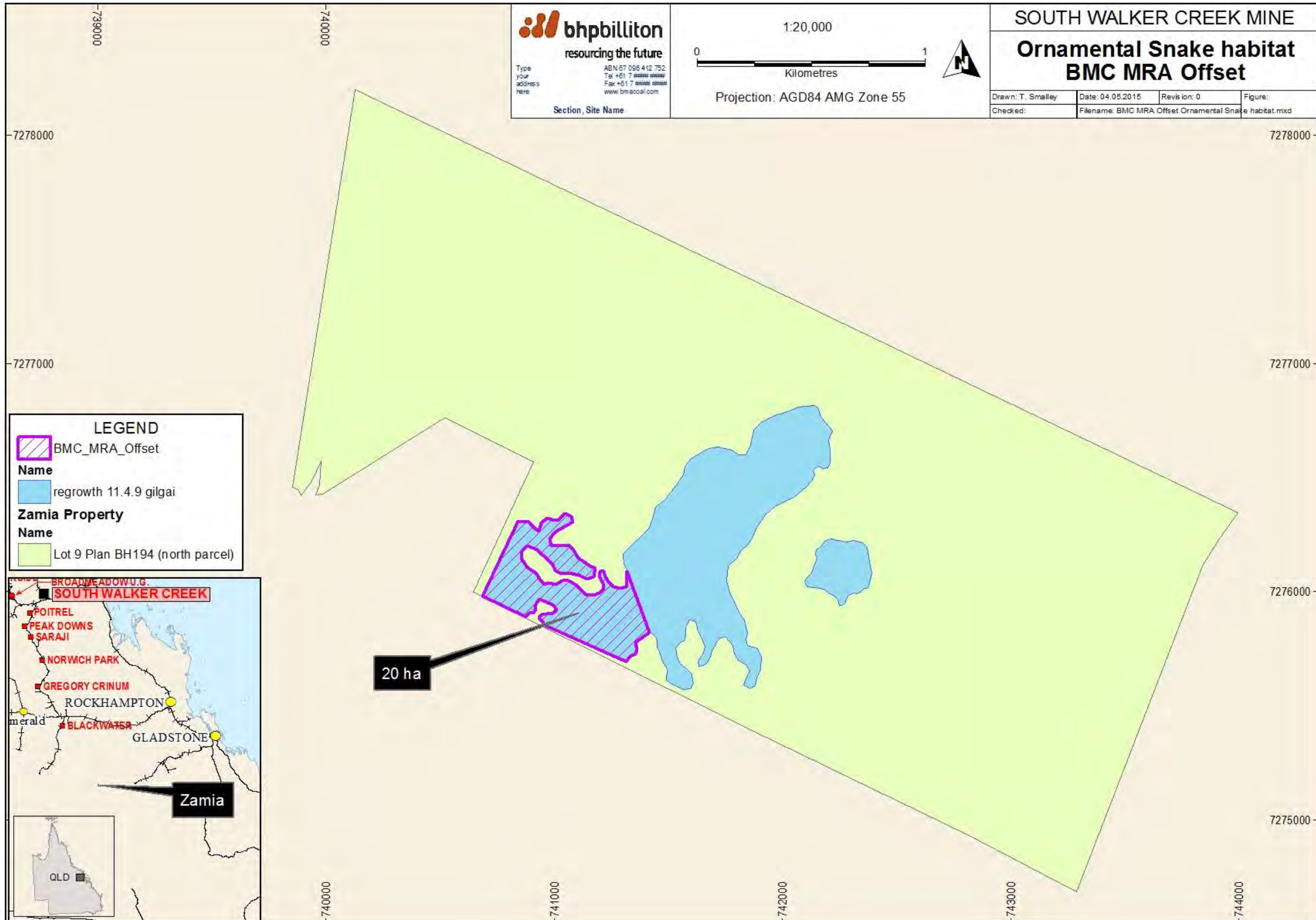
Date.....

# Appendix A:

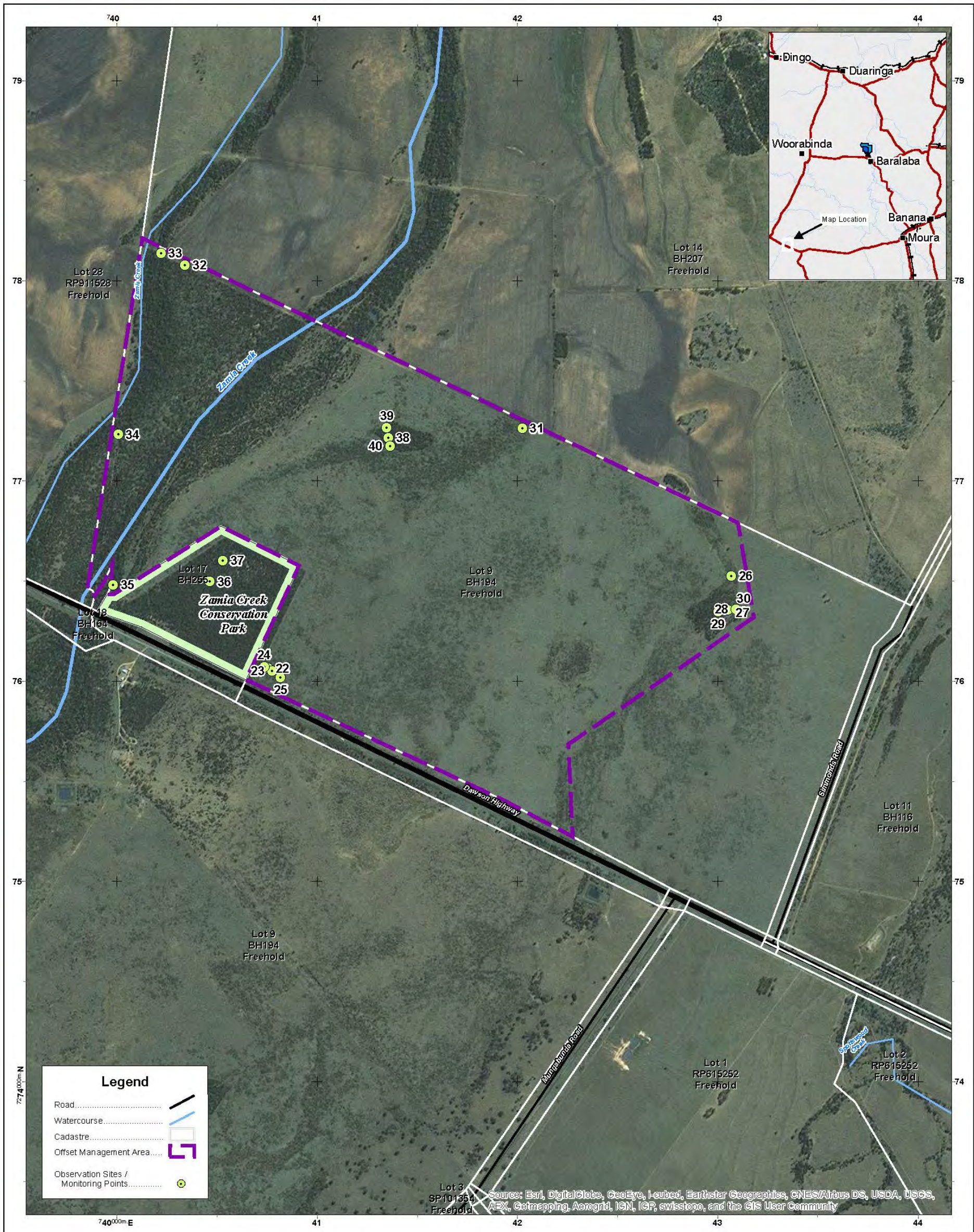
## A1: BMC MRA Offset Management Area including Location Map



A2: BMC Ornamental Snake Offset Area Map



# A3: Offset Area Monitoring Points Map

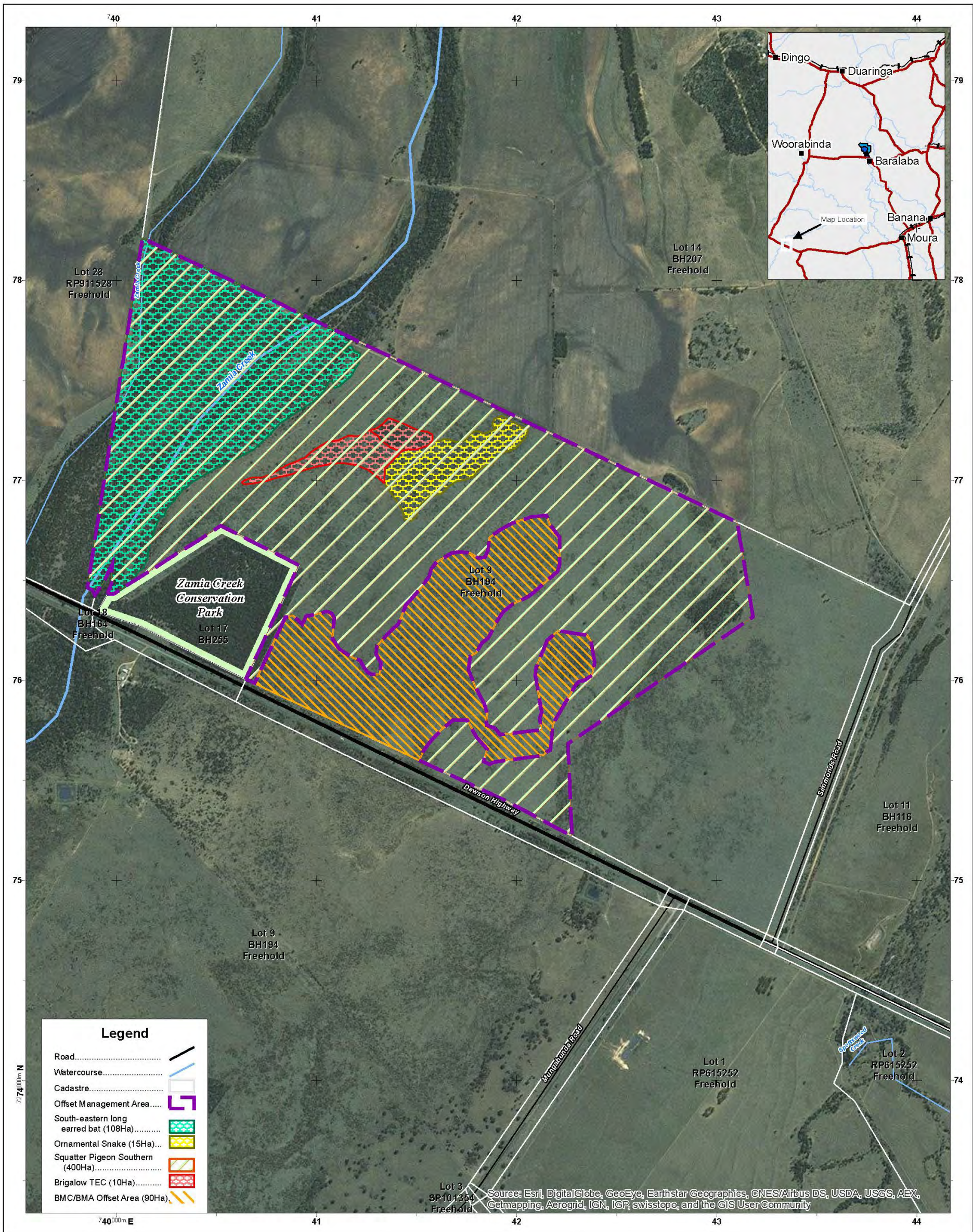


<b>PROJECT</b> <b>'ZAMIA' OFFSET AREA MANAGEMENT PLAN</b>		<b>DISCLAIMER:</b> Cockatoo Coal Ltd has exercised all due care in the production of this map. Cockatoo Coal Ltd makes no warranty or representation to the client or third parties (expressed or implied) in respect to the information conveyed on this map, particularly with regard to any commercial investment decision made on the basis of this map. Use of this map by the client or third parties shall be at their own risk, and extracts from this map may only be published with the permission of Cockatoo Coal Ltd.				<b>DATA SOURCES:</b> VECTOR DATA: © DERM - LAND & PROPERTY DATA © GEOSCIENCE AUSTRALIA  PUBLICLY ACCESSIBLE DATA HAS BEEN INCORPORATED INTO THIS MAP (ACCREDITED ABOVE). COCKATOO COAL PROVIDES NO WARRANTY TO THE ACCURACY, COMPLETENESS OR CURRENCY OF THIS DATA.			
<b>TITLE</b> <b>Figure 4</b> <b>Offset Area Monitoring Points</b>		REV 0	DESCRIPTION Original map output	DATE 06/02/15	SCALE 1:17,500	CURRENT ISSUE SIGNATURES DRAWN: MJS CHECKED: VM APPROVED: VM		STATUS <b>DRAFT</b>	
		REV 1	DESCRIPTION Text Updates	DATE 10/02/15	DATUM GDA 94			PROJECT NO BARALABA	DRAWING NO BAR-091-08-01-150210

Path: N:\Baralaba\Baralaba\_Overview\PROJECTS\1501\BAR\_091\_150122\_Zamia\_Offset\_Area\_MPI\BAR\_091\_08\_01\_150210\_Offset\_Site\_Monitoring\_Pts\_A3P.mxd



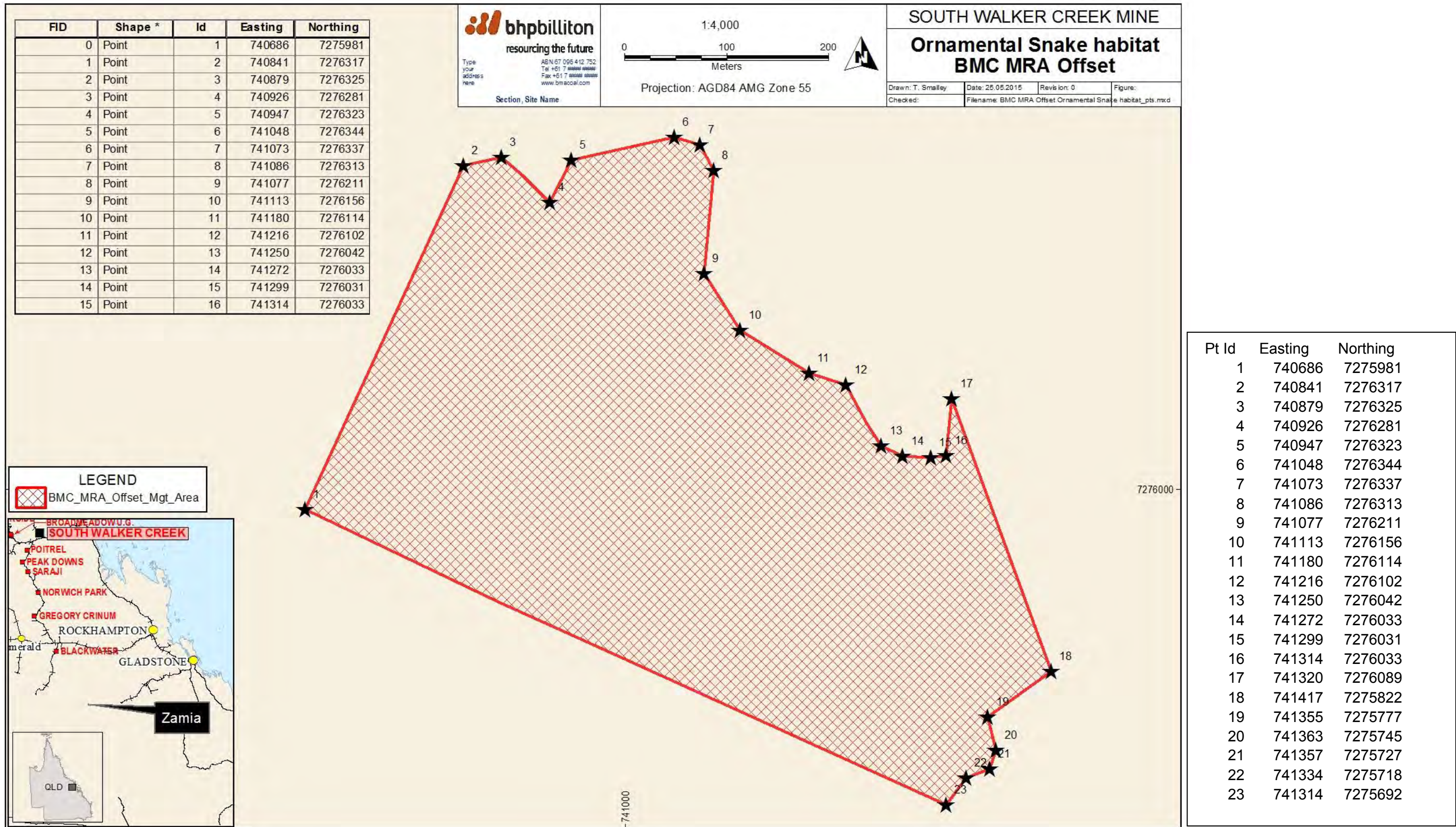
# A4: Co-located Offsets Map including Zamia Creek Conservation Park



<b>PROJECT</b> <b>'ZAMIA' OFFSET AREA MANAGEMENT PLAN</b>		<small>DISCLAIMER:</small> Cockatoo Coal Ltd has exercised all due care in the production of this map. Cockatoo Coal Ltd makes no warranty or representation to the client or third parties (expressed or implied) in respect to the information conveyed on this map, particularly with regard to any commercial investment decision made on the basis of this map. Use of this map by the client or third parties shall be at their own risk, and extracts from this map may only be published with the permission of Cockatoo Coal Ltd.				<small>DATA SOURCES:</small> VECTOR DATA: © DERM - LAND & PROPERTY DATA © GEOSCIENCE AUSTRALIA  PUBLICLY ACCESSIBLE DATA HAS BEEN INCORPORATED INTO THIS MAP (ACCREDITED ABOVE). COCKATOO COAL PROVIDES NO WARRANTY TO THE ACCURACY, COMPLETENESS OR CURRENCY OF THIS DATA.				
<b>TITLE</b> <b>Figure 3C BNCOP Offset Area</b>		REV 0	DESCRIPTION Original map output	DATE 06/02/15	SCALE <b>1:17,500</b>	CURRENT ISSUE SIGNATURES		STATUS <b>DRAFT</b>		
		1	Update Area	25/02/15	SIZE A3	DRAWN MJS	CHECKED VM			
				DATUM GDA 94	APPROVED VM				PROJECT NO BARALABA	DRAWING NO BAR-091-07-03-150210

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**A5: Offset Area Map showing boundary points, and table of boundary points**



## Appendix B: Baseline Data

**Zamia Creek (North Section) Property – Site Observations** (Table 4.15 from *Investigation and Assessment Of Potential Biodiversity Offsets Baralaba North Project and Associated Infrastructure December 2014, Footprints Environmental Consultants*).

Observation site	Easting (Zone 55 GDA94)	Northing (Zone 55 GDA94)	Vegetation description*	Comments
023	740775	7276052	Brigalow regrowth 1-3m tall (avg. 2m) on moderate gilgai. Ground layer sparse in gilgai, mostly buffel on gilgai rims and in small flat cleared areas. Patchy cover to 40%.	BioCondition site1. Site centre - 50m mark.
024	740735	7276073	As above.	BioCondition site1. 0m mark.
025	740817	7276019	As above.	BioCondition site1. 100m mark.

# Zamia Creek (North Section) Property – BioCondition Scoresheet

APPENDIX A

A-2

<b>BioCondition Site no:</b>	1		<b>Relevant quaternary site no. if applicable:</b>				23							
RE/landtype:	regrowth 11.4.9		Bioregion:	BB		Property: "Zamia North" (Lot 9 BH194 north)								
Date: 09/10/14	Photos:		N: *	E: *	S: *	W: *								
Landscape photos: *	Spot photos:		1:	2:	3:	4:	5:							
Datum: WGS84/GDA94/specify if other:			Zone: 55		Transect bearing: W-E (90 deg)									
0m mark	E 740734		N 7276174		100m mark: E 740818 N 7276019									
50m mark	E 740774		N 7276052											
General description: Brigalow regrowth on gilgai.														
<b>100m x 50m area:</b>														
Eucalypt large tree DBH benchmark (cm):			n/a		Non-eucalypt large tree DBH benchmark (cm):			n/a						
Number of large eucalypt trees:			0		Number of large non-eucalypt trees:			0						
Total large trees:			0											
Tree canopy height (for EDL Ecologically Dominant Layer) (m):				2m		1-3m tall (avg, 2m) on moderate gilgai. Patchy cover to 40%.								
Subcanopy height (if present) (m):				-										
Emergent height (if present) (m):				-										
Proportion of dominant canopy species with evidence of recruitment (%):						100%								
Total tree species richness:			1		Includes all tree species in 100m x 50m, not just EDL. Trees are single-stemmed and over 2m tall.									
Tree species list:			Acacia harpophylla.											
<b>50m x 10m area:</b>														
Shrub species richness:			1		Defined as single-stemmed and below 2m tall, or multi-stemmed from base, or from below 20cm.									
Shrub species list:			Acacia harpophylla.											
Grass species richness:			4											
Grass species list:			Leptochloa digitata, Eriachne sp., Enteropogon acicularis, Sporobolus caroli. Note: loose head of Homopholis belsonii - possibly from adjacent conservation park, not counted.											
Forbs and others (non-grass ground) species richness:			9											
Forbs and other ground species:			Enchylaena tomentosa, Atalaya hemiglauca, Apophyllum anomalum, Terminalia oblongata, Evolvulus alsinoides, Capparis lasiantha, Glycine sp., Citrus glauca, Solanum sp. (possibly S.johnsonianum).											
Non-native plant cover (%):			30%		Species: Pennisetum ciliare, Oxalis corniculatum, (Parthenium hysterophorus <1%).									
<b>50m x 20m area:</b>														
Coarse woody debris (>10cm diameter, >0.5m long, measure to plot boundary). Total length (m):							0m							
Note: much woody debris but only up to 8cm diameter.														
<b>Five 1m x 1m plots (ground cover %):</b>														
Quadrat:			1		2		3		4		5		Mean	
Native perennial "decreaser" grass:			n/r		n/r		n/r		n/r		n/r		n/r - see below	



Native other grass cover:	0	0	0	25	0	5
Native forbs and other species:	0	0	0	1	0	0.2
Native shrubs (<1m tall):	0	0	5	0	0	1
Non-native grass:	0	35	20	3	35	22.6
Non-native forbs and shrubs:	0	0	0	<1	0	<1
Litter:	25	10	75	30	60	40
Rock:	0	0	0	0	0	0
Bare ground:	75	55	0	30	5	33
Cryptogams:	0	0	0	0	0	0
<b>Total:</b>	<b>=100%</b>	<b>=100%</b>	<b>=100%</b>	<b>=100%</b>	<b>=100%</b>	<b>=100.8</b>

**100m transect:**

Tree canopy cover: (Tree or Group code: C=canopy, S=subcanopy, E=emergent)

Total % canopy:		0	Total % subcanopy:		2.5	Total % emergent:		0			
Tree or group (C, S or E)	Distance (m)	Total	Tree or group (C, S or E)	Distance (m)	Total	Tree or group (C, S or E)	Distance (m)	Total	Tree or group (C, S or E)	Distance (m)	Total
S		2.5									

**Shrub canopy cover: (indicate non-native with \*)**

Total % native:		5.5	Total % non-native:		0						
*	Distance (m)	Total	*	Distance (m)	Total	*	Distance (m)	Total	*	Distance (m)	Total
		1.5									
		3									
		0.5									
		0.5									



# Parthenium weed

*Parthenium hysterophorus*



Parthenium costs the beef industry a total of \$16.5 million per year and cropping industries several million dollars per year.

## Declaration details

In Queensland, Parthenium is a Class 2 declared plant.

Under the *Land Protection (Pest and Stock Route Management) Act 2002*, Class 2 declaration requires landholders to control pests on the land and waters under their control. A local government may serve a notice upon a landholder requiring control of declared pests.



PP2 June 2011

## Description and general information

### Size

Parthenium weed is an annual herb with a deep tap root and an erect stem that becomes woody with age. As it matures, the plant develops many branches in its top half and may eventually reach a height of two metres.

### Leaves

Its leaves are pale green, deeply lobed and covered with fine soft hairs.

### Flowers

Small creamy white flowers occur on the tips of the numerous stems. Each flower contains four to five black seeds that are wedge-shaped, two millimetres long with two thin, white scales.

### Lifecycle

Parthenium weed normally germinates in spring and early summer, produces flowers and seed throughout its life and dies around late autumn. However, with suitable conditions (rain, available moisture, mild temperatures), parthenium weed can grow and produce flowers at any time of the year. In summer, plants can flower and set seed within four weeks of germination, particularly if stressed.

## Potential damage

Parthenium weed is a vigorous species that colonises weak pastures with sparse ground cover. It will readily colonise disturbed, bare areas along roadsides and heavily stocked areas around yards and watering points. Parthenium weed can also colonise brigalow, gidgee and softwood scrub soils. Its presence reduces the reliability of improved pasture establishment and reduces pasture production potential.

Parthenium weed is also a health problem as contact with the plant or the pollen can cause serious allergic reactions such as dermatitis and hay fever.

## Habitat and distribution

Parthenium weed is capable of growing in most soil types but becomes most dominant in alkaline, clay loam soils.

The plant is well established in Central Queensland and present in isolated infestations west to Longreach and in northern and southern Queensland.

Infestations have also been found in northern and central parts of New South Wales and it is capable of growing in most states of Australia.

## Control

### Prevention and weed seed spread

As with most weeds, prevention is much cheaper and easier than cure. Pastures maintained in good condition, with high levels of grass crown cover, will

limit parthenium weed colonisation. Drought, and the subsequent reduced pasture cover, creates the ideal window of opportunity for parthenium weed colonisation when good conditions return.

Parthenium seeds can spread via water, vehicles, machinery, stock, feral and native animals and in feed and seed. Drought conditions aid the spread of seed with increased movements of stock fodder and transports.

Vehicles and implements passing through parthenium weed infested areas should be washed down with water. Wash down facilities are located in Alpha, Biloela, Charters Towers, Emerald, Gracemere, Injune, Monto, Moura, Rolleston, Springsure and Taroom. Particular care should be taken with earthmoving machinery and harvesting equipment. The wash down procedure should be confined to one area, so that plants that establish from dislodged seed can be destroyed before they set seed.

Extreme caution should be taken when moving cattle from infested to clean areas. Avoid movement during wet periods as cattle readily transport seed in muddy soil. On arrival, cattle should be held in yards or small paddocks until seed has dropped from their coats and tails prior to their release into large paddocks. Infestations around yards can be easily spotted and controlled whereas infestations can develop unnoticed in large paddocks.

Particular care should be taken when purchasing seed, hay and other fodder materials. Always keep a close watch on areas where hay has been fed out for the emergence of parthenium or other weeds.

Property hygiene is important. Owners of clean properties should ensure that visitors from infested areas do not drive through their properties. If your property has parthenium weed on it, ensure that it is not spread beyond the boundary or further within the property.

### Pasture management

Grazing management is the most useful method of controlling large-scale parthenium weed infestations. Maintain pastures in good condition with high levels of ground and grass crown cover. This may require rehabilitation of poor pastures, followed by a sound grazing maintenance program.

**Sown pasture establishment**—Poor establishment of sown pastures can allow parthenium weed colonisation. pasture agronomist Aerial seeding prior to scrub pulling is normally beneficial.

**Overgrazing**—High grazing pressure caused by drought or high stock numbers decreases the vigour and competitiveness of pastures and allows the entry and spread of parthenium weed. Maintenance of correct stock numbers is most important in controlling parthenium weed. pasture agronomist

**Pastures spelling**—In situations of serious infestation, pasture spelling is essential for rehabilitation. Total spelling is much more effective than simply reducing the

stocking rate. However, overgrazing of the remainder of the property must be avoided.

The most appropriate time for pasture spelling is the spring–summer growing period, with the first 6–8 weeks being particularly important. If the condition of perennial grasses (native or sown) is low, spelling for the entire growing season may be required or introduced grasses may need to be re-sown. Herbicide treatment can hasten the rehabilitation process by removing a generation of parthenium seedlings and allowing grass seedlings to establish without competition. In the presence of parthenium weed, grass establishment is poor.

Grazing during winter should not increase the parthenium weed risk. Most tropical grasses are dormant and can tolerate moderate grazing during this period. However, parthenium weed may germinate and grow at this time.

**Fencing**—One of the main problems in controlling parthenium weed is the large paddock size and the variability of country within paddocks. The resulting uneven grazing pressures encourage parthenium weed to colonise the heavily grazed country. Ideally, similar land types should be fenced as single units. Fencing can be used to great effect to break up large paddocks, allowing more flexible management such as pasture spelling or herbicide application, options not available previously.

**Burning**—Burning is not promoted as a control strategy for parthenium weed. However, research suggests that burning for pasture management (e.g. woody weed control) should not result in an increased infestation if the pasture is allowed to recover prior to the resumption of grazing. Stocking of recently burnt areas known or suspected to contain parthenium decreases pasture competition and favours parthenium, ultimately creating a more serious infestation.

### Herbicide control

**Non-crop areas**—Parthenium weed should be sprayed early before it can set seed. A close watch should be kept on treated areas for at least two years.

Small and/or isolated infestations should be treated immediately. Herbicide control will involve a knockdown herbicide to kill plants that are present and a residual herbicide to control future germinations. Repeated spraying may be required even within the one growing season to prevent further seed production.

Extensive infestations will require herbicide treatment in conjunction with pasture management. Timing of spraying is critical so that parthenium weed is removed when plants are small and before seeding has occurred. Grasses should be actively growing and seeding so that they can recolonise the infested area.

Table 1 shows the herbicides registered for parthenium weed control and application rates. Before using any herbicide always read the label carefully. All herbicides must be applied strictly in accordance with the directions on the label.

**Cropping areas**—Controlling parthenium weed in cropland requires selective herbicide use and/or crop rotations. For further information on parthenium weed control in crops consult your local biosecurity officer.

### Biological control

The combined effects of biological control agents reduced the density and vigour of parthenium weed and increased grass production.

There are currently a number of insect species and two rust pathogens that have been introduced to control parthenium weed—a selection of these are outlined below.

***Epiblema strenuana*** is a moth introduced from Mexico established in all parthenium weed areas. The moth's larvae feed inside the stem, forming galls that stunt the plant's growth, reduce competitiveness and seed production.

***Listronotus setosipennis*** is a stem-boring weevil from Argentina but is of limited success in reducing parthenium weed infestations.

***Zygogramma bicolorata*** is a defoliating beetle from Mexico which is highly effective where present. It emerges in late spring and is active until autumn.

***Smicronyx lutulentus*** (Mexico) lays eggs in the flower buds where the larvae feed on the seed heads.

***Conotrachelus albocinereus*** (stem-galling weevil from Argentina) produces small galls and is still becoming established in Queensland.

***Bucculatrix parthenica*** (leaf mining moth from Mexico) larvae feed on leaves, leaving clear windows in the leaf.

***Carmentia ithacae*** is a stem boring moth from Mexico which is becoming established at favourable sites in the northern Central Highlands.

***Puccinia abrupta*** is a winter rust from Mexico that infects and damages leaves and stems. It is currently established over a wide area from Clermont south. It requires a night temperature of less than 16 degrees and 5–6 hours of leaf wetness (dew). Sporadic outbreaks occur where weather conditions are suitable.

***Puccinia melampodii*** is a summer rust from Mexico that weakens the plant by damaging the leaves over the summer growing season. It is currently established and spreading at a number of sites from north of Charters Towers to Injune in the south.

### Manual control

Hand pulling of small areas is not recommended. There is a health hazard from allergic reactions and a danger that mature seeds will drop off and increase the area of infestation.



## Further information

Further information is available from your local government office, or by contacting Biosecurity Queensland (call 13 25 23 or visit our website at [www.biosecurity.qld.gov.au](http://www.biosecurity.qld.gov.au)).

**Table 1 Herbicides registered for parthenium weed.**

Herbicide	Rate	Situation	Comments
2,4-D amine 500 g/L	0.4 L/100 L	Land—industrial, pastures; rights-of-way	Spot spray
atrazine 500 g/L max 3 kg/ha/yr	3.6–6 L/ha	Fields and fallow	Boom spray
	6 L/ha	Land—industrial, commercial, non-agricultural, roadside, right-of-way	Boom spray
atrazine 900 g/kg max 3 kg/ha/yr	2–3.3 kg/ha	Fields and fallow	Boom spray
	3.3 kg/ha	Land—non-agricultural, commercial, industrial	Boom spray
2,4-D + picloram (Tordon 75-D)	125 ml/100 L	Land—commercial, industrial, pastures, right-of-way	Spot spray
	3 L/ha	Land—commercial, industrial, pastures, right-of-way	Boom spray
2,4-D ester <sup>1</sup>	.025 L/10 L	Land—non-agricultural, pastures	Rosette stage
glyphosate (450 g/L)	0.8–1.2 L/ha	Fields and fallow	Spot spray
metsulfuron methyl	5–7 g/ha	Fields and fallow	Seedlings only
	5 g/100 L	Land—commercial, industrial, pastures, rights-of-way	Spot spray
hexazinone	3.5 L/ha or 7 L/10 L/20 m <sup>2</sup>	Land—commercial, industrial, pastures, rights-of-way	Boom spray or spot spray
dicamba (200 g/L)  (500 g/L)  (700 g/kg)	0.7–2.8 L/ha or 0.1–0.19 L/100L	Grass pastures	Boom spray or spot spray
	0.28–1.1 L/ha or 0.40–0.76 L/100L	Grass pastures	Boom spray or spot spray
	200–800 g/ha or 30–60 g/100 L	Grass pastures	Boom spray or spot spray

<sup>1</sup>Use restricted in some areas of Central Queensland

**Notes** The registered rates are for non-crop uses. Consult label for in-crop recommendations. For power hand spray or knapsack use, spray plants to the point of runoff.

Fact sheets are available from Department of Employment, Economic Development and Innovation (DEEDI) service centres and our Customer Service Centre (telephone 13 25 23). Check our website at [www.biosecurity.qld.gov.au](http://www.biosecurity.qld.gov.au) to ensure you have the latest version of this fact sheet. The control methods referred to in this fact sheet should be used in accordance with the restrictions (federal and state legislation, and local government laws) directly or indirectly related to each control method. These restrictions may prevent the use of one or more of the methods referred to, depending on individual circumstances. While every care is taken to ensure the accuracy of this information, DEEDI does not invite reliance upon it, nor accept responsibility for any loss or damage caused by actions based on it.

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#### 4 Parthenium weed *Parthenium hysterophorus*

# Prickly pear

*Opuntia*, *Nopalea* and *Acanthocereus* spp.



The introduction and spread of prickly pear into Queensland and New South Wales is one of the greatest environmental invasions of modern times.

Prickly pear was introduced into pastoral districts in the 1840s. By 1900, over 4 million hectares in Queensland and New South Wales was infested by prickly pear. By 1925, the pest had invaded over 24 million hectares. Control costs were prohibitive and the only effective herbicide at the time was hazardous. This resulted in landholders abandoning large tracts of land.

Research for biological control agents commenced in 1912, and in 1914 cochineal insects were released to control one of the minor prickly pear species. Control of this minor prickly pear species by these introduced insects occurred within a few years.

The success of the cochineal insects led to renewed efforts against other types of prickly pear in the 1920s. These efforts resulted in the control of the major pest prickly pear by the moth *Cactoblastis cactorum*; by the mid-1930s, prickly pear was no longer a major problem.

Several prickly pear species have since remained as minor weeds.

**Great state. Great opportunity.**



## Declaration details

*O. ficus-indica* is not declared. *O. Stricta*, *O. aurantiaca*, *O. monacantha*, *O. tomentosa* and *O. streptacantha* species are Class 2 declared pest plants and all other species are declared Class 1 under Queensland legislation.

## Description and general information

'Prickly pear' is a general term used to describe some plants of the Cactaceae family. The term includes species of *Opuntia*, *Nopalea* and *Acanthocereus*. All of these plants originate in the Americas. The term 'prickly pear' also relates to the fruit, which is often spiny and pear-shaped. Plants are normally leafless succulent shrubs. Stems are divided into segments (pads or joints) that are flat and often incorrectly called leaves.

Young shoots have true leaves resembling small fleshy scales that fall off as the shoot matures.

Flowers are large, normally seen during spring and can be yellow, orange, red, pink, purple or white depending on the species. Prickly pear fruits vary between species and can be red, purple, orange, yellow or green.

Areoles (spots with clusters of spines) are found on both the pads (joints, segments) and fruit. In addition to spines, areoles often have clusters of sharp bristles (glochids) and tufts of fibre ('wool'). Each areole contains a growing point that can produce roots or shoots.

## Life cycle

Prickly pear species have several features that enable them to compete and become pests.

Prickly pear species are drought resistant because of their succulent nature, their lack of leaves and their thick, tough skins. These features result in plants that use the majority of their internal tissues for water storage and their outer parts to reduce water loss and damage by grazing and browsing animals. They can remain vigorous in hot, dry conditions that cause most other plants to lose vigour or even die. Some species develop underground bulbs that enable the plant to resist fire and mechanical damage.

Prickly pear species reproduce both sexually and asexually. Birds and other animals readily eat the many-seeded fruits and deposit seeds in their droppings. The seeds have hard seed coats that allow them to survive heat and lack of water. Asexual reproduction (cloning) of prickly pear occurs when pads (joints, segments) or fruits located on the ground take root and produce shoots. Animals and floods move broken pads long distances. These pads can survive long periods of drought before weather conditions allow them to set roots.

## Habitat and distribution

Prickly pear species considered pests in Queensland are:

- Common pest pear *Opuntia stricta* var. *stricta* (= *O. inermis*)
- Spiny pest pear *Opuntia stricta* var. *dillenii* (= *O. stricta*)
- Tiger pear *Opuntia aurantiaca*
- Drooping tree pear *Opuntia vulgaris* (= *O. monacantha*)
- Velvety tree pear *Opuntia tomentosa*
- Westwood pear *Opuntia streptacantha*
- Devil's rope pear *Opuntia imbricata*
- Coral cactus *Opuntia cylindrica*
- Snake cactus *Opuntia fulgida* × *O. imbricate*
- Sword pear *Acanthocereus pentagonus*

### Common pest pear (*Opuntia stricta* var. *stricta*)

This bushy, spreading plant grows up to 1.5 m high and forms large clumps. The stems are divided into oval, blue-green spineless pads 20 cm long and 10 cm wide. Areoles are in diagonal lines along the pads 2.5 cm to 5 cm apart and have a cushion of brown wool containing bristles but usually no spines. When spines occur they are stout, yellow and up to 4 cm long.

Common pest pear produces flowers that are 7.5 cm wide, bright lemon yellow and green at the base. The fruit is oval-shaped, has a deep cavity on one end and tapers at the other. It is purple, 6 cm long and 3 cm wide, with carmine-coloured (dark red) seeds and a fleshy pulp.

Common pest pear is found as small to large clumps of varying density. The clumps are usually broken up by the action of *Cactoblastis cactorum*. Common pest pear occurs throughout most of central and southern Queensland and is still spreading westwards. It is often found along beaches and on offshore islands.

### Spiny pest pear (*Opuntia stricta* var. *dillenii*)

This succulent shrub grows 1–2 m high. The stems are hairless and bluish-green or dull green. The stems are divided into pads up to 30 cm long, 15 cm wide and 1–2 cm thick. The areoles have tufts of short and finely barbed bristles accompanied by one or two yellow spines between 2 cm and 4 cm long. Small scale-like leaves are found on areoles of immature pads.

Spiny pest pear produces 6–8 cm wide flowers that are lemon yellow with green or pink markings on the back. The fruit is pear-shaped and about 4–6 cm long with a red-purple skin. The areoles located on fruits have fine, barbed bristles. The red flesh of fruits contains rounded seeds that are yellow or pale brown.

While this prickly pear once formed large-scale dense infestations, it is now found as small clumps or as scattered plants. These clumps are usually broken by the action of *Cactoblastis cactorum*. It is found in eastern central Queensland, the Burnett district, the Darling Downs and south-eastern Queensland.

#### **Tiger pear (*Opuntia aurantiaca*)**

This succulent low shrub with underground tubers usually grows 30–60 cm high. The stems are divided into very spiny, slightly flattened pads that are 1–30 cm long and 1–5 cm wide. The stems are dark green to purple and red in colour. The areoles have 3–7 brown barbed spines up to 4 cm long surrounded by tufts of short, fine bristles. The pads detach easily and are transported on the skins of animals. Small and scale-like leaves are found on areoles of immature pads.

Tiger pear produces 6 cm wide yellow flowers. The rarely formed fruits are pear-shaped and about 2.5 cm long. When ripe, they are red with purple markings.

Dense tiger pear forms an impenetrable spiny groundcover and is prevalent in southern Queensland but extends into central Queensland.

#### **Drooping tree pear (*Opuntia vulgaris*)**

This erect succulent shrub with fibrous roots grows up to 5 m high but is usually 2–3 m high. The branches are divided into glossy light green pads up to 45 cm long, 15 cm wide and 1.5 cm thick. The dark grey trunk grows up to 25 cm in diameter. Drooping tree pear gets its name because the upper segments tend to droop. The areoles on the older pads have 1–5 sharp spines about 5 cm long.

Small, scale-like leaves are found on areoles of very young pads and are quickly shed as the pad grows. Drooping tree pear produces yellow flowers that are 6 cm wide and have red markings on the back. The fruit is pear-shaped and 4–7 cm long with a green skin. The flesh of the fruit is red and pulpy and contains round seeds that are yellow or pale brown. The fruits have areoles with tufts of fine, barbed bristles.

Dense thickets result when drooping tree pear is allowed to grow freely. Small scattered infestations occur in the south-east corner of Queensland and in coastal northern Queensland.

#### **Velvety tree pear (*Opuntia tomentosa*)**

This tree-like plant forms a central woody trunk over 40 cm wide and grows up to 5 m high. The stems are divided into oblong pads that are dull green and velvety to touch due to the dense covering of short fine hairs. The pads are 15–35 cm long, 8–12 cm wide and 1.5–2 cm thick.

Young plants have 2–4 white or pale yellow spines located in the areoles with one spine reaching a length of 2.5 cm. The areoles usually become spineless as the plant matures. A more spiny variety does exist and has more than 50 spines in each areole on the trunk.

The flowers are a deep orange. The fruit is egg-shaped, about 5 cm long and 3 cm wide, and dull red. The top of the fruit is saucer-shaped with circular lines that meet in the centre and give the fruit a shrivelled appearance. The fruit produces many seeds within a reddish pulp.

Velvety tree pear is found predominantly throughout the brigalow belt of Queensland and is still extending its range. It is occasionally found as dense shrubs, but more usually as small clumps of trees or as trees scattered over the landscape.

#### **Westwood pear or Cardona pear (*Opuntia streptacantha*)**

Westwood pear is a shrub-like or tree-like plant that forms clumps by branching from the base and is usually 2–4 m high. The stems are divided into almost circular dull green pads, 25–30 cm long and 15–20 cm wide. The areoles have white spines that vary in number and size when the plant matures.

Young pads have 2–5 white spines 1–2 cm long, accompanied by two hair-like spines 0.5 cm long in the lower part of the areole. Spines increase in number (up to 20) and size (5 cm long) in areoles along the trunk of the plant.

The flowers are yellow and fruits are barrel-shaped, 6 cm long and 5 cm wide with a flat top. The fruit has a purple skin and a rind that is 1 cm thick. Fruits contain red seeds buried in a dark red (carmine) pulp.

Westwood pear is found in eastern central Queensland as small clumps or as plants scattered over the landscape.

#### **Devil's rope pear (*Opuntia imbricata*)**

This open-branching shrub grows 1.5–3 m high. The stems are divided into hairless, dull green, cylindrical pads that vary up to 37 cm in length and are 3.5–5 cm thick. The pads have a series of short raised ridges that give them a twined, rope-like appearance. The areoles are found on these ridges and produce 3–11 pale yellow or white spines, with the longest being 2.5 cm long. Papery sheaths cover these spines.

The flowers are a dull, red-purple colour and found at the ends of pads. The yellow fruit resembles a small, 5 cm wide custard apple and has a spineless areole at the top.

Devil's rope pear occurs in Queensland as a small infestation at Gladfield.

### **Coral cactus (*Opuntia cylindrica*)**

Coral cactus grows as a branching shrub 1–1.5 m high. The stems of coral cactus are divided into green cylinder-like pads that are fist-like and obtuse at their apex. Mature coral cactus pads widen, become distorted and wavy, and resemble a piece of coral. Areoles along the pads have a number of short white spines.

Coral cactus produces small (1–2 mm wide) scarlet flowers. The fruit is yellow-green and 2–5 cm wide.

Coral cactus has been located near Mount Isa, Longreach, Wyandra, Eulo and Hungerford but its potential spread includes all of far western Queensland.

### **Snake cactus (*Opuntia fulgida* × *O. imbricata*)**

This open-branching shrub grows 1–2 m high. The stems are divided into hairless, dull green, cylindrical pads that vary up to 20 cm in length and are 3.5–5 cm thick. The pads have a series of short raised ridges that give them a twined rope-like appearance. The areoles are found on the bottom of these ridges and produce 5–10 pale yellow to brown spines, with the longest being 3 cm long.

The flowers are light red to dark rose and commonly 5–7 cm wide. Snake cactus produces fruit that is yellow and 2–5 cm wide.

Snake cactus has been located near Longreach but its potential spread includes all of north-western Queensland.

### **Sword pear (*Acanthocereus pentagonus*)**

This elongated branching shrub grows in clumps up to 4 m high. The stems are erect, up to 1.5 m long, 3–8 cm wide and divided into many joints. Sword pear stems are three-angled, four-angled or five-angled and resemble star-picket posts. The areoles are found on the edges of the joints and produce many white spines 1–4 cm long.

The flowers are white, funnel-shaped and 14–20 cm long. The flowers open at night between spring and summer. Sword pear produces bright red sphere-shaped fruits that are 5 cm in diameter. The fruit has a red pulp and black seeds.

Sword pear occurs in the Gogango area west of Rockhampton.

## **Control**

### **Biological control**

Investigations into biological control agents against prickly pear began in 1912. Over 150 insect species were studied throughout the world, with 52 species selected for transport to Queensland. Following intensive host specificity testing, 18 insects and one mite were released in Queensland. Nine insects and the mite remain established in Queensland. These species are:

- *Cactoblastis cactorum*, a stem-boring moth
- *Dactylopius ceylonicus*, a cochineal mealy bug
- *Dactylopius opuntiae*, a cochineal mealy bug
- *Dactylopius confusus*, a cochineal mealy bug
- *Dactylopius tomentosus*, a cochineal mealy bug
- *Dactylopius austrinus*, a cochineal mealy bug
- *Chelinidea tabulata*, a cell-sucking bug
- *Tucumania tapiacola*, a stem-boring moth
- *Archlagocheirus funestus*, a stem-boring beetle
- *Tetranychus opuntiae*, prickly pear red spider mite.

These biological control agents continue to keep several prickly pear species under control. It is important to remember not all the agents attack all species.

The most successful of these agents were the moth *Cactoblastis cactorum* and five cochineal mealy bugs—*Dactylopius ceylonicus*, *D. opuntiae*, *D. confusus*, *D. tomentosus* and *D. austrinus*. The other agents are still around but not in sufficient numbers to provide control.

### ***Cactoblastis cactorum* (cactoblastis moth)**

Larvae of this moth were introduced from Argentina in 1925. *Cactoblastis* proved to be the most effective agent against the common and spiny pest pears, destroying massive infestations in Australia. Larvae keeps these two pest pears controlled to an acceptable level most of the time, although it is less effective in some coastal and far western areas.

The larvae collectively eat out the contents of the pads, leaving empty pad skins and piles of mushy droppings. The orange and black larvae are occasionally observed on the outsides of pads. *Cactoblastis* also attacks most types of prickly pear but is not effective against them.

### ***Dactylopius* spp. (cochineal insects)**

All female cochineal insects are small, sessile mealy bugs that spend their adult lives permanently attached to their host plants sucking plant juices. They are covered by a fine, white, waxy secretion and when crushed yield a carmine colouring. The adult males are small, free-flying insects that do not feed.

### ***Dactylopius ceylonicus* (monacantha cochineal, Argentine cochineal)**

This South American mealy bug was released in 1914 and 1915 to control drooping tree pear. It destroyed the dense infestations existing at that time. It is specific to drooping tree pear and today remains the only effective biological control agent for drooping tree pear. This insect needs to be distributed manually.

4 Prickly pear *Opuntia*, *Nopalea* and *Acanthocereus* spp.

### ***Dactylopius opuntiae* (prickly pear cochineal)**

This mealy bug was introduced from Mexico and southern United States between 1920 and 1922. It is effective against common pest pear, spiny pest pear, velvety tree pear and Westwood pear and remains the main biological control agent against velvety tree pear and Westwood pear. This insect spreads slowly in nature and can be assisted manually.

### ***Dactylopius confusus* (prickly pear cochineal)**

This mealy bug was introduced from Florida and released in 1933 against spiny pest pear. It remains effective against spiny pest pear in central Queensland but spreads slowly. This insect can be spread manually.

### ***Dactylopius tomentosus* (devil's rope pear cochineal)**

This mealy bug was introduced from southern United States in 1925 and 1926. It is effective against devil's rope pear but works slowly.

### ***Dactylopius austrinus* (tiger pear cochineal)**

This mealy bug was introduced from Argentina in 1932. It is specific to and effective against tiger pear. It rapidly reduces tiger pear populations but dies out in a paddock after the destruction of tiger pear. It needs to be reintroduced after tiger pear regrows.

### ***Chelinidea tabulata* (prickly pear bug)**

This plant-sucking bug was introduced from Texas in 1921. It was effective against dense common pest pear before *Cactoblastis cactorum* was but is now relatively ineffective. This insect also attacks most other prickly pears. The adult is a pale brown bug up to 20 mm long that leaves characteristic round bleached spots on the surface of the cactus.

### ***Tucumania tapiacola* (prickly pear moth-borer)**

This moth was introduced from Argentina in 1934 against tiger pear. Its solitary larvae feed internally and eat out tiger pear pads with limited effect. It has been observed attacking common pest pear and harrisia cactus.

### ***Archlagocheirus funestus* (tree pear beetle)**

This stem-boring beetle was introduced from Mexico in 1935. It was effective against velvety tree pear and Westwood pear but has become rare since the dense stands of these prickly pears have gone.

### ***Tetranychus opuntiae* (prickly pear spider mite)**

This mite was introduced from southern United States and Mexico in 1922. It was effective against common pest pear but is now rare and difficult to find. It causes distinctive scar tissue formation around areoles.

## **Distributing biological control agents**

### **Cactoblastis**

Cactoblastis can be spread manually by distributing eggs or larvae. Cactoblastis moths lay chains of eggs (eggsticks) on prickly pear pads from January to February and from September to November. The eggsticks are distinguished from spines by their curved appearance.

1. Collect the fragile eggsticks carefully.
2. Glue single eggsticks to small pieces of paper using a starch-based adhesive.
3. Pin the egg papers to prickly pear pads. (Eggs take up to one month to hatch.)
4. Collect pads or plants in which larvae are obviously still active.
5. At a release site place all the collected plant material in a small part of the infestation.
6. Subsequent generations of moths will disperse through the infestation.
7. Follow up the biological control with either herbicide or mechanical treatment.

### **Cochineals**

Because several cochineal insects affect some prickly pears and not others, it is essential to know what prickly pear you wish to control.

1. Identify your prickly pear type.
2. Find the same prickly pear type which is being attacked by a cochineal.
3. Collect pads of the prickly pear with the insects.
4. Place affected pads against unaffected prickly pears at the release site.
5. Follow up the biological control with either herbicide or mechanical treatment.

### **Tiger pear cochineal**

Tiger pear cochineal is easy to multiply quickly after collection.

1. Carefully collect a reasonable quantity of unaffected tiger pear in a container (box or bucket).
2. Place a few pieces of cochineal-affected tiger pear into the same container.
3. Cover the container with a cloth and store under cover for a few weeks.
4. Check the cactus occasionally.
5. When most of the tiger pear in the container has cochineal, it is ready to distribute.
6. At the release site place affected pads against unaffected prickly pears.
7. Follow up the biological control with either herbicide or mechanical treatment.

Note: It is best to multiply tiger pear cochineal before release.

5 Prickly pear *Opuntia*, *Nopalea* and *Acanthocereus* spp.

## Mechanical control

Mechanical control using machinery is difficult because prickly pear pads can easily re-establish. A hot fire is an effective control method for dense prickly pear infestations. Before burning, consult Biosecurity Queensland to see if this practice is suitable for your pasture and land management practices.

## Herbicide control

Herbicide options available for the control of prickly pears in Queensland are shown in Table 1.

Landholders and contractors should check if the property is in a hazardous area as defined in the *Agricultural Chemicals Distribution Control Act 1966* prior to spraying.

## Further information

Further information is available from your local government office, or by contacting Biosecurity Queensland (call 13 25 23 or visit our website at [www.biosecurity.qld.gov.au](http://www.biosecurity.qld.gov.au)).

**Table 1** Herbicides registered for the control of prickly pears

Pest name	Situation	Herbicide	Rate	Method
Common prickly pear	Agricultural land—non-crop	Triclopyr (240 g/L) + picloram (120 g/L)	1 L/60 L diesel	Basal bark/cut stump
		Triclopyr (600 g/L)	3 L/100 L or 0.8 L/60 L diesel	
	Forests—timber production	Triclopyr (240 g/L) + picloram (120 g/L)	1 L/60 L diesel	Basal bark/cut stump
		Triclopyr (300 g/L) + picloram (100 g/L)	0.5 L/100 L	
		Triclopyr (600 g/L)	3 L/100 L or 0.8 L/60 L diesel	Basal bark/cut stump
			3 L/100 L or 1 L/75 L diesel	Foliar
	Land—commercial/industrial/public	Triclopyr (240 g/L) + picloram (120 g/L)	1 L/60 L diesel	Basal bark/cut stump
		Triclopyr (300 g/L) + picloram (100 g/L)	0.5 L/100 L	
		Triclopyr (600 g/L)	3 L/100 L or 0.8 L/60 L diesel	Basal bark/cut stump
			3 L/100 L or 1 L/75 L diesel	Foliar
	Land—non-agricultural	Triclopyr (300 g/L) + picloram (100 g/L)	0.5 L/100 L	
		Triclopyr (600 g/L)	3 L/100 L or 0.8 L/60 L diesel	Basal bark/cut stump
	Land—rights of way	Triclopyr (240 g/L) + picloram (120 g/L)	1 L/60 L diesel	Basal bark/cut stump
		Triclopyr (300 g/L) + picloram (100 g/L)	0.5 L/100 L	
		Triclopyr (600 g/L)	3 L/100 L or 0.8 L/60 L diesel	Basal bark/cut stump
			3 L/100 L or 1 L/75 L diesel	Foliar
	Pastures	Triclopyr (240 g/L) + picloram (120 g/L)	1 L/60 L diesel	Basal bark/cut stump
		Triclopyr (300 g/L) + picloram (100 g/L)	0.5 L/100 L	
Triclopyr (600 g/L)		3 L/100 L or 0.8 L/60 L diesel	Basal bark/cut stump	
		3 L/100 L or 1 L/75 L diesel	Foliar	
Coral cactus	Agricultural non-crop areas, fence lines and forestry	Triclopyr (240 g/L) + picloram (120 g/L)	1 L/60 L diesel	Basal bark/cut stump Apply as an overall spray, wetting all areas of the plant to ground level
	Commercial/industrial areas, rights-of-way and pastures	Triclopyr (240 g/L) + picloram (120 g/L)	1 L/60 L diesel See permit PER13812 (expires 30 November 2017)	Basal bark/cut stump

Continued

## 6 Prickly pear *Opuntia*, *Nopalea* and *Acanthocereus* spp.

Pest name	Situation	Herbicide	Rate	Method
Tiger pear	Agricultural land—non-crop	Triclopyr (240 g/L) + picloram (120 g/L)	1 L/60 L diesel	Basal bark/cut stump
		Triclopyr (600 g/L)	3 L/100 L or 0.8 L/60 L diesel	
	Forests—timber production	Triclopyr (240 g/L) + picloram (120 g/L)	1 L/60 L diesel	Basal bark/cut stump
		Triclopyr (600 g/L)	3 L/100 L or 0.8 L/60 L diesel 3 L/100 L or 1 L/75 L diesel	Basal bark/cut stump Foliar
	Land—commercial/ industrial/public	Triclopyr (240 g/L) + picloram (120 g/L)	1 L/60 L diesel	Basal bark/cut stump
		Triclopyr (600 g/L)	3 L/100 L or 0.8 L/60 L diesel 3 L/100 L or 1 L/75 L diesel	Basal bark/cut stump Foliar
	Land—non-agricultural	Triclopyr (600 g/L)	3 L/100 L or 0.8 L/60 L diesel	Basal bark/cut stump
	Land—rights of way	Triclopyr (240 g/L) + picloram (120 g/L)	1 L/60 L diesel	Basal bark/cut stump
		Triclopyr (600 g/L)	3 L/100 L or 0.8 L/60 L diesel 3 L/100 L or 1 L/75 L diesel	Basal bark/cut stump Foliar
	Pastures	Triclopyr (240 g/L) + picloram (120 g/L)	1 L/60 L diesel	Basal bark/cut stump
		Triclopyr (600 g/L)	3 L/100 L or 0.8 L/60 L diesel 3 L/100 L or 1 L/75 L diesel	Basal bark/cut stump Foliar
	Drooping tree pear	Agricultural land—non-crop	Triclopyr (240 g/L) + picloram (120 g/L)	1 L/60 L diesel
Triclopyr (600 g/L)			0.8 L/60 L diesel	
Forests—timber production		Triclopyr (240 g/L) + picloram (120 g/L)	1 L/60 L diesel	Basal bark/cut stump
		Triclopyr (300 g/L) + picloram (100 g/L)	0.5 L/100 L	
		Triclopyr (600 g/L)	0.8 L/60 L diesel 1 L/75 L diesel	Basal bark/cut stump Foliar
		Land—around buildings	Amitrole (250 g/L) + ammonium thiocyanate (220 g/L)	1 mL/3 cm (inject) or 1 L/25 L (small plants/regrowth)
Land—commercial/ industrial/public		Amitrole (250 g/L) + ammonium thiocyanate (220 g/L)	1 mL/3 cm (inject) or 1 L/25 L (small plants/regrowth)	
		Triclopyr (240 g/L) + picloram (120 g/L)	1 L/60 L diesel	Basal bark/cut stump
		Triclopyr (300 g/L) + picloram (100 g/L)	0.5 L/100 L	
		Triclopyr (600 g/L)	0.8 L/60 L diesel 1 L/75 L diesel	Basal bark/cut stump Foliar
		Land—non-agricultural	Amitrole (250 g/L) + ammonium thiocyanate (220 g/L)	1 mL/3 cm (inject) or 1 L/25 L (small plants/regrowth)
Triclopyr (300 g/L) + picloram (100 g/L)			0.5 L/100 L	
Land—rights of way		Triclopyr (600 g/L)	0.8 L/60 L diesel	Basal bark/cut stump
		Amitrole (250 g/L) + ammonium thiocyanate (220 g/L)	1 mL/3 cm (inject) or 1 L/25 L (small plants/regrowth)	Basal bark/cut stump
		Triclopyr (240 g/L) + picloram (120 g/L)	1 L/60 L diesel	
		Triclopyr (300 g/L) + picloram (100 g/L)	0.5 L/100 L	
		Triclopyr (600 g/L)	0.8 L/60 L diesel 1 L/75 L diesel	Basal bark/cut stump Foliar

Continued

7 Prickly pear *Opuntia*, *Nopalea* and *Acanthocereus* spp.



Pest name	Situation	Herbicide	Rate	Method
Drooping pear	Pastures	Triclopyr (240 g/L) + picloram (120 g/L)	1 L/60 L diesel	Basal bark/cut stump
		Triclopyr (300 g/L) + picloram (100 g/L)	0.5 L/100 L	
		Triclopyr (600 g/L)	0.8 L/60 L diesel	Basal bark/cut stump
			1 L/75 L diesel	Foliar
Velvety tree pear	Agricultural land—non-crop	Triclopyr (240 g/L) + picloram (120 g/L)	1 L/60 L diesel	Basal bark/cut stump
	Forests—timber production	Triclopyr (240 g/L) + picloram (120 g/L)	1 L/60 L diesel	Basal bark/cut stump
	Land—around buildings	Amitrole (250 g/L) + ammonium thiocyanate (220 g/L)	1 mL/3 cm (inject) or 1 L/25 L (small plants/regrowth)	
Velvety tree pear	Land—commercial/industrial/public	Amitrole (250 g/L) + ammonium thiocyanate (220 g/L)	1 mL/3 cm (inject) or 1 L/25 L (small plants/regrowth)	
		Triclopyr (240 g/L) + picloram (120 g/L)	1 L/60 L diesel	Basal bark/cut stump
	Land—non-agricultural	Amitrole (250 g/L) + ammonium thiocyanate (220 g/L)	1 mL/3 cm (inject) or 1 L/25 L (small plants/regrowth)	
	Land—rights of way	Amitrole (250 g/L) + ammonium thiocyanate (220 g/L)	1 mL/3 cm (inject) or 1 L/25 L (small plants/regrowth)	
		Triclopyr (240 g/L) + picloram (120 g/L)	1 L/60 L diesel	Basal bark/cut stump
Pastures	Triclopyr (240 g/L) + picloram (120 g/L)	1 L/60 L diesel	Basal bark/cut stump	
Spiny pest pear Westwood pear Devil's rope pear Snake cactus	Agricultural land—non-crop Forests—timber production Land—commercial/industrial/public Land—rights of way Pastures	Triclopyr (240 g/L) + picloram (120 g/L)	1 L/60 L diesel	Basal bark/cut stump

This fact sheet is developed with funding support from the Land Protection Fund.



Fact sheets are available from Department of Agriculture, Fisheries and Forestry (DAFF) service centres and our Customer Service Centre (telephone 13 25 73). Check our website at [www.biosecurity.qld.gov.au](http://www.biosecurity.qld.gov.au) to ensure you have the latest version of this fact sheet. The control methods referred to in this fact sheet should be used in accordance with the restrictions (federal and state legislation, and local government laws) directly or indirectly related to each control method. These restrictions may prevent the use of one or more of the methods referred to, depending on individual circumstances. While every care is taken to ensure the accuracy of this information, DAFF does not invite reliance upon it, nor accept responsibility for any loss or damage caused by actions based on it.

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# Mother-of-millions

*Bryophyllum delagoense* (syn. *B. tubiflorum*, *Kalanchoe delagoensis*), *Bryophyllum* × *houghtonii* (syn. *B. daigremontianum* × *B. delagoense*, *Kalanchoe* × *houghtonii*)



Mother-of-millions are native to Madagascar and are escaped ornamental plants. Five species are commonly naturalised in Queensland. It is well adapted to dry areas because of its succulent features.

As the name suggests, one plant can reproduce a new generation from masses of embryoids (plantlets) that are formed on the leaf edges. This makes these plants hard to eradicate and follow up controls are essential.

These plants, especially their flowers, are poisonous to stock and occasionally cause a significant number of cattle deaths. When cattle are under stress or in unusual conditions they are more likely to eat plants that they would not normally eat. Shifting cattle to new paddocks, moving stock through infested rubbish dumps and wastelands, and reduction of availability of feed due to flood or drought can all contribute to cattle eating mother-of-millions and being poisoned. The plant flowers from May to October (during the drier months of the year) and the scarcity of feed at this time may cause cattle to consume lethal amounts of mother-of-millions.

Poisoned cattle show signs of dullness, loss of appetite, diarrhoea and heart failure. Some cattle may drool saliva or dribble urine. There are two responses to poisoning:

1. acute—where cattle die within a day
2. chronic—where cattle may take up to five days to die.

Some cattle may make a slow recovery if insufficient plant material was eaten.

Poisoned cattle must be treated within 24 hours of consuming the plant. The treatment is intense and needs to be given by a veterinarian, or under their direction, because of the drugs and materials used. The treatment is costly—\$70 or more for one adult cow, plus veterinary fees.

## Declaration details

*Bryophyllum delagoense* syn. *B. tubiflorum*, *Kalanchoe delagoensis* and the hybrid *Bryophyllum* × *houghtonii* syn. *B. daigremontianum* × *delagoense*, *Kalanchoe* × *houghtonii* are declared Class 2 plants under the *Land Protection (Pest and Stock Route Management) Act 2002*.

Great state. Great opportunity.



A Class 2 pest is one that has already spread over substantial areas of Queensland, but its impact is so serious that there is a need to try and control it and avoid further spread onto properties that are still free of the pest. By law, all landholders must try to keep their land free of Class 2 pests and it is an offence to keep or sell these pests without a permit. A local government may serve a notice upon a landholder requiring control of declared pests.

## Description and general information

Mother-of-millions are erect, smooth, fleshy succulent plants growing to 1 m or more in height.

All species form tall flower spikes in winter with clusters of bell-shaped flowers. Each species has a distinctive leaf shape, but all produce small plantlets along the edges of the leaves. These plantlets drop readily, develop roots and establish quickly to form a new colony.

*Bryophyllum delagoense* syn. *B. tubiflorum* and *Kalanchoe delagoensis* (common mother-of-millions, mission bells, Christmas bells) has grey-brown, fleshy, tubular-like leaves with up to seven projections at the tip of each leaf. The flowers are orange-red and occur in a cluster at the top of a single stem. Seeds can germinate for some years.

*Bryophyllum* × *houghtonii* syn. *B. daigremontianum* × *B. delagoense*, *Kalanchoe* × *houghtonii* (hybrid or crossbred mother-of-millions) has similar flowers arranged in a branched cluster at the top of the stem. Its leaves are boat shaped with thick stalks and notches along the edges of the leaves.

A third species, *Bryophyllum pinnatum* (resurrection plant, live-leaf), is also problematic but is not a declared pest plant. This plant has yellow-green, oval, fleshy leaflets with wavy edges and up to five leaflets per leaf. Its flowers are yellowish-green, often tinged with pink, and occur in loose clusters on stalks growing at intervals along the upper portion of the stem.

## Habitat and distribution

These popular garden plants have escaped cultivation and spread in various areas of Queensland. They have become a problem in pasture lands in the central highlands around Clermont, Emerald and Dingo, and the Burnett, Moreton and Darling Downs scrub regions. The plants establish well in leaf litter or other debris on shallow soils in shady woodlands, and often grow on roadsides, along fence lines and around old rubbish dumps. They can spread from these areas, especially in flood, and establish if pastures are run down. They are adapted to dry conditions and can survive long periods of drought.

Map 1. Distribution of mother-of-millions in Queensland



## Prevention

The best form of weed control is prevention. Always treat weed new infestations when small—do not allow weeds to establish. Weed control is not cheap, but it is cheaper to do it now rather than next year, or the year after. Proper planning ensures better value for each dollar spent.

Permanent control of mother-of-millions infested areas is best ensured by establishing more desirable plants in that location to compete successfully with future mother-of-millions seedlings and plantlets. This is best achieved through soil preparation, replanting, fertilising and using the area more productively.

Ensure scattered infestations and small dumping areas on properties are regularly checked and cleaned up. Day-to-day hygiene management will help prevent establishment of these weeds.

Co-operative control upstream and downstream of problem areas will help prevent re-infestation from other areas.

To prevent poisoning, keep stock (especially hungry stock) away from infested areas until the plants are controlled.

## Control

Look at weed problems carefully. Decide whether to contain the weed to stop new infestations developing while reducing existing weeds. Determine what weed control is required by legislation. Determine how weed control fits into your property management. What can be done to restore and prevent re-establishment?

The best approach is usually to combine different methods. Control may include chemical, mechanical, fire and biological methods combined with land management changes. The control methods chosen should suit the specific weed and particular situation.

## Fire

When suitable (e.g. after grading firebreaks), burn infestations and the accompanying debris on which mother-of-millions plants thrive. This is the most economical form of control, encourages grass competition and lessens the problem for following years, requiring only spot spraying with selective herbicides.

## Biological control

The South African citrus thrips is present in Queensland and is quite widespread through the south of the state. The thrip damages the outer tissue of the mother-of-millions plant and also lays its eggs under the outer tissue. Where high populations of thrips exist, the number of viable plantlets and flowers forming on mother-of-millions is reduced.

The thrips populations vary from year to year, according to mother-of-millions populations and climate. The South African citrus thrips should not be seen as a long term control strategy—only a control option to complement other techniques such as herbicide treatment and burning.

## Mechanical control

For small areas, pull up plants by hand and burn on a wood heap. Alternatively, bag the plants and dump them in a bin, the contents of which are buried at council refuse tips rather than being recycled into mulch.

## Herbicide control

Before using any herbicide always read the label carefully. All herbicides must be applied strictly in accordance with the directions on the label. Where the addition of a wetting agent is recommended, always use a commercial wetting agent or surfactant.

Mother-of-millions may be controlled with herbicides at any time of the year, but infestations are easiest to see in winter when the plants are in flower. Treating infestations at this time of year also has the benefit of preventing new seeds from developing on common mother-of-millions.

Table 1 details the herbicides registered for mother-of-millions control.

## Further information

Further information is available from your local government office, or by contacting Biosecurity Queensland (call 13 25 23 or visit our website at [www.biosecurity.qld.gov.au](http://www.biosecurity.qld.gov.au)).



South African citrus thrips adult



South African citrus thrips damage to mother-of-millions

**Table 1. Herbicides registered for the control of mother-of-millions**

Situation	Herbicide	Rate	Comments <sup>1</sup>
Pastures, non-crop land	2,4-D acid (AF 300)	7 L/1000 L water per ha	Overall spray handgun
		70 ml/10 L water	Overall spray knapsack
Pastures, rights of way, non-crop land, forests, non-agricultural land, commercial/industrial areas	picloram + triclopyr (e.g. Grass-up, Grazon DS, Picker)	50 ml/10 L water	Overall spray knapsack Apply at flowering
	fluroxypyr	600 ml/100 L water + sufactant	Apply to seedlings and young plants before flowering
	picloram + triclopyr + aminopyralid (e.g. Grazon Extra)	50 ml/10 L water	Add 100% concentrate non-ionic surfactant (e.g. BS 1000) at 100 ml/100 L water Apply at flowering

**Read the label carefully before use. Always use the herbicide in accordance with the directions on the label.**

Note: 1. Thorough, even coverage of leaves and plantlets is necessary.



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# Queensland Government

## Wildlife Online Extract

Search Criteria: Species List for a Specified Point  
Species: All  
Type: All  
Status: All  
Records: All  
Date: Since 1980  
Latitude: -24.623725  
Longitude: 149.3557  
Distance: 10  
Email: [thomas.key@earthtrade.com.au](mailto:thomas.key@earthtrade.com.au)  
Date submitted: Monday 15 Dec 2014 11:31:02  
Date extracted: Monday 15 Dec 2014 11:40:26

The number of records retrieved = 88

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Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	birds	Acanthizidae	<i>Acanthiza nana</i>	yellow Thornbill		C		2
animals	birds	Accipitridae	<i>Haliastur sphenurus</i>	whistling kite		C		1
animals	birds	Anatidae	<i>Chenonetta jubata</i>	Australian wood duck		C		1
animals	birds	Anatidae	<i>Cygnus atratus</i>	black swan		C		1
animals	birds	Anatidae	<i>Anas superciliosa</i>	Pacific black duck		C		1
animals	birds	Anhingidae	<i>Anhinga novaehollandiae</i>	Australasian darter		C		1
animals	birds	Artamidae	<i>Cracticus tibicen</i>	Australian magpie		C		5
animals	birds	Artamidae	<i>Artamus personatus</i>	masked woodswallow		C		1
animals	birds	Artamidae	<i>Strepera graculina</i>	piebald currawong		C		1
animals	birds	Artamidae	<i>Cracticus torquatus</i>	grey butcherbird		C		1
animals	birds	Artamidae	<i>Cracticus nigrogularis</i>	piebald butcherbird		C		3
animals	birds	Cacatuidae	<i>Eolophus roseicapillus</i>	galah		C		1
animals	birds	Cacatuidae	<i>Nymphicus hollandicus</i>	cockatiel		C		3
animals	birds	Campephagidae	<i>Coracina papuensis</i>	white-bellied cuckoo-shrike		C		1
animals	birds	Climacteridae	<i>Climacteris picumnus</i>	brown tree creeper		C		2
animals	birds	Columbidae	<i>Ocyphaps lophotes</i>	crested pigeon		C		3
animals	birds	Columbidae	<i>Geopelia humeralis</i>	bar-shouldered dove		C		1
animals	birds	Columbidae	<i>Geopelia striata</i>	peaceful dove		C		2
animals	birds	Corvidae	<i>Corvus coronoides</i>	Australian raven		C		1
animals	birds	Corvidae	<i>Corvus sp.</i>					2
animals	birds	Corvidae	<i>Corvus orru</i>	Torresian crow		C		5
animals	birds	Estrildidae	<i>Taeniopygia bichenovii</i>	double-barred finch		C		2
animals	birds	Falconidae	<i>Falco cenchroides</i>	Nankeen kestrel		C		1
animals	birds	Falconidae	<i>Falco berigora</i>	brown falcon		C		1
animals	birds	Maluridae	<i>Malurus lamberti</i>	variegated fairy-wren		C		3
animals	birds	Maluridae	<i>Malurus cyaneus</i>	superb fairy-wren		C		4
animals	birds	Megaluridae	<i>Megalurus timoriensis</i>	tawny grassbird		C		1
animals	birds	Meliphagidae	<i>Lichmera indistincta</i>	brown honeyeater		C		2
animals	birds	Meliphagidae	<i>Plectorhyncha lanceolata</i>	striped honeyeater		C		3
animals	birds	Meliphagidae	<i>Melithreptus albogularis</i>	white-throated honeyeater		C		1
animals	birds	Meliphagidae	<i>Manorina melanocephala</i>	noisy miner		C		2
animals	birds	Meliphagidae	<i>Meliphaga lewinii</i>	Lewin's honeyeater		C		1
animals	birds	Meliphagidae	<i>Entomyzon cyanotis</i>	blue-faced honeyeater		C		1
animals	birds	Meliphagidae	<i>Gavicalis virescens</i>	singing honeyeater		C		1
animals	birds	Monarchidae	<i>Myiagra rubecula</i>	leaden flycatcher		C		1
animals	birds	Monarchidae	<i>Grallina cyanoleuca</i>	magpie-lark		C		4
animals	birds	Nectariniidae	<i>Dicaeum hirundinaceum</i>	mistletoebird		C		2
animals	birds	Pachycephalidae	<i>Pachycephala rufiventris</i>	rufous whistler		C		2
animals	birds	Pardalotidae	<i>Pardalotus striatus</i>	striated pardalote		C		1
animals	birds	Phalacrocoracidae	<i>Microcarbo melanoleucos</i>	little pied cormorant		C		1
animals	birds	Phasianidae	<i>Coturnix ypsilophora</i>	brown quail		C		1
animals	birds	Pomatostomidae	<i>Pomatostomus temporalis</i>	grey-crowned babbler		C		1
animals	birds	Psittacidae	<i>Trichoglossus haematodus moluccanus</i>	rainbow lorikeet		C		1
animals	birds	Ptilonorhynchidae	<i>Ptilonorhynchus maculatus</i>	spotted bowerbird		C		1
animals	birds	Rhipiduridae	<i>Rhipidura albiscapa</i>	grey fantail		C		2
animals	birds	Rhipiduridae	<i>Rhipidura leucophrys</i>	willie wagtail		C		4

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	birds	Threskiornithidae	<i>Platalea regia</i>	royal spoonbill		C		1
animals	birds	Threskiornithidae	<i>Platalea flavipes</i>	yellow-billed spoonbill		C		1
fungi	sac fungi	Parmeliaceae	<i>Parmotrema praesorediosum</i>			C		2/2
plants	higher dicots	Aizoaceae	<i>Tetragonia tetragonoides</i>	New Zealand spinach		C		1/1
plants	higher dicots	Amaranthaceae	<i>Alternanthera</i>			C		1/1
plants	higher dicots	Amaranthaceae	<i>Alternanthera denticulata</i>	lesser joyweed		C		1/1
plants	higher dicots	Apiaceae	<i>Centella asiatica</i>			C		1/1
plants	higher dicots	Asteraceae	<i>Centipeda minima subsp. minima</i>			C		2/2
plants	higher dicots	Asteraceae	<i>Parthenium hysterophorus</i>	parthenium weed	Y			1/1
plants	higher dicots	Asteraceae	<i>Gnaphalium polycaulon</i>		Y			1/1
plants	higher dicots	Asteraceae	<i>Xanthium occidentale</i>		Y			1/1
plants	higher dicots	Asteraceae	<i>Aster subulatus</i>	wild aster	Y			1/1
plants	higher dicots	Asteraceae	<i>Soliva anthemifolia</i>	dwarf jo jo weed	Y			1/1
plants	higher dicots	Boraginaceae	<i>Heliotropium indicum</i>		Y			1/1
plants	higher dicots	Brassicaceae	<i>Rorippa eustylis</i>			C		1/1
plants	higher dicots	Caesalpiniaceae	<i>Senna barclayana</i>			C		1/1
plants	higher dicots	Chenopodiaceae	<i>Einadia nutans subsp. linifolia</i>			C		1/1
plants	higher dicots	Chenopodiaceae	<i>Sclerolaena tetracluspis</i>	brigalow burr		C		1/1
plants	higher dicots	Chenopodiaceae	<i>Einadia polygonoides</i>	knotweed goosefoot		C		1/1
plants	higher dicots	Chenopodiaceae	<i>Atriplex semibaccata</i>	creeping saltbush		C		1/1
plants	higher dicots	Euphorbiaceae	<i>Euphorbia hyssopifolia</i>		Y			1/1
plants	higher dicots	Fabaceae	<i>Glycine tabacina</i>	glycine pea		C		1/1
plants	higher dicots	Fabaceae	<i>Desmodium varians</i>	slender tick trefoil		C		1/1
plants	higher dicots	Fabaceae	<i>Tephrosia leptoclada</i>			C		1/1
plants	higher dicots	Fabaceae	<i>Sesbania cannabina var. cannabina</i>			C		1/1
plants	higher dicots	Lamiaceae	<i>Basilicum polystachyon</i>			C		1/1
plants	higher dicots	Onagraceae	<i>Ludwigia peploides subsp. montevidensis</i>			C		1/1
plants	higher dicots	Solanaceae	<i>Solanum elaeagnifolium</i>			E		1/1
plants	higher dicots	Verbenaceae	<i>Glandularia aristigera</i>		Y			1/1
plants	higher dicots	Verbenaceae	<i>Stachytarpheta jamaicensis</i>	Jamaica snakeweed	Y			1/1
plants	lower dicots	Papaveraceae	<i>Argemone mexicana</i>	prickly poppy	Y			1/1
plants	monocots	Alismataceae	<i>Damasodium minus</i>	starfruit		C		1/1
plants	monocots	Alismataceae	<i>Caldesia oligococca</i>			C		1/1
plants	monocots	Cyperaceae	<i>Cyperus pygmaeus</i>	dwarf sedge		C		2/2
plants	monocots	Cyperaceae	<i>Fimbristylis aestivalis</i>			C		1/1
plants	monocots	Juncaginaceae	<i>Cycnogeton dubius</i>			C		1/1
plants	monocots	Najadaceae	<i>Najas tenuifolia</i>	water nymph		C		1/1
plants	monocots	Poaceae	<i>Chloris gayana</i>	rhodes grass	Y			1/1
plants	monocots	Poaceae	<i>Walwhalleya subxerophila</i>			C		1/1
plants	monocots	Poaceae	<i>Eragrostis trichophora</i>		Y			1/1
plants	monocots	Poaceae	<i>Sporobolus elongatus</i>			C		1/1
plants	monocots	Poaceae	<i>Astrebla squarrosa</i>	bull mitchell grass		C		1/1



**QES**

Y indicates that the taxon is introduced to Queensland and has naturalised.

Indicates the Queensland conservation status of each taxon under the *Nature Conservation Act 1992*. The codes are Extinct in the Wild (PE), Endangered (E), Vulnerable (V), Near Threatened (NT), Least Concern (C) or Not Protected ( ).

Indicates the Australian conservation status of each taxon under the *Environment Protection and Biodiversity Conservation Act 1999*. The values of EPBC are Conservation Dependent (CD), Critically Endangered (CE), Endangered (E), Extinct (EX), Extinct in the Wild (XW) and Vulnerable (V).

oids – The first number indicates the total number of records of the taxon for the record option selected (i.e. All, Confirmed or Specimens).

s number is output as 99999 if it equals or exceeds this value. The second number located after the / indicates the number of specimen records for the taxon. s number is output as 999 if it equals or exceeds this value.

# Appendix C: Land Manager's Monitoring Guide

Department of Environment  
and Resource Management

## Land Manager's Monitoring Guide Ground cover indicator

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Tomorrow's Queensland:  
strong, green, smart, healthy and fair



Prepared by:

Environment and Resource Sciences

Department of Environment and Resource Management

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August 2010

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## What is it?

Ground cover is provided by living or dead plants and any of their parts that fall to the surface of the ground.

Cover may also be provided by pebbles and rocks or a crust of cryptogamic materials (plant life without 'true' flowers and seeds, such as mosses, lichens and fungi). Groundcover may be considered as being anything below your eye level that intercepts a vertically falling raindrop.

In most landscapes under natural conditions, there is usually some form of cover on the soil surface. Exceptions include environments that are inhospitable to plant growth including degraded or eroded landscapes, some deserts, and salt pans. In forests, much of the ground cover is provided by fresh or slightly decomposed leaves, bark, fallen logs/limbs, twigs, flowers and fruits (collectively referred to as forest litter). In woodlands and grasslands most of the cover is provided by a variety of herbaceous plants and low growing shrubs. In arid and sub arid Australia, cryptogamic crusts can provide a significant amount of ground cover. These crusts are made up of various cyanobacteria, lichens, mosses and fungi.

Cover is also provided by crops and the stubble that remains after harvest. Weeds have few positive benefits, but the ability of many weed species to rapidly colonise an area can provide effective ground cover. In the urban environment, cover may be provided by landscaped surfaces, gardens and infrastructure such as concrete, bitumen and buildings; however such impermeable surfaces generate high rates of runoff which may lead to off-site erosion problems.

Tree canopies usually provide minimal protection against raindrop impact and tree trunks have no effect on impeding surface flows. For control of erosion, surface cover is essential and bare areas beneath trees are vulnerable.

The amount of ground cover is constantly varying and is dependent on a range of factors including:

- **plant type**—Plants have different growing habits (spreading or erect), life spans (annual or perennial), and decomposition rates. (The stubble of cereal crops can provide protection for up to 12 months while the leaves of some crops such as sunflower, legumes and cotton rapidly break down.)
- **growth rates**—Plant growth is affected by many factors including soil moisture, fertility levels and seasonal conditions.
- **land management**—Grazing, crop and fire management practices have a major impact on ground cover levels.

Ground cover has a number of important functions relating to productivity and environmental health:

- It prevents water erosion by absorbing the impact of falling raindrops that may otherwise cause the soil surface to seal and contribute to excessive runoff.
- It reduces the velocity of runoff and encourages it to spread out rather than to concentrate and develop into an erosive force. Organic matter (including animal dung) and soil can be deposited when overland flow is obstructed by surface cover. Such accumulations are referred to as 'sinks' or 'fertile patches' (Tongway 1994) where the additional water and nutrients provide an improved environment for plants to germinate and grow.
- It prevents erosion from wind by reducing the wind velocity adjacent to the soil surface and provides an effective barrier between the soil and the air above it.
- It moderates the temperature on the soil surface and helps to reduce evaporation rates from the soil surface.
- It is a natural habitat and food source for a wide variety of living organisms and is used to assess and monitor the health of native vegetation.
- It allows for the recycling of nutrients as plant products are allowed to decompose and nutrients are returned to the soil.

## Other factors and related indicators

Consideration could be given towards monitoring the following indicators that have an association with ground cover:

- Hillslope erosion
- Gully erosion
- Wind erosion
- Water infiltration
- Pasture composition
- Native species richness

- Soil condition
- Saline land
- Impact of fire
- A range of indicators relating to water quality.

### Why monitor this indicator?

The section 'What is it?' indicates the essential role that ground cover plays in ensuring the healthy functioning of a landscape. Land management practices that contribute to low levels of ground cover leave the land vulnerable to land degradation. Monitoring ground cover can:

- help you assess the degree of risk of land degradation occurring
- determine landscapes that are already in a degraded condition.

Graziers make a mental note of the condition of their pastures during their day-to-day activities on the property. However, it becomes difficult to recall how the pastures may have looked in previous seasons unless some observations have been recorded. Our memories can be short, confused or biased; a documented record allows comparison with previous seasons and allows the data to be shared. Grazing lands that have a consistently low level of cover provide a strong indication of excessive stocking rates and degraded land. Figure 1 shows how photographs have been used to compare pasture condition at the same point over a span of three years.



Figure 1: Photographs comparing ground cover at the same point over a three year span

Cover levels in cropping lands may vary dramatically depending on land management practices, the stage of growth of the crop and the crop type. An alternative to regularly monitoring ground cover in paddocks used for cropping is to monitor the adoption of land management practices that affect cover levels, for example, fallow management techniques such as zero tillage and green cane trash blanketing may provide 100% cover throughout the year.

At the catchment scale, an overall indication of ground cover can be used as an assessment of catchment health and the vulnerability of the land to soil erosion and its associated impact on water quality. Techniques such as cross-landscape transects and assessment of satellite imagery can be used. By monitoring on a regular basis, relevant stakeholders can assess change in ground cover levels and associated land management practices over time.

Ground cover measurement is an important component of assessing the health of a landscape from a biodiversity viewpoint. When making observations for biodiversity purposes, we are interested in the different components that make up ground cover, rather than the total amount of cover.

## Planning to monitor this indicator

### What are your monitoring objectives?

Consider what you are trying to achieve by monitoring ground cover. You may just be interested in the total amount of ground cover, or for an assessment of biodiversity you will need to assess the amount of cover provided by different components such as native plants, weeds, litter and rocks.

If you are confident that your land management practices are consistently providing adequate levels of ground cover, then there may be little point in measuring it. Land managers should be aware of ground cover levels under different land use and management practices because it affects the susceptibility of their property to land degradation. Of special interest is any land with cover levels of less than 40%.

As ground cover may be subject to considerable variation from month to month, there is generally not a great need to monitor it with a high level of precision. A visual assessment of ground cover, as provided in Level 1 of 'How do you measure it?' will provide you with a method of making a rapid assessment of ground cover. Measurements at established sites can be taken to provide a higher level of accuracy, as described in Levels 2a (for overall ground cover) and 2b (for biodiversity assessment) of 'How do you measure it?'.

You also need to consider other indicators that you may wish to measure, for example, if you wanted to monitor plant species as well as cover, you would need to take more measurements if you had an interest in finding rare plants.

### How will your data be used?

Primarily your data will be for your own use. However other land managers, catchment groups or your regional body may be interested in your ground cover monitoring. Some regional bodies have set targets of ground cover that they hope land managers in their region will be able to achieve. If you intend to share your data with others, you should check to see if your proposed data collection procedures will be compatible with theirs.

### What will you monitor?

#### Existing standards

Some Queensland Government programs, including the Reef Protection Package and Delbessie Agreement (for renewal of rural land leases) have monitoring requirements tailored for each program, but based on existing monitoring methods. These requirements may be fulfilled in part by the methods in this and other indicator guides, however if your property occurs in selected reef catchments or includes leased land you should refer to the specific guides provided for these individual programs. These include guides for producers that are preparing Environmental Risk Management Plans (ERMPs) under the Reef Protection Package <<http://www.reefwisefarming.qld.gov.au/>> and for land condition assessment under Delbessie land management agreements <[http://www.derm.qld.gov.au/land/state/rural\\_leasehold/land\\_cond\\_assessments.html](http://www.derm.qld.gov.au/land/state/rural_leasehold/land_cond_assessments.html)>.

There are no formal standards for monitoring ground cover in Queensland. The use of a quadrat (described in Levels 2a and 2b of 'How do you measure it?') is recommended in order to estimate percentage ground cover. Comparisons can be made with graphical presentations (Figure 2) or photos of a range of different cover levels (Figure 3).

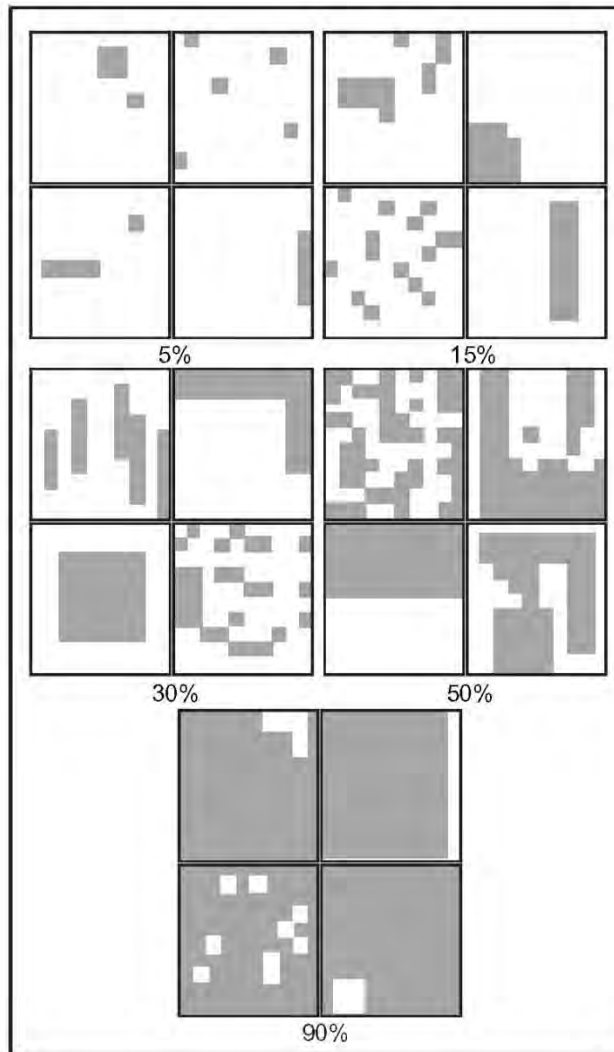
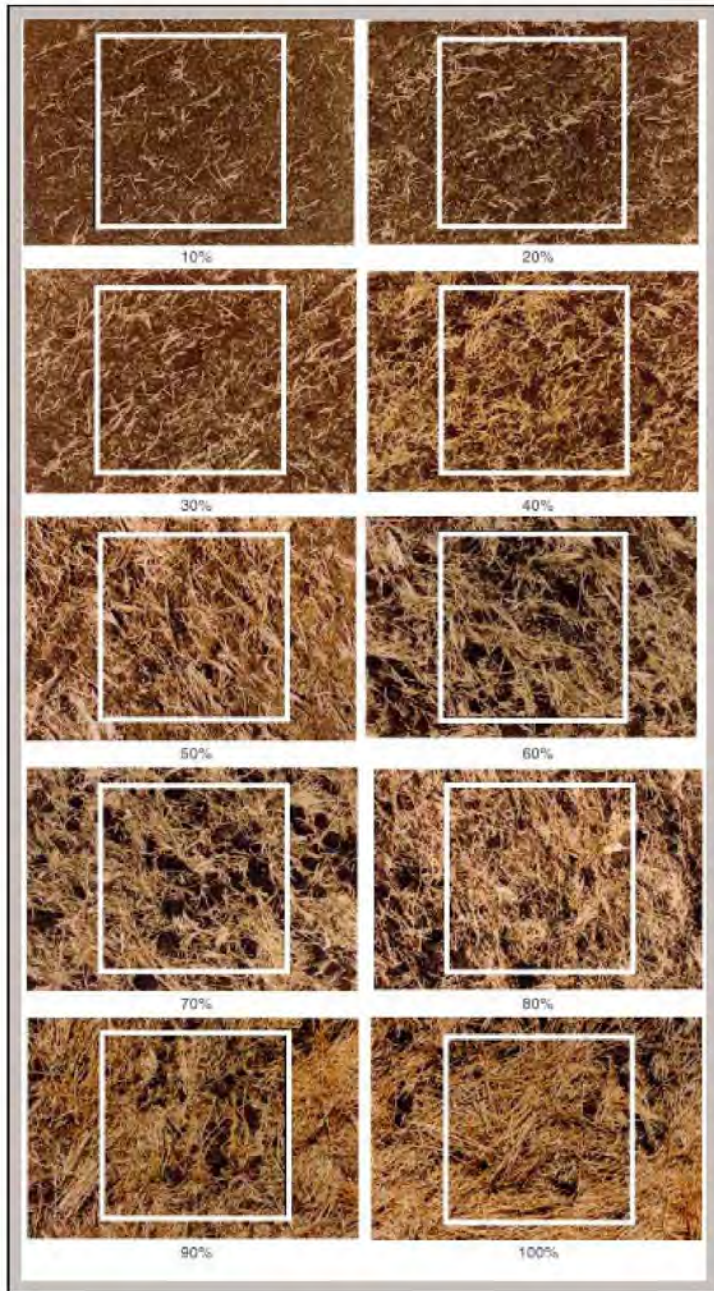


Figure 2: Examples of ground cover patterns as they appear in a quadrat for 5%, 15%, 30%, 50% and 90% cover (Department of Natural Resources 1997)





**Figure 3: Photographs of wheat stubble cover levels in 10% increments (Molloy 1988)**

The spreadsheets provided for Level 2a and 2b allow you to add quadrat measurements in increments of 10%. The spreadsheet will then calculate an average cover level for the site.

An alternative way of grouping cover levels into categories is provided in Grass Check (Department of Natural Resources 1997). These categories are less than 5%, 5–15%, 15–30%, 30–50%, 50–90% and >90%. This categorisation places emphasis on the measurements at the lower end of the scale because surface cover levels are considered to become critical once they drop below 30%.

When monitoring for biodiversity assessment, your data can be compared with benchmark data prepared for the vegetation

zone or regional ecosystem you are monitoring. It is intended that this information will become available on the Queensland Department of Environment and Resource management website.

The CD, 'Pasture photo standards' (Department of Primary Industries 2003) provides colour photos of oblique views of different pasture types (Brigalow belt, Channel country, Central Queensland coast, Cape York Peninsula, Desert uplands, Einasleigh uplands and Wet Tropics, Gulf Plains, Mitchell Grass Downs, Mulga Lands, North West Highlands, Wide Bay and Southeast Queensland, and Southern Brigalow and New England Tablelands). For each pasture type there are photos of six pasture yields from very low to very high. The photos can be used for estimating the amount of fodder available (in kg/ha) to assist in determining future grazing strategies. Because they are oblique views, they are not suitable for directly estimating ground cover as they can tend to result in overestimating the real value. The CD is available from the Queensland Government Bookshop <<https://www.bookshop.qld.gov.au/>> - Search for 'Pasture photo standards'.

### Existing monitoring in your area

Before you start monitoring any indicator, it is recommended that you explore who else is monitoring in your area, what they are monitoring and how they are monitoring it. Doing this will not only make sharing your data easier if you choose to do so but will also help you become more familiar with:

- Any area-specific issues that may influence your monitoring
- What strategies and/or methods have proven successful within your area.

### Where will you monitor?

You need to determine whether you will monitor ground cover levels on the whole of your property or selected areas that may be of concern, for example, areas that may have cover levels that are less than the critical value of 30–40% (either permanently or occasionally).

If you decide to establish monitoring sites, a decision is needed on whether it is better to take many cover measurements at one site in a paddock or to make a similar number of measurements spread over a number of sites. There are no hard and fast rules as to how many sites you should monitor in a paddock and how many observations you should make. The sites should be accessible and away from fences, tracks, waterways and watering points to ensure that they are representative of a large area of your paddock. Aerial photos or satellite images may be useful in assisting with site selection.

Where different land types occur in the one paddock or where there are areas of special interest (e.g. an area being rehabilitated), it is preferable to have at least one site in each system or zone. The records for each system should be kept separately, since averaging them may lead to a misleading result. For example, if one half of a paddock has 20% cover and the other half 80% cover, the average cover is 50%. This approach does not convey the message that half of this paddock is at high risk from land degradation and may indicate a case for creating an additional paddock so that appropriate management practices can be applied.

To monitor for BioCondition Assessment <<http://www.derm.qld.gov.au/wildlife-ecosystems/biodiversity/biocondition.html>>, ideally all vegetation types and all areas subject to different levels of management on the property should be monitored for ground cover. The combination of a particular vegetation type and management action is called a zone. Considerable thought needs to go into the placement of your monitoring areas within these zones to minimise the number of sites but to still ensure you represent the range of vegetation and management actions on the property.

### When and how often will you monitor?

While adequate cover levels are desirable throughout the year, the summer months represent the period of highest erosion risk in Queensland. Figure 4 shows the average monthly erosivity value of the rainfall for Emerald and Pittsworth. Erosivity combines the amount and intensity of rainfall and is highly related to erosion potential.

This period of high erosion risk is a desirable time in which to monitor ground cover. However, in grazing lands there are advantages in monitoring pastures at the end of the growing season, around April. This allows graziers to make decisions on future stocking rates. An added bonus is that temperatures at this time of the year are more comfortable for field monitoring!

Additional monitoring can be undertaken at strategic times such as during a drought, at the end of the dry season or a month after major rainfall.

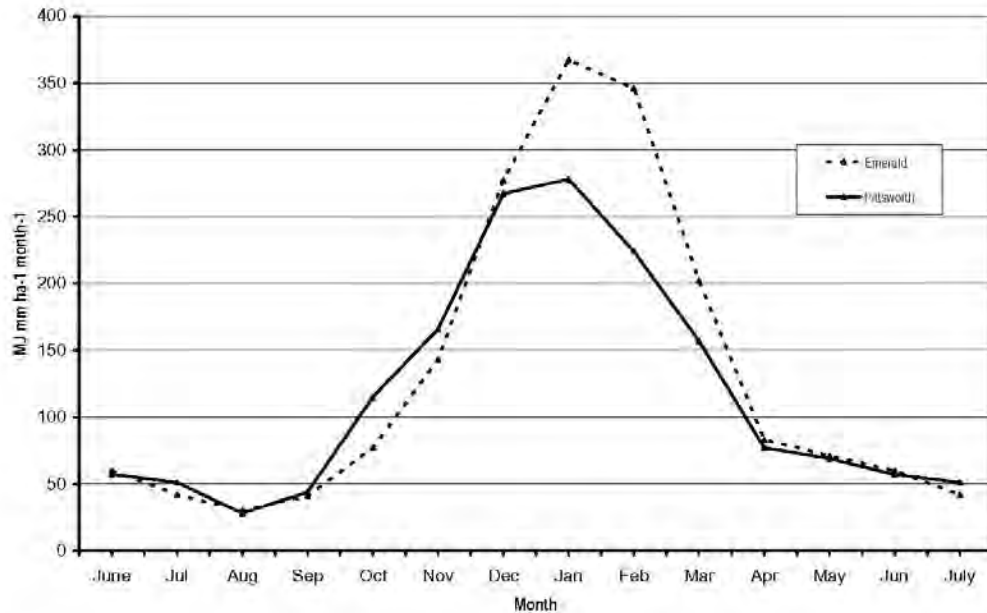


Figure 4: Average monthly rainfall erosivity values for Emerald and Pittsworth

### How do you measure it?

For this indicator, two levels for estimating ground cover are described:

- Level 1 involves an overall visual assessment while driving or walking around a paddock. It is appropriate for all forms of land use.
- Level 2 provides a more accurate assessment by estimating ground cover levels using quadrat readings at established monitoring sites:
  - Level 2a describes a system that is most appropriate for grazing lands although it could be used in a cropping situation
  - Level 2b is recommended when monitoring for biodiversity assessment.

A number of methods of measuring ground cover have been published and there are no set rules as to which is the best method to use. However, some Queensland Government programs including the Reef Protection Package and Delbessie Agreement (for renewal of rural land leases) have monitoring requirements which may be fulfilled in part by the methods in this and other indicator guides. If your property occurs in selected reef catchments or includes leased land you should refer to the specific guides provided for these individual programs including those for Environmental Risk Management Plans (ERMPs) <<http://www.reefwisefarming.qld.gov.au/>> and for land condition assessment under Delbessie land management agreements <[http://www.derm.qld.gov.au/land/state/rural\\_leasehold/land\\_cond\\_assessments.html](http://www.derm.qld.gov.au/land/state/rural_leasehold/land_cond_assessments.html)>.

Since ground cover levels are constantly changing, there may not be a need for you to measure with a high level of precision and the visual assessment described for Level 1 may suffice for most situations. In Levels 2a and 2b, the use of quadrats is described for estimating cover levels where a higher level of precision is required.

Besides using quadrats, it is also possible to measure ground cover using a point observation method rather than a quadrat. In this case, a straight piece of wire or a point on the toe of your boot can be used to record the presence or absence of cover. To avoid confusion, this method has not been described in this indicator. A description of such a method can be found in Francis and Payne (2003).

A Queensland Department of Environment and Resource Management state wide ground cover monitoring program reports annually on percentage of ground cover in Queensland based on Landsat imagery starting in 1988. This low cost imagery enables a more dynamic monitoring of ground cover by remote sensing and opens up new opportunities for monitoring and time series analysis of up to 20 images per year. Recent research by the Queensland Department of Environment and Resource Management (as at 2010) indicates that ground cover may soon be able to be monitored remotely and at low cost with the ability to distinguish between bare ground, green vegetation and dry (or non-green) vegetation cover.

The use of photopoints is recommended to support any system of assessing ground cover.

### Use of photopoints – photographic records

It is preferable that a photographic record is kept for all ground cover monitoring sites. A sequence of photos taken annually from exactly the same location in a paddock can record changes in ground cover, woody plant populations and feed availability (Figure 1). They show the long-term effects of management as well as short-term changes caused by seasonal conditions and the effects of grazing management.

Photos should be taken on a clear day between 9 am and 3 pm. You will always get a better photo by having the sun behind your back. To do this you need to be facing south (in the Southern Hemisphere!). Photos can be taken from two angles: the 'trayback' and the 'landscape'.

#### The 'trayback' photo

This photo angle will best illustrate ground condition and the amount of feed available in a pasture. A step ladder could be used as an alternative to a vehicle. The vehicle trayback is set up at the post from which the photo is being taken (Figure 5). Facing south, focus the middle of the viewfinder on the base of the sighter post.

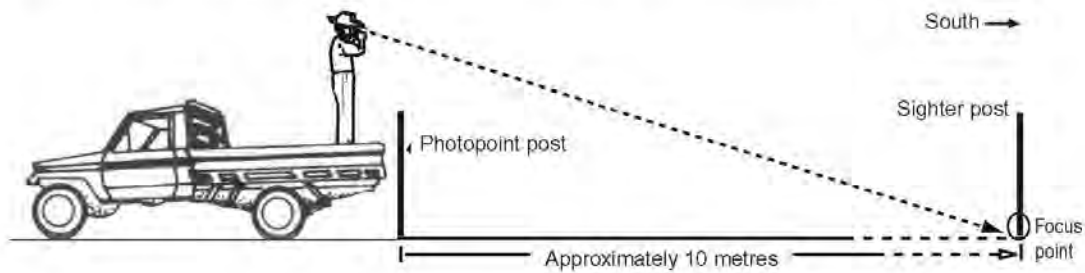


Figure 5: Taking the 'trayback' photo (Department of Natural Resources 1997)

#### The landscape photo

This photo angle will best illustrate the general condition of the site showing major changes in shrub and tree populations. Stand next to the photopoint post as in Figure 6. Position the top of the sighter post in the middle of the viewfinder and focus on infinity.

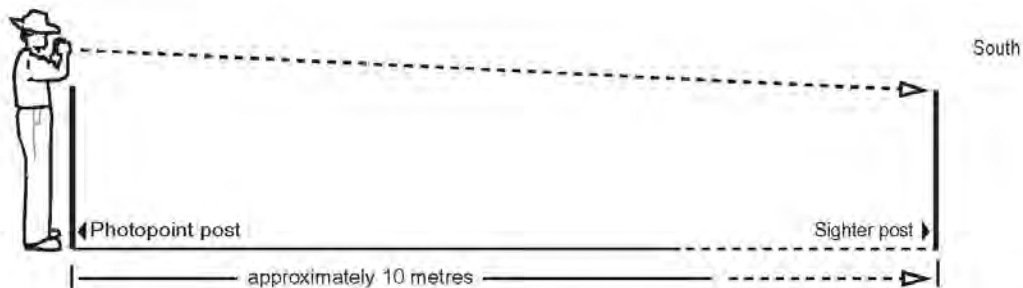


Figure 6: Taking the landscape photo (Department of Natural Resources 1997)

It is a good idea to have a sign on the post in the photograph to indicate the site details. The date should be noted (cameras often have the facility to do this automatically) as well as the time, photo number and site number. If the photos are printed, appropriate details should be written on the back and they should be filed appropriately. If you are using a digital camera, most suppliers provide software for storing and showing a collection of photographs and adding notes for each picture. As with all computer records, you should make regular backups of your electronic records, such as by burning a CD.

## How do you measure it? – Level 1 monitoring

### Key aspects of level 1 monitoring

Level 1 monitoring involves a visual assessment of percentage ground cover by making a number of observations as you drive or walk around a paddock. The method does not require the use of quadrats although they could be used initially to assist the observer in gaining skills in estimating cover by making comparisons with the diagrams in Figures 2 and 3.

It is recommended that photographs be taken to provide a permanent record as described in 'Use of photopoints – photographic records'.

In grazing lands, you need to decide if you are going to establish some permanent monitoring sites within each paddock or whether you are going to make an estimate by just walking or driving around the paddock. Permanent monitoring sites are useful when taking photographs so that you can compare identical locations over a period of years.

Paddocks used for cropping will generally have much more uniform ground cover levels than grazing paddocks. It is generally not practical to establish permanent monitoring sites in cropping areas because of their interference with tillage, spraying and harvesting activities. It is usually sufficient to make observations of ground cover in cultivated paddocks by making an overall observation. There is little point in going to a lot of effort to establish a precise level of ground cover for a cultivated paddock since the cover levels can change rapidly as a crop develops.

### Skills needed

- Knowledge of the paddock or resource area to allow you to determine suitable monitoring sites
- Ability to estimate ground cover. You can 'calibrate' your eye by using some quadrats and making comparisons with the cover levels provided in Figures 2 and 3

### Equipment

- A camera
- If monitoring sites are to be established, two steel pegs are required for each site.

### Time taken

- 15 minutes to establish each monitoring site (if required)
- 5 minutes per site, plus travel time in moving from site to site

### Setting up

If setting up permanent monitoring sites, consideration needs to be given to the information provided in the selection of monitoring sites in 'Developing your monitoring plan'. It may be appropriate to divide a paddock into two or more zones, keeping separate records for each zone. This would be advisable where there were contrasting cover levels in a paddock resulting from different land types or different grazing pressure associated with the location of a watering point.

Install two steel pegs at the selected sites. The posts should be in a north-south direction at a distance of around 10 metres apart and provided with an identification number. For more information see 'Use of photopoints – photographic records'.

### Monitoring procedure

1. Make a visual assessment of the cover at the site. Record the percentage cover using 'Recording sheet' (refer also to 'How to record your results').

2. Where monitoring sites are being used, take a photograph from the photopoint post.

### Data quality considerations

As this method is only a visual assessment it is somewhat subjective and there is likely to be some variation in the assessments made by different people. As ground cover levels are constantly changing depending on seasonal conditions and land management practices, a high level of precision is generally not required and this method of assessment should suffice for many situations.

## How do you measure it? – Level 2a monitoring

### Key aspects of level 2a monitoring

Level 2a monitoring involves setting up a 'monitoring triangle' (see 'Setting up', Figure 8) and taking measurements using a quadrat as you walk around each side of the triangle. It is primarily intended for use in monitoring ground cover in grazing lands.

An advantage of using a monitoring triangle compared to a straight line transect is that you end up at your starting point, rather than having to 'backtrack' to the starting point. A triangle may also provide a better sample of the landscape because of the three different directions of travel.

### Skills needed

- Knowledge of the paddock or resource area to allow you to determine suitable monitoring sites
- Ability to estimate ground cover percentage within a quadrat
- Basic maths and ability to use a computer spreadsheet for calculating average percentage cover at a site

### Equipment

- Four steel posts for each site. Three are required for the monitoring triangle and another for the photopoint post
- A quadrat for measuring cover (can be made for minimal cost in the property workshop)
- A camera
- GPS unit (optional)

Figure 7 shows two different types of quadrats. Grass Check (Department of Natural Resources 1997) makes the following recommendations for their use:

- 50 cm by 50 cm quadrat for areas with more than 500 mm rainfall, or areas with good Mitchell or buffel grass cover
- 100 cm by 50 cm quadrat for other pasture areas.

To facilitate the estimation of percentage cover, the sides of the quadrat can be painted in alternate colours to divide it into 10 cm lengths. An open end allows the quadrat to be used where there are obstructions such as trees or shrubs.

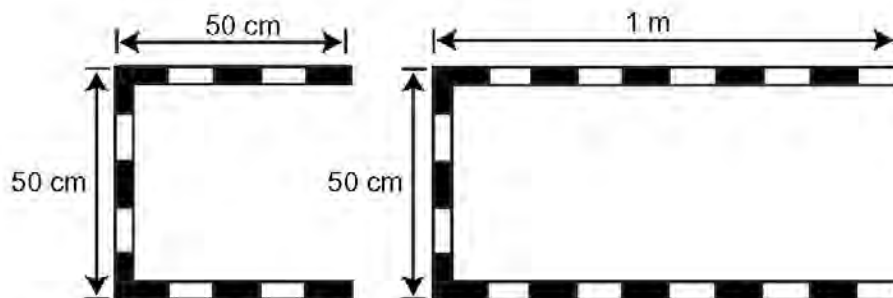


Figure 7: Two types of quadrats used for measuring ground cover

**Time taken**

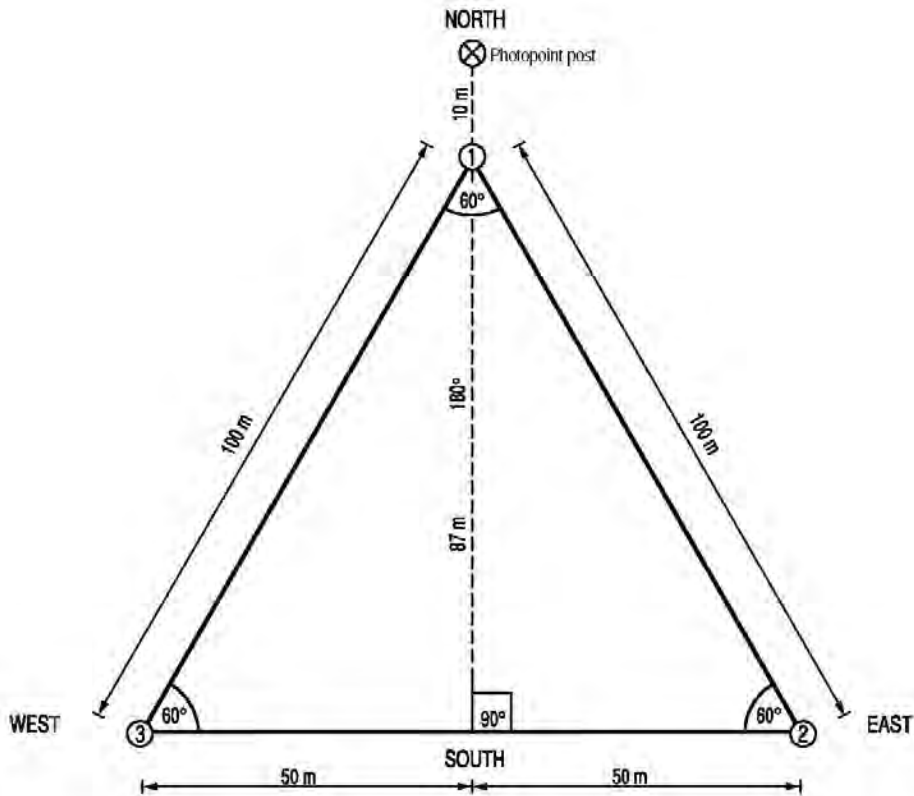
- 45 minutes to locate and establish a monitoring site
- 30 minutes to take the recordings and the photograph per site

**Setting up**

You need to decide how many monitoring sites you will establish in a paddock and where you will locate them. The section 'Where will you monitor?' has advice on selecting suitable monitoring sites.

The monitoring triangle as indicated in Figure 8 is marked out as follows:

1. At the northern end of the triangle, drive in two posts or place markers, 10 m apart in a north-south direction. The northernmost marker is the photopoint point and the other is referred to as point 1.
2. From point 1, measure or step out a triangle with each side 100 m long and place markers for points 2 and 3. The easiest way to do this is to go south 87 m, then 50 m left and right from that point.
3. If the site is covered with trees and shrubs, mark the sides of the triangle with a marker every 50 m or put coloured markers on some trees.
4. The location of each site should be numbered and marked on a property plan. GPS recordings may also be taken.



**Figure 8: Approximate dimensions for a monitoring triangle**

Note that a high level of precision is not required when marking out the triangle. It would be acceptable to use 100 paces instead of 100 metres. It would also be appropriate to reduce or enlarge the size of the triangle (e.g. a triangle with 50 metre sides would be acceptable in small paddocks).

If using steel posts they should be made safe and visible to motor bike and horse riders; for example, attach a piece of PVC pipe over the top or paint the posts white and place a protective cap over them. On open areas such as Mitchell

grass downs, it may be necessary to place some old tyres around the posts to alleviate the effects of stock gathering to rub on the posts and increasing stock pressure in the area.

### Monitoring procedure

1. In order to take 50 recordings around the triangle, you would need to make 17 observations on two sides and 16 on the third side. This would mean taking observations at regular spacings of every 6 or 7 paces depending on your length of stride.
2. At each observation point, place the quadrat in front of the leading foot and estimate the ground cover percentage by comparing with Figure 2 or Figure 3. The measurement includes cover occupied by grass, herbage, leaves, litter and manure. Cover provided by low shrubs of less than 1 metre is included but not higher shrub or tree canopy. Tip: Consider cover as being anything below your eye level that intercepts a raindrop that is falling vertically, or mentally 'move' all of the cover to one corner of the quadrat and estimate the cover that way.
3. Record your estimated percentage using the 'Level 2a Recording sheet' (refer also to 'How to record your results').
4. Continue walking around the transect until you have a total of 50 estimates.
5. Take your landscape and trayback photographs at the photosite point. Record any relevant notes that relate to the photo.

### Data quality considerations

This technique is based on the method described in Grass Check (Department of Natural Resources 1997). However, the recommended number of observations along the three sides of the triangle has been reduced from 100 to 50. There is a trade-off between the number of observations you make at a single monitoring site and the number of sites you have in a paddock. There is little point in making a large number of observations at one site if that site is not representative of the whole paddock.

## How do you measure it? – Level 2b monitoring

### Key aspects of level 2b monitoring

Level 2B monitoring is consistent with the BioCondition Assessment Framework developed by the Queensland Department of Environment and Resource Management <<http://www.derm.qld.gov.au/wildlife-ecosystems/biodiversity/biocondition.html>>. The framework provides a means of assessing biodiversity at a patch, property or paddock scale that is compared to benchmarks for a particular vegetation type. A total of ten site-based attributes and three landscape-based attributes are assessed. For BioCondition Assessment, the following components of ground cover are measured: organic litter, native perennial and annual grasses, native non-grasses (herbs, forbs and others), introduced plants (weeds), rock cover, fallen logs and bare ground.

### Skills needed

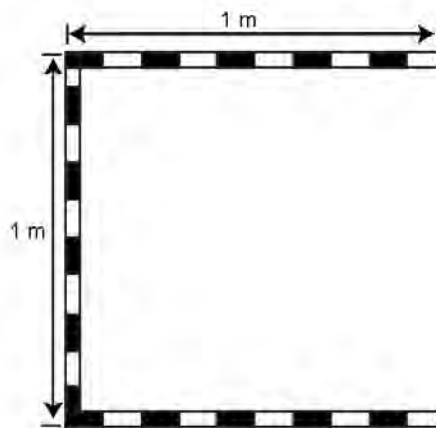
- Knowledge of local vegetation types and associated land management practices to allow you to determine suitable monitoring sites
- Ability to estimate ground cover percentage within a quadrat
- Basic maths and ability to use a computer spreadsheet for calculating average percentage cover at a site

### Equipment

- Two steel posts for permanently marking the transect
- A 1 m by 1 m quadrat (can be made for minimal cost in the property workshop). To facilitate the estimation of percentage cover, the sides of the quadrat can be painted in alternate colours to divide it into 10 cm lengths. An open end allows the quadrat to be used where there are obstructions such as trees or shrubs.
- A camera
- GPS unit (optional)

Figure 9 shows an example of a quadrat recommended for use in monitoring for biodiversity.





**Figure 9: Quadrat recommended for use in measuring ground cover for BioCondition assessment**

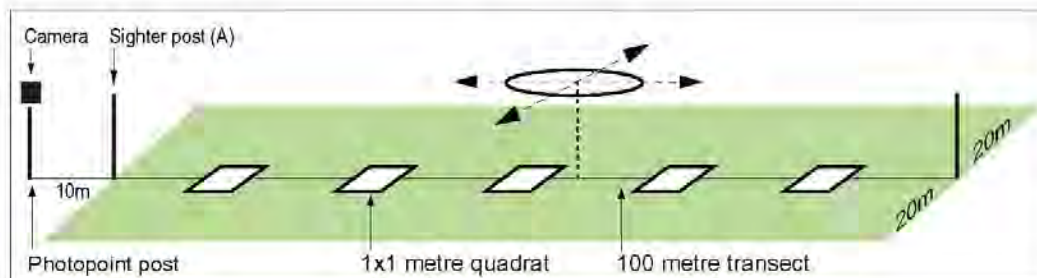
### Time taken

- 30 minutes to locate and establish a monitoring site as illustrated in Figure 10.
- 15 minutes to take and record the ground cover observations and to take a photograph at each site

### Setting up

To monitor for BioCondition Assessment, ideally all vegetation types and all areas subject to different levels of management on the property should be monitored for ground cover. The combination of a particular vegetation type and management action is called a zone. Some thought needs to go into the placement of your monitoring areas within these zones to minimise the number of sites but still ensure you represent the range of vegetation and management actions on the property.

Figure 10 shows the layout for a monitoring site used to assess the ground cover component for BioCondition Assessment. Ideally the transect should be across the slope and the photopoint should be the most northerly post.



**Figure 10: Standard monitoring site for BioCondition Assessment**

The two end points of the transect should be permanently marked with, for example, steel posts. If using posts they should be made safe and visible to motor bike and horse riders (e.g. by attaching a piece of PVC pipe over the top or painting the posts white and placing a protective cap over them). On open areas such as Mitchell grass downs, it may be necessary to place some old tyres around the posts to alleviate the effects of stock gathering to rub on the posts and increasing stock pressure in the area. The location of each site should be numbered and marked on a property plan and/or GPS recordings should also be taken and entered into your GIS.

### Monitoring procedure

1. Commencing at one end of the 100 m transect, walk a distance of 10 metres and place the quadrat in front of your leading foot and estimate the ground cover within the quadrat. You need to make separate ground cover assessments

for the following components:

- native perennial grasses
- native annual grasses
- native herbs and forbs (non-grass)
- native shrubs (less than 1 metre height)
- weeds
- litter
- rock
- bare
- fallen logs
- cryptograms.

Tip: Consider cover as being anything below your eye level that intercepts a raindrop that is falling vertically or mentally 'move' all of the cover to one corner of the quadrat and estimate the cover that way. Cover provided by low shrubs of less than 1 metre is included but not higher shrubs or tree canopies.

2. Record your estimated percentage cover within the quadrat on the relevant level 2b recording sheet. (refer also to 'How to record your results').
3. Continue walking along the transect making estimates with the quadrat every 20 metres until you have a total of five estimates
4. Take your landscape and trayback photographs at the photopoint. For biodiversity monitoring, you should also take four additional landscape photographs from the centre point of the transect, one each facing the four points of the compass (north, south, east and west). Make any relevant notes against your photographs.

## How to record your results

The information you collect while monitoring is referred to as data. Data is distinct pieces of information (e.g. numbers, text or images) that can be stored electronically, on paper or as samples. An organised collection of data with a common theme is called a dataset. For example, a collection of data about a particular geographic area for a particular time period would form a dataset.

When you are working in the field, the simplest way to record your data is to have a field recording sheet with you. A field recording sheet will help ensure that your data is recorded in a way that is easy to enter into a spreadsheet and also acts as a checklist to ensure that you don't miss recording any important information.

'Recording sheets' for each of the different methods of measuring cover (Levels 1, 2a and 2b) are provided with this indicator material. Examples of completed recording sheets are also provided. Blank data sheets can be printed off for use in the field. Your data can be entered into the electronic version of the field recording sheet if you want to use the automatic totalling and averaging functions. You can also enter the summary data on to the data recording sheet for the long-term collation of your data and creation of charts.

## Metadata

There are two aspects to recording information: the information (data) you collect each time you monitor and the metadata associated with your monitoring data. Metadata is pieces of information that describe data or is 'data about data'. It describes the 'who, what, when, where, why and how' about a data set. Metadata is critical to preserving the usefulness of data over time.

It is important to record the information shown in Table 1 below. This table is available in the spreadsheets that can be downloaded for each of the indicator levels in 'How do you measure it?'

**Table 1: Typical data sheet for recording metadata that describes the dataset**

Key element	Metadata
Short description of the contents of the dataset	
Name of the land manager or business responsible for the dataset	
Brief assessment of reliability of the information in the dataset	
Brief history of the source and processing steps used to produce the dataset	
Maintenance and update frequency of the dataset	
Location or area the data relates to	

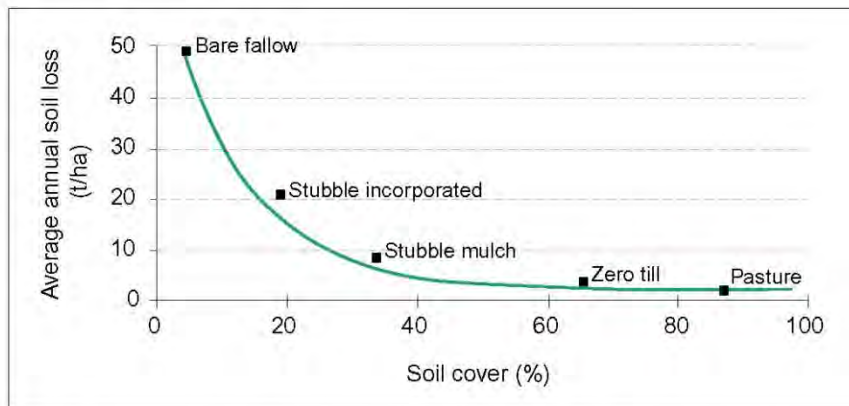
### What does your data mean?

Percentage ground cover can be highly variable and strongly influenced by the weather, seasonal growth patterns, land type and land use and management practices. Figure 11 provides an example of how the average cover levels may vary in a paddock (similar graphs can be produced from the spreadsheets provided in 'How to record your results' of this indicator. The annual rainfall has been added to the graph. Keep in mind that rainfall occurs sporadically and it is quite possible that a high proportion of the rainfall may have occurred in one or two months at the beginning, middle or end of the recording period.

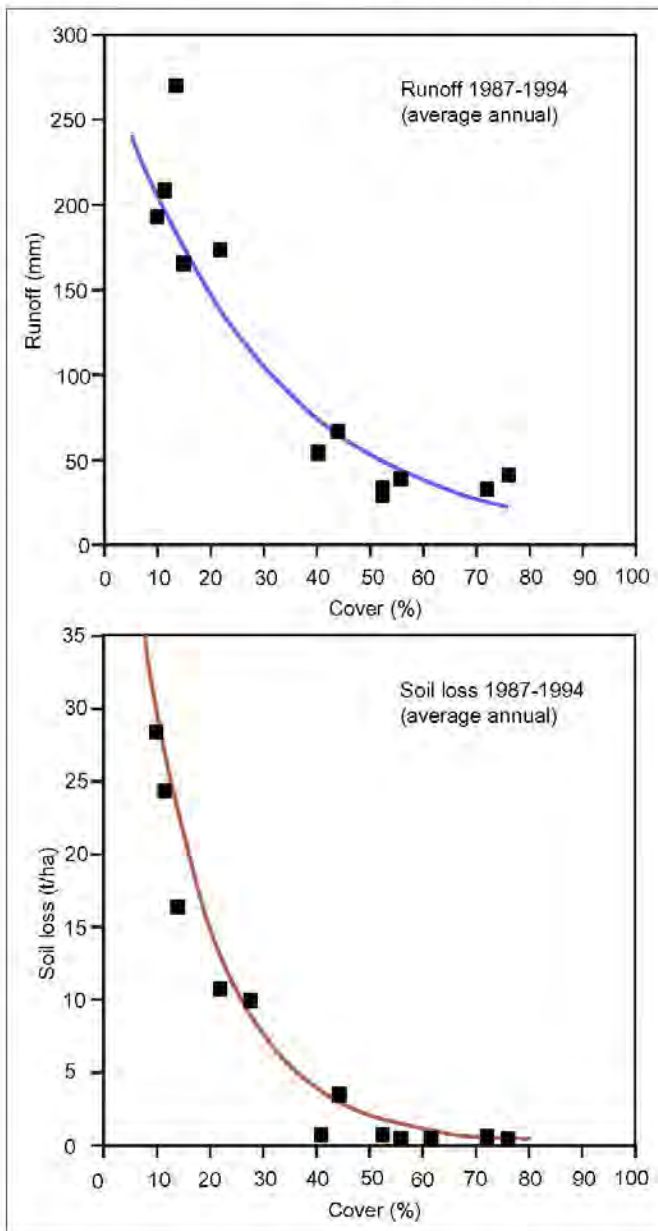
A minimum level of 30–40% cover is required in order to ensure a reasonable level of protection from erosion and to perform the other ecological functions of ground cover as described in 'What is it?'. Higher levels of cover will increase the benefits that cover provides. In grazing lands the 30% to 40% cover level should exist at the beginning of the summer storm season. To achieve this, a surface cover level of around 70% is desirable at the end of the summer growing season.

Figure 11 shows the relationship between annual soil erosion and ground cover over 14 years at Greenmount on the Darling Downs. Figure 12 shows the relationship between ground cover and runoff as well as soil loss derived from 7 years of measurements on pasture land in Central Queensland.

Minimising soil erosion and runoff has important implications for water quality since runoff will usually contain sediment, nutrients and any agricultural chemicals that may have been applied to the soil (Finlayson and Silburn 1996).



**Figure 11: Annual average soil loss (1978–92) vs. cover for contour bay catchments on the eastern Darling Downs (Freebairn 2004)**



**Figure 12: Average annual runoff and soil loss (1987–94) vs. ground cover for native pasture in Central Queensland (Mark Silburn, Queensland Department of Natural Resources and Water, pers. comm. 2005)**

When monitoring for biodiversity values in the ground cover, your data would need to be compared with benchmark data prepared for the vegetation zone or regional ecosystem type you are monitoring. It is intended that this information will become available soon on the Queensland Department of Environment and Resource Management website. However, in general, to maintain ecological processes important for biodiversity, good ground cover (>50%) comprising litter, fallen logs and native plant species is the key. Litter and fallen logs provide habitat for ground-dwelling vertebrate and invertebrate fauna, as well as influencing soil microclimate, structure and composition.

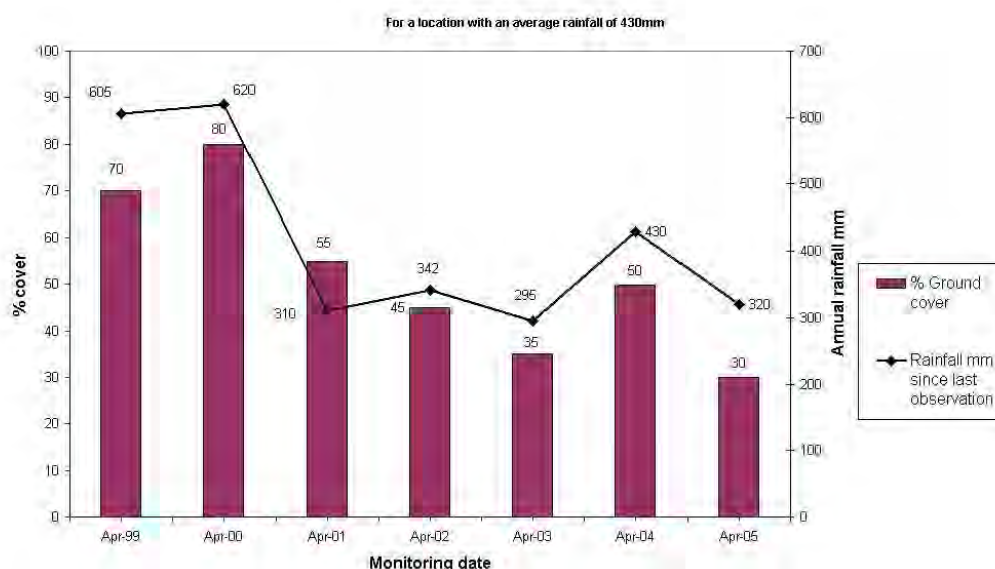


Figure 13: Rainfall and changes in pasture ground cover from 1999 to 2005

## What are some management options?

These management options are only generalisations and should be interpreted with caution. It is important to remember that each situation is unique and so the most appropriate management option will also vary.

### Grazing lands

Pastures need to be managed so that adequate levels of cover are maintained on the soil surface. Excessive grazing pressure, especially during periods of drought, leads to bare, vulnerable soil surfaces. The period of greatest risk is in late spring and early summer when cover levels are often low and rainfall intensities can be high. High grazing pressure also has an impact on both biodiversity and productivity because it can lead to pressure on the most palatable species, remove litter and lead to the introduction of weeds.

The data you collect and the charts you prepare, combined with your production records, can help you identify which paddocks or parts of a paddock are most productive and the conditions under which they maintain good cover. Your monitoring will also highlight the areas that lose cover quickly and require careful management.

Stocking rates should be based on the amount of grass in the paddock and the condition of the pasture, taking into account likely rainfall patterns for the next spring and summer. Seasonal forecasts including the Southern Oscillation Index (SOI) are a useful aid to management decisions at certain times of the year. A strongly negative SOI, especially in spring, can herald an El Niño and significant chance of drought; a positive SOI indicates a chance of wetter than normal conditions.

AussieGRASS (Australian Grassland and Rangeland Assessment by Spatial Simulation) is a simulation model developed to predict and to monitor historical grass production and land cover across Queensland and all Australian regions <<http://www.longpaddock.qld.gov.au/rainfallandpasturegrowth/index.php>>. At property or regional scale, maps from AussieGRASS output give the user a free monthly updated view of the current, historical and 3-month projected outlook of rainfall, pasture growth and grassfire risk. By taking account of livestock grazing by region, the pasture growth maps provide another valuable tool for producers to help base their decisions of stock and pasture management upon. These may include sites for stock agistment, buying and selling of produce and livestock decisions or status of pasture growth regionally or State wide.

As you increase your understanding of the responsiveness of your paddocks, you can begin to incorporate your results into your property management plan or farm management system by identifying different areas of your property according to their risk of developing low ground cover.

Strategies that can be used to respond to a poor seasonal outlook include heavy culling and sale, early weaning, agisting,

custom feedlotting and supplementary feeding. Regular planning includes stocking up with hay and supplements when prices are attractive. Some of these stockpiles can be used each winter to enhance normal management and replaced to ensure the reserves are always of good quality. Overdependence on supplementary feeding is an indication of excessive grazing pressure.

When assessing stocking rates the effects of native animals such as kangaroos and pests such as rabbits need to be considered.

Opportunistic spelling should be part of a grazing strategy. A total spell in a good summer season may be required to allow desirable grasses to recover from past overgrazing. Grazing pressure can also be managed by the location of watering points. They need to be located to minimise stock concentration in areas vulnerable to erosion.

Fire is a key tool for managing pastures and woody weeds but it needs to be managed carefully. Burnt pastures need to be spelled to allow around 20 cm regrowth before grazing. Your fire regime should be tailored to the land type, needs of the pasture species and any nature conservation considerations such as ground feeding or nesting birds. Burning too frequently may prevent pasture species from seeding or regenerating after drought or heavy grazing. No fire will allow regeneration of native trees and shrubs and woody weed species in cleared or naturally open country. A permit is necessary before burning and the conditions of the Vegetation Management Act need to be complied with.

The Queensland Department of Employment, Economic Development and Innovation provides a range of guides on management of specific types of pastures <[http://www.dpi.qld.gov.au/27\\_7791.htm](http://www.dpi.qld.gov.au/27_7791.htm)>. For more details check the reference Partridge (1992).

Graziers may wish to use the Stocktake package <[www.dpi.qld.gov.au/stocktake](http://www.dpi.qld.gov.au/stocktake)>. It is a paddock-scale land condition monitoring method used as part of a grazing land management package recommended by the Queensland Department of Employment, Economic Development and Innovation. It has been developed to provide grazing land managers with a practical, systematic way to:

- Assess land condition and long-term carrying capacity
- Calculate seasonal forage budgets
- Integrate this information into a sustainable long-term production system.

### Cropping lands

Crops need to be managed so that cover levels of at least 30–40% are provided throughout the year but especially during the summer months when there is a greater chance of high-intensity rainfall. After harvest, crop stubbles (referred to as 'trash' in the sugar cane industry) need to be retained on the soil surface, rather than being burnt or buried by tillage implements. Table 2 shows the amount of wheat or barley stubble cover removed by various tillage operations. The use of herbicides and specialised machinery has allowed the practices of reduced or zero tillage which result in maximum levels of ground cover retention.

**Table 2: Estimated reduction in wheat or barley stubble cover from different farming operations (Department of Primary Industries and Fisheries brochure 'Measuring stubble cover – Photostandards for winter cereals')**

Implement	Residue buried by each tillage operation	
	Fresh stubble	Old (brittle) stubble
Disc plough	60–80%	80–90%
Chisel plough	30–40%	40–60%
Blade plough	20–30%	30–50%
Boomspray	Negligible	Negligible

The term 'opportunity cropping' refers to the practice of planting a crop when sufficient soil water is available rather than according to a fixed rotation. It allows landholders to maximise surface cover levels.

Some non-cereal row crops such as sunflower, grain legumes and cotton provide inadequate levels of surface cover. Row spacings also affect the amount of cover provided by a crop.

Minimum tillage practices also apply to horticultural cropping. Cover crops can be grown during a fallow period to provide

protection from erosion as well as providing organic matter to improve the water-holding capacity of the soil. Cover may also be provided by using a surface mulch of plant residue from crops such as pineapples and bananas while in many tree crops a grass sod is recommended beneath the trees.

### Urban areas

In an established urban environment, adequate ground cover should be provided by appropriate landscaping. Vulnerable areas will be land that has been disturbed while it is undergoing development and areas subject to high rates of pedestrian traffic on land that has not been given adequate protection (e.g. school grounds often have bare areas where high rates of runoff and erosion may occur).

A range of specialised products including hydromulching and geotextiles can be used to provide surface cover and to manage runoff on development sites. Disturbed land in urban areas is sometimes protected by fast-growing vegetation such as millet (summer growing) or oats (winter growing). These plants provide protection while the soil is in a loose and friable condition. When these annual crops mature, the remaining stubble will continue to provide some protection and by this time the soil will have consolidated and be less prone to erosion.

### Protected areas

Private landholders can assist with maintaining biodiversity by providing a nature refuge on their property with assistance provided by the Queensland Department of Environment and Resource Management. A nature refuge is established via a voluntary conservation agreement between a landholder and the Queensland Government. A nature refuge is a category of protected area under the *Nature Conservation Act 1992*.

Each agreement is tailored to suit the management needs of the particular area and the needs of the landholder. In most cases, the agreement allows for the ecologically sustainable use of natural resources to continue. A nature refuge can cover part or all of a property protecting wildlife and wildlife habitat and emphasising the conservation of biodiversity as an important part of property management.

### Other information sources

#### Books

Boulter, SI, Wilson, BA, Westrup, J, Anderson, ER, Turner, EJ, and Scanlan, JC (Editors) 2000, *Native vegetation management in Queensland – Background science and values*, Queensland Department of Natural Resources.

Tongway, DJ and Hindley, NL 2005, *Landscape function analysis – Procedures for monitoring and assessing landscapes, with special reference to minesites and rangelands*, CSIRO Sustainable Ecosystems.

#### CD-ROMs

Department of Primary Industries 2003, *Pasture Photo Standards CD*, Queensland Department of Primary Industries, is available from the Queensland Government Bookshop <<https://www.bookshop.qld.gov.au/>> - Search for 'Pasture photo standards'.

PrimeNotes CD ROM Version 18 produced in May 2005 by the Queensland Department of Primary Industries and Fisheries contains over 5000 fact sheets about issues related to natural resource management and agricultural production. Fourteen agencies throughout Australia contributed information to the CD. This publication is available from some libraries.

#### Fact sheets

The Queensland Department of Environment and Resource Management has several fact sheets that are related to this topic:

- Soil limitation to water entry – understanding restrictive soil layers (L40)
- Erosion control in cropping land (L13)
- Erosion in school grounds (L42)
- Erosion control in grazing lands (L91)
- Managing for drought in grazing lands (L90)
- Identifying and monitoring salt-affected areas (L53)
- Catchments and water quality (C2)



Cater, D 2002, *The amount of stubble needed to reduce wind erosion*, Farmnote No 67/2002, Western Australia Department of Agriculture. <[http://www.agric.wa.gov.au/objtwr/imported\\_assets/content/lwe/land/erosion/frn067\\_2002.pdf](http://www.agric.wa.gov.au/objtwr/imported_assets/content/lwe/land/erosion/frn067_2002.pdf)>

### Journal articles

Molloy, JM and Moran, CJ 1991, Compiling a field manual from overhead photographs for estimating crop residue cover, *British Soil Use and Management Journal* 7, 177–83.

### Websites

Landscape function analysis: A systems approach to assessing rangeland condition, CSIRO Sustainable Ecosystems web site <<http://www.csiro.au/services/EcosystemFunctionAnalysis.html>>

Stocktake – Grazing land management package, Queensland Department of Primary Industries and Fisheries <[http://www.dpi.qld.gov.au/27\\_11643.htm](http://www.dpi.qld.gov.au/27_11643.htm)>

Queensland Department of Environment and Resource Management fact sheets <[http://www.derm.qld.gov.au/services\\_resources/item\\_list.php?category\\_id=123](http://www.derm.qld.gov.au/services_resources/item_list.php?category_id=123)>

BioCondition Assessment Framework, Queensland Department of Environment and Resource Management <<http://www.derm.qld.gov.au/wildlife-ecosystems/biodiversity/biocondition.html>>.

## Glossary

### Fallen logs

Fallen logs refer to coarse woody debris or dead timber on the ground greater than 10 cm diameter and greater than 0.5 m in length.

### Grazing pressure

This term refers to the amount of feed available compared to the rate of removal by grazing animals. The ideal stocking rate is flexible, so as to maintain a moderate grazing pressure most of the year and to match stock numbers to available feed. When assessing stocking rates, the effects of native animals such as kangaroos and pests such as rabbits need to be considered.

### Ground cover

Ground cover is provided by plants (living or dead) and any parts of the plant that fall to the surface of the ground. Cover may also be provided by pebbles and rocks and 'crusts' formed by fungi, mosses, etc. In the urban environment, infrastructure such as concrete, bitumen and buildings may provide cover but their impermeability leads to high rates of runoff with consequent water loss and adverse effects downstream.

### Herbaceous plants

Plants with soft, rather than woody stem tissues.

### Infiltration

The movement of water from the soil surface into the soil profile. Surface cover assists infiltration by minimising raindrop impact and by retarding the flow of runoff across the soil surface. Soil characteristics affecting infiltration rates include surface seals, hard-setting layers, surface and subsurface compaction and impermeable subsoils. Infiltration rates are usually higher within plant tussocks compared to the area between tussocks because of the presence of plant roots and higher levels of biological life in this zone.

### Litter

The ground cover provided in forests, woodlands and pastures by fresh or slightly decomposed leaves, bark, twigs, flowers and fruits. Litter is defined in BioCondition as including both fine and coarse organic material such as fallen leaves, twigs and branches less than 10 cm diameter.

### Minimum tillage

A conservation tillage system in which the crop is grown with the fewest possible tillage operations. Herbicides and/or grazing may be used for fallow weed control.

### **Opportunity cropping**

The practice of planting a crop whenever soil moisture reserves are considered sufficient, rather than according to a rigid rotational pattern. This leads to an increase in cropping frequency (e.g. two crops in three years) and greater levels of surface cover.

### **BioCondition Assessment Framework**

The BioCondition Assessment Framework developed by the Queensland Department of Environment and Resource Management provides a means of assessing ecosystem condition for biodiversity at a patch, property or paddock scale that is compared to benchmarks for the particular vegetation type. It uses data from ten attributes to compile a dataset for conducting a BioCondition Assessment.

### **Rainfall erosivity**

A measure of the capacity of the rainfall in a given location to cause erosion. It takes into account the combined effects of rainfall quantity and its kinetic energy (intensity). In most areas of Queensland, rainfall erosivity peaks in January–February and reaches a low point in August–September.

### **Raindrop impact**

The result of the violent break-up and dispersion of raindrops when they hit the ground surface. If the surface is not protected, soil particles may be dislodged and scattered a considerable distance, due to the energy of the raindrop's impact. Dislodged particles are easily transported away by overland flow.

### **Stubble**

The straw residue that remains after a grain crop has been harvested. It includes standing straw and that discharged by a harvester.

### **Stubble burning**

A management practice in which the stubble from a crop is burnt after the harvest or prior to the sowing of the next crop. Stubble burning exposes the soil to erosion and destroys a potential source of soil organic matter.

### **Stubble incorporation**

A management practice where stubble is incorporated into the surface soil by tillage, thereby promoting stubble breakdown and reducing the amount of protection that surface stubble can provide against erosion.

### **Stubble mulching**

A conservation farming practice where stubble is retained on the surface of the soil by using suitable farm machinery such as chisel or blade ploughs. Implements such as disc ploughs are not suitable for stubble mulching since they incorporate an excessive amount of stubble into the soil.

### **Trash**

Trash is the stubble remaining after the harvest of a sugarcane crop. The term 'green cane trash blanket' refers to a protective blanket of cane trash over the soil surface.

### **Zero tillage (or no tillage)**

A minimum tillage practice in which the crop is sown directly into a soil not tilled since the harvest of the previous crop. Weed control is achieved by the use of herbicides and the retained stubble provides erosion control.

## References

- Department of Natural Resources 1997, *Grass check*, Publication DNRQ97002, Queensland Department of Natural Resources.
- Department of Primary Industries 2003, *Pasture photo standards CD*, Queensland Department of Primary Industries.
- Finlayson, B and Silburn, M 1996, 'Soil, nutrient and pesticide movements from different land use practices and subsequent transport by rivers and streams', in HM Hunter, AG Eyles and GE Rayment (eds), *Downstream effects of land use*, pp. 129–40, Department of Natural Resources, Queensland.
- Francis, A and Payne, R 2003, *Field method for measuring soil surface cover*, Primary Industries and Resources SA fact sheet No. 8/01.
- Freebairn, D 2004, Some observations on the role of soil conservation structures and conservation, *Journal of the Australian Association of Natural Resource Management* 7(1), 8–13.
- Molloy, J 1988, *Field manual for measuring stubble cover*, Queensland Department of Primary Industries.
- Partridge, I 1992, *Managing native pastures – a grazier's guide*, Information Series QI92009, Queensland Department of Primary Industries.
- Tongway, D 1994, *Rangeland soil condition assessment manual*, CSIRO Division of Wildlife and Ecology, Canberra.

## The Land Manager's Monitoring Guide

### *Indicator: Ground cover*

#### **Metadata recording sheet**

Key element	Metadata
Short description of the contents of the dataset.	<i>e.g. Ground cover at "specified property"</i>
Name of the land manager or business responsible for the dataset.	
Brief assessment of reliability of the information in the dataset.	<i>Record which method you have decided to use, e.g. Level 1, 2a or 2b monitoring plus brief description of the method</i>
Brief history of the source and processing steps used to produce the dataset.	<i>Record which method you have decided to use, e.g. Level 1, 2a or 2b monitoring plus brief description of the method</i>
Maintenance and update frequency of the dataset.	
What location or area does the data relate to.	<i>Provide property or other location details and/or GPS Eastings and Northings</i>

The Land Manager's Monitoring Guide

*Indicator: Ground cover*

**Level 1 field recording sheet - visual observations**

Date	Observation number					Average	Recorder
Paddock name	1	2	3	4	5	% cover	Comments

The Land Manager's Monitoring Guide

*Indicator: Ground cover*

**Level 1 example field recording sheet - visual observations**

Date	30/2/05					Recorder	Jane W	
Paddock name	Observation					Average cover (%)	Comments	
	1	2	3	4	5			
Tank paddock	40	60	40	35	35	42		
Creek paddock	45	30	55	65	45	48		
Carinya paddock	35	40	55	25	35	38		
Home paddock	60	40	45	55	65	53		
Far paddock	40	35	45	60	55	47		

The Land Manager's Monitoring Guide

*Indicator: Ground cover*

Level 1 field spreadsheet - pastures

Paddock name				Additional data
Site name number				
GPS reading				
Date	Ground cover (%)	Recording person	Comments (seasonal conditions, grazing pressure)	Rainfall mm since last observation

The Land Manager's Monitoring Guide

*Indicator: Ground cover*

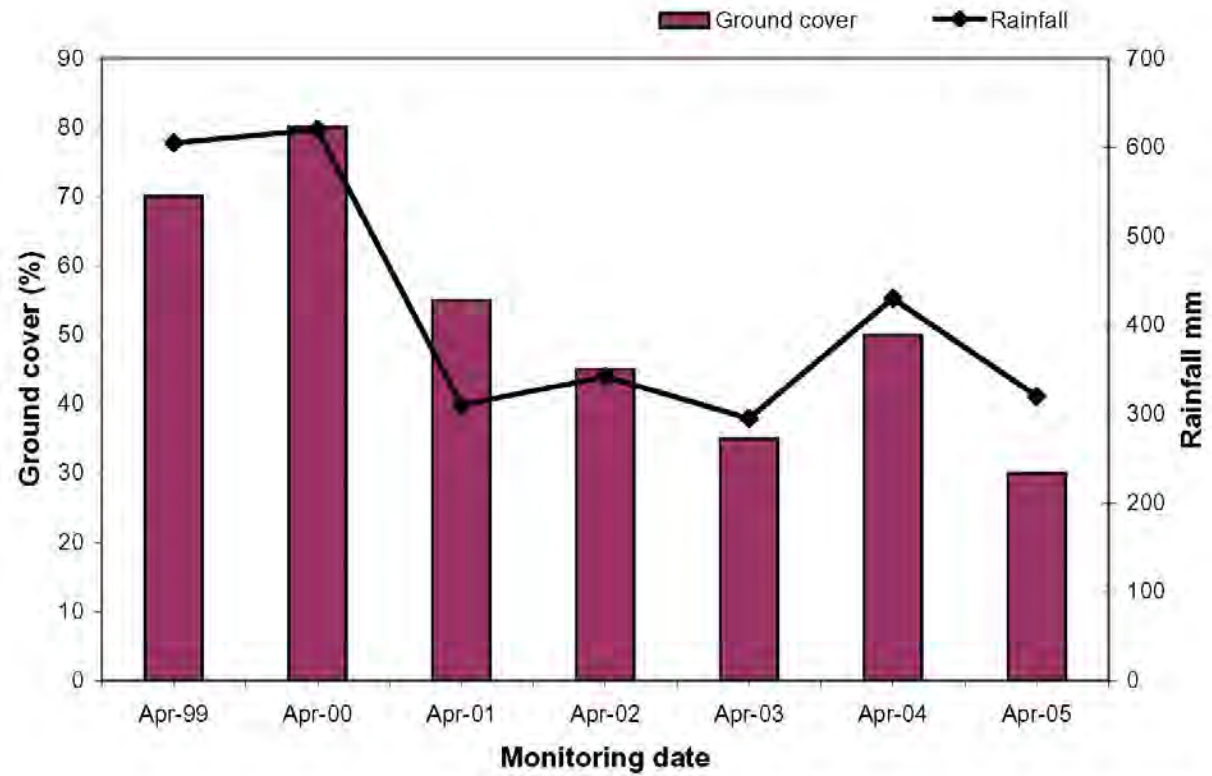
**Level 1 example field spreadsheet - pastures**

<b>Paddock name</b>		Tank paddock		
<b>Site name number</b>				
<b>Date</b>	<b>Ground cover (%)</b>	<b>Recording person</b>	<b>Comments (seasonal conditions, grazing pressure)</b>	<i>Additional data</i> <b>Rainfall mm since last observation</b>
Apr-99	70	Jane W		605
Apr-00	80	Jane W		620
Apr-01	55	Jane W		310
Apr-02	45	Jane W		342
Apr-03	35	Jane W		295
Apr-04	50	Jane W		430
Apr-05	30	Jane W		320



The Land Manager's Monitoring Guide

Rainfall and changes in pasture cover from 1999 to 2005



For a location with an average rainfall of 430mm

## **The Land Manager's Monitoring Guide**

### ***Indicator: Ground cover***

While every care is taken to ensure the accuracy of this information, the Department of Environment and Resource Management does not invite reliance upon it, nor accept responsibility for any loss or damage caused by actions based on it.

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# Appendix D

## EPBC Offset Assessment Tool Calculator Output

**Offsets Assessment Guide**  
 For use in determining offsets under the Environment Protection and Biodiversity Conservation Act 1999  
 2 October 2012  
 This guide refers to Microsoft being installed in your browser

Matter of National Environmental Significance	
Name	Dormant mountain Craters & Shale
EPBC Act name	Various
Annual probability of extinction Based on IUCN category definition	0.2%

Key to Cell Colours	
Use input required	
Drop down list	
Calculated output	
Not applicable to attribute	

Impact calculator					
Protected matter attributes	Attribute relevant to case?	Description	Quantum of impact	Units	Information source
<i>Ecological communities</i>					
Area of community	No		Area		
			Quality		
			Total quantum of impact	0.00	
<i>Threatened species habitat</i>					
Area of habitat	Yes	Rifer supporting documentation	Area	175	Hectares
			Quality	1	Scale 0-10
			Total quantum of impact	8.75	Adjusted hectares
<i>Threatened species</i>					
Birth rate e.g. Nest failure, habitat loss	No				
Condition of habitat Change in habitat condition, but no change in extent	No				
Birth rate e.g. Change in nest success	No				
Mortality rate e.g. Change in number of road kills per year	No				
Number of individuals e.g. Individual plant/animal	No				

Offset calculator																
Protected matter attributes	Attribute relevant to case?	Total quantum of impact	Units	Proposed offset	Time horizon (years)	Start area and quality	Future area and quality without offset	Future area and quality with offset	Raw gain	Confidence in result (%)	Adjusted gain	Net present value (adjusted hectares)	% of impact offset	Minimum (90%) direct offset requirement met?	Cost (\$ total)	Information source
<i>Ecological Communities</i>																
Area of community	No				Risk-related time horizon (max. 20 years)	Start area (hectares)	Risk of loss (%) without offset	Risk of loss (%) with offset								
						Future area without offset (adjusted hectares)	0.0	0.0								
						Future area with offset (adjusted hectares)	0.0	0.0								
Area of habitat	Yes	8.75	Adjusted hectares	Rifer supporting documentation	Time over which loss is averted (max. 20 years)	Start area (hectares)	Risk of loss (%) without offset	Risk of loss (%) with offset	14.00	72%	12.00	11.53	8.95	102.32%	Yes	
						Future area without offset (adjusted hectares)	2.0	2.0								
						Future area with offset (adjusted hectares)	1.0	1.0	5.00	79%	4.50	4.41				
<i>Threatened species habitat</i>																
Area of habitat	Yes	8.75	Adjusted hectares	Rifer supporting documentation	Time over which loss is averted (max. 20 years)	Start area (hectares)	Risk of loss (%) without offset	Risk of loss (%) with offset	14.00	72%	12.00	11.53	8.95	102.32%	Yes	
						Future area without offset (adjusted hectares)	2.0	2.0								
						Future area with offset (adjusted hectares)	1.0	1.0	5.00	79%	4.50	4.41				
<i>Threatened species</i>																
Birth rate e.g. Change in nest success	No															
Mortality rate e.g. Change in number of road kills per year	No															
Number of individuals e.g. Individual plant/animal	No															

Summary							
Protected matter attributes	Quantum of impact	Net present value of offset	% of impact offset	Direct offset adequate?	Cost (\$)		
					Direct offset (\$)	Other compensatory measures (\$)	Total (\$)
Birth rate	0				\$0.00		\$0.00
Mortality rate	0				\$0.00		\$0.00
Number of individuals	0				\$0.00		\$0.00
Number of features	0				\$0.00		\$0.00
Condition of habitat	0				\$0.00		\$0.00
Area of habitat	8.75	8.95	102.32%	Yes	\$0.00	N/A	\$0.00
Area of community	0				\$0.00		\$0.00
					\$0.00	\$0.00	\$0.00