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Macedon Gas Project

Compliance Assessment Report

Disclaimer

BHP Billiton Disclaimer

Cover

Photograph on cover of report shows the Macedon Gas Plant

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Tables

1.0 Introduction

The Macedon Gas Development is a domestic gas project designed to develop the gas reserves in the offshore Macedon gas field located in Production Lease WA-42-L.

The project comprises the connection of the Macedon field via a subsea pipeline to an onshore gas treatment and compression plant located in an area proposed for strategic industrial use at Ashburton North (Ashburton North) located approximately 17 km southwest of Onslow, and a sales gas pipeline which follows the Onslow Road to the Dampier to Bunbury Natural Gas Pipeline (DBNGP, Figure 1).

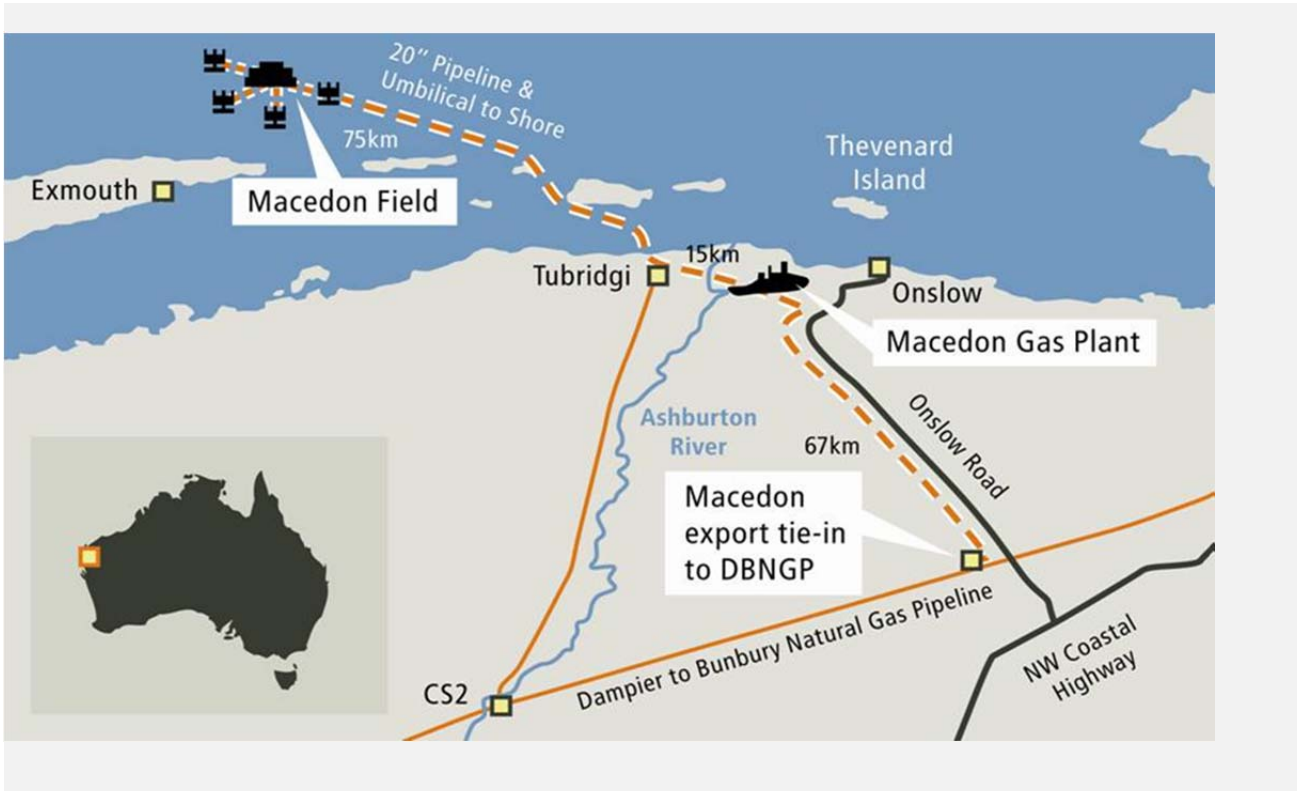

Figure 1 Macedon Gas Project Location

The Macedon Gas Plant Lease area for the gas processing facility and associated infrastructure, including the ground flares and evaporation pond, construction lay down areas and construction accommodation areas is shown in Figure 2.

Introduction continued

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Figure 2 Macedon Gas Plant Lease and Layout

1.1. Purpose of the Compliance Assessment Report

The purpose of this Compliance Assessment Report (CAR) is to assess compliance at the Macedon Gas Plant with the Environment Protection Authority (EPA) Statement 844 dated 28 October 2010 in accordance with the Compliance Assessment Plan originally approved on 18 March 2011.

The CAR 2014 covers activities undertaken during the period 1 January 2014 to 31 December 2014.

1.2. Compliance Assessment Reporting Requirements

This report complies with the compliance reporting requirements as defined in the 2014 Compliance Assessment Plan (PMA-BHP-EN-EIA-0002).

1.3. Endorsement of CAR

This Compliance Assessment Report has been endorsed by Mr Doug Handyside, BHP Billiton Petroleum General Manager Australia.

2.0 Project Status

2.1. Current Status of Project (construction, operation, etc.)

The project is currently in operation.

2.2. Project Activities covered by CAR

This CAR covers the following project activities undertaken in the period 1 January 2014 to 31 December 2014:

1. Operations 1 Jan 2014 to 31 December 2014

3.0 Compliance with Ministerial Statement 844

3.1. Compliance with Conditions

Operation of the Macedon Gas Project is compliant with Ministerial Statement No. 844 as reported in Table 1.

3.2. Rehabilitation Monitoring

The Macedon Gas Project rehabilitation of the onshore pipeline has been completed; the rehabilitation monitoring was completed in July 2014 and the report submitted to the Office of the Environmental Protection Authority (OEPA). A copy of the Macedon Rehabilitation Monitoring Report is attached at Appendix 1.

Rehabiliation monitoring completed in July 2014 indicated species diversity of the rehabilitated sites exceeds 60 percent, no new weed speices have been identified; however weed coverage may be increasing. Condtion 8-1 of Ministerial Statement 844 sets the following criteria to be met within three years of commencement of rehabilitation:

1. Species diversity is not less than 60 percent of the known original species diversity
2. Weed coverage is equal to or less than that of pre-cleared levels

As a contingency measure BHP Billiton Petroleum will complete weed spraying of rehabilitated sites during 2015 to mitigate weed coverage exceeding criteria required by condition 8-1.

3.3. Greenhouse Gas

3.3.1. Greenhouse Gas (GHG) Emissions and Intensity

Macedon Gas Project GHG emissions for the period 1 Jan 2014 to 30 December 2014 are illustrated in Figure 3 and Table 1.

Annual GHG emissions for the period 1 Jan 2014 to 30 December were 72,430 tonne equivalaent of carbon dioxide (CO_2-e); carbon emissions intensity for the period was 8 t CO_2-e per 1000 barrels of oil equivalent production. Recorded emissions are lower than emissions predicted for 2014 in the Final EPS (85,000 t CO_2-e); variance between predicted and actual emissions is due to higher production rates used to estimate carbon emissions in the EPS when compared to current operations.

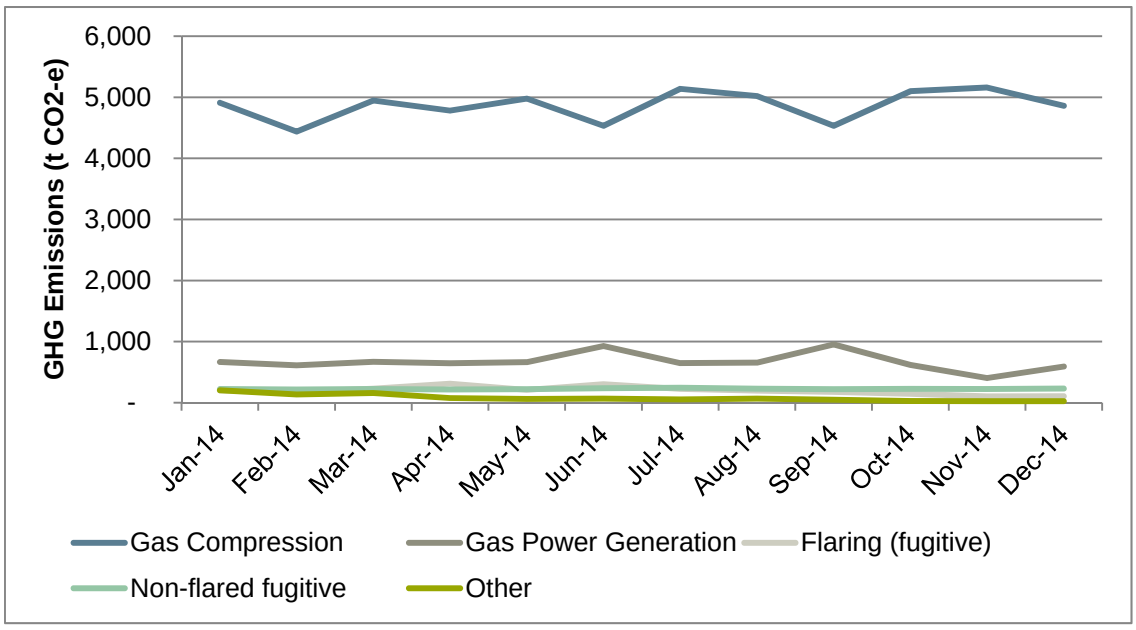

Figure 3: Macedon Gas Project GHG Emissions (1 January 2014-31 December 2014)

Compliance with Ministerial Statement 844 continued

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Table 1: Macedon Gas Project GHG Emissions (1 January 2014-31 December 2014)

	Greenhouse Gas Emissions (t CO_2-e)												
Emission Source	Jan-14	Feb-14	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Total
Gas Compression	4,909	4,439	4,947	4,783	4,978	4,533	5,138	5,020	4,533	5,100	5,159	4,860	58,400
Gas Power Generation	665	610	668	645	662	926	646	654	954	617	403	592	8,042
Flaring (fugitive)	200	171	227	310	208	303	224	195	176	145	102	104	2,367
Non-flared fugitive	223	215	222	215	220	234	243	227	220	225	221	231	2,695
Other	201	133	155	75	59	63	51	63	46	26	24	23	921
Total	6,198	5,569	6,219	6,028	6,128	6,061	6,302	6,159	5,928	6,113	5,909	5,811	72,425

3.3.2. GHG Reduction Measure Investigated

Details of improvements in equipment, technology or procedures were investigated in 2010 through an energy optimisation study aimed at cost savings, energy and greenhouse gas emission reductions across all operations of the Macedon Gas Plant. Projects were identified and evaluated with intent to incorporate in design of the Macedon Gas Project.

BHP Billiton Petroleum continues to identify and evaluate GHG reduction opportunities through internal processes designed implement greenhouse gas abatement opportunities.

3.3.3. GHG Reduction Measure Implemented

Several improvements in equipment, technology and procedures identified in the Macedon Gas Project energy optimization study were implemented in design:

- Low resistance internal pipeline coating
- Wasteheat recovery
- Equipment selection designed to minimize facility pressure drop

4.0 Audit Table

Table 2 Audit Table

Audit Code	Subject	Action (from Ministerial Statement 844)	How	Evidence	Satisfy	Advice	Phase	When	Status	Further Information
844:M1.1	Implementation	The proponent shall implement the proposal as documented and described in schedule 1 of this statement subject to the conditions and procedures of this statement.	Project implemented in accordance with these criteria	Compliance Assessment Report (CAR)	Min for Env		Overall		C	2014 CAR (this document)
844:M2.1	Proponent Nomination and Contact Details	The proponent for the time being nominated by the Minister under sections 38(6) or 38(7) of the Act is responsible for the implementation of the proposal.			Min for Env		Overall		C	Proponent remains BHP Billiton Petroleum Pty Ltd
844:M2.2	Proponent Nomination and Contact Details	The proponent shall notify the CEO of any change of the name and address of the proponent for the serving of notices or other correspondence within 30 days of such change.	Letter notifying CEO of any change in proponent details	Letter notifying CEO of any change in proponent details	CEO		Overall	Within 30 days of such change	C	Updated January 2013 (letter dated 14.1.13)
844:M3.1	Time Limit of Authorisation	The authorisation to implement the proposal provided for in this statement shall lapse and be void five years after the date of this statement if the proposal to which this statement relates is not substantially commenced.	Implement project		Min for Env		Overall	Commence implementation by 27 October 2015	CLD	Implementation commenced in 2011 OEPA Desktop Audit report 31.08.2012
844:M3.2	Time Limit of Authorisation	The proponent shall provide the CEO with written evidence which demonstrates that the proposal has substantially commenced on or before the expiration of five years from the date of this statement.	Letter notifying CEO that proposal has substantially commenced	Letter to the CEO demonstrating that the proposal has substantially commenced	CEO		Overall	Within one month of commencement	CLD	Letter sent to CEO dated 16.01.12 OEPA Desktop Audit report 31.08.2012
844:M4.1	Compliance Reporting	The proponent shall prepare and maintain a compliance assessment plan (CAP) to the satisfaction of the CEO.	CAP will be developed prior to implementation and maintained	CAP	CEO		Overall	Prior to implementation and ongoing	C	OEPA accepted 18.3.11 (updated 27.01.2014)
844:M4.2	Compliance Reporting	The proponent shall submit to the CEO the CAP required by condition 4-1 at least six months prior to the first compliance report required by condition 4-6, or prior to implementation, whichever is sooner. The CAP shall indicate: 1. the frequency of compliance reporting; 2. the approach and timing of compliance assessments; 3. the retention of compliance assessments; 4. the method of reporting of potential non-compliances and corrective actions taken; 5. the table of contents of compliance assessment reports; and 6. public availability of compliance assessment reports.	CAP will be developed prior to implementation and submitted to CEO	CAP	CEO		Pre-construction	At least six months prior to the first CAR required by Condition 4-6, or prior to implementation, whichever is sooner	CLD	OEPA accepted 18.3.11

Audit Table continued

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Audit Code	Subject	Action (from Ministerial Statement 844)	How	Evidence	Satisfy	Advice	Phase	When	Status	Further Information
844:M4.3	Compliance Reporting	The proponent shall assess compliance with conditions in accordance with the CAP required by condition 4-1.	Prepare Compliance Assessment Report (CAR)	CAR	Min for Env		Overall	When requested by the CEO	C	2011 CAR, 2012 CAR, 2013 CAR, 2014 CAR (this document)
844:M4.4	Compliance Reporting	The proponent shall retain reports of all compliance assessments described in the CAP required by condition 4-1 and shall make those reports available when requested by the CEO.	CAR to include compliance assessments (audit table), retain CAR for the life of the project in electronic and hard copy format	CAR	CEO		Overall	Annual	C	2011 CAR, 2012 CAR, 2013 CAR, 2014 CAR (this document)
844:M4.5	Compliance Reporting	The proponent shall advise the CEO of any potential non-compliance within seven days of that non-compliance being known.	Advise CEO of potential non-compliance in writing	Log of phone call, email or letter	CEO		Overall	Within seven days of that non-compliance being known	C	No non-compliances
844:M4.6	Compliance Reporting	The proponent shall submit to the CEO the first CAR fifteen months from the date of issue of this Statement addressing the twelve month period from the date of issue of this Statement and then annually from the date of submission of the first CAR. The CAR shall: 1. be endorsed by the proponent's Managing Director or a person delegated to sign on the Managing Director's behalf; 2. include a statement as to whether the proponent has complied with the conditions; 3. identify all potential non-compliances and describe corrective and preventative actions taken; 4. be made publicly available in accordance with the approved CAP; and 5. indicate any proposed changes to the CAP required by condition 4-1.	CAR will be issued Make CAR publicly available in accordance with 'Proposal Implementation Monitoring Branch – Draft Fact Sheet 1 – Making Documents Publicly Available – April 2010'	CAR	CEO		Overall	Annually by 28 January each year with the first CAR due 28 January 2012	C	2011 CAR, 2012 CAR, 2013 CAR, 2014 CAR (this document)
844:M5.1	Non-Indigenous Marine Species	Prior to mobilisation of vessels and submersible equipment for the construction of the Macedon Gas Project marine pipeline and umbilical, the proponent shall update the Introduced Marine Pest Management Procedure contained in Appendix Q of the Final EPS to be consistent with the Commonwealth and State guidelines approved and published at that time, to the satisfaction of the CEO on advice from the Department of Fisheries.	Revise and obtain approval of Introduced Marine Pest Management Procedure (IMP MP)	IMP MP	CEO	DoF	Pre-construction	Prior to mobilisation of vessels and submersible equipment for the construction of the Macedon Gas Project marine pipeline and umbilical	CLD	Letter of Approval from CEO of EPA received 28.11.11

Audit Table continued

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Audit Code	Subject	Action (from Ministerial Statement 844)	How	Evidence	Satisfy	Advice	Phase	When	Status	Further Information
844:M5.2	Non-Indigenous Marine Species	The proponent shall implement the updated Introduced Marine Pest Management Procedure for the construction and maintenance of the Macedon Gas Project marine pipeline and umbilical.	Offshore pipelay and maintenance implemented in compliance with IMP MP	Inspection of IMP MP vessel risk assessments, certificates of vessel cleanliness	Min for Env		Overall	For the construction and maintenance of the Macedon Gas Project marine pipeline and umbilical	C	IMP MP implemented during construction phase Pipeline maintenance survey completed in accordance with IMP MP
844:M6.1	Marine Fauna	The proponent shall not cause physical damage to turtles, disrupt turtle nesting behaviour or cause a change to hatchling orientation in waters and/or beaches adjacent to the pipeline shore crossing during construction.	Implement Marine Turtle Impacts Management Protocol (MTI MP)	Implementation of MTI MP, Marine Fauna Observer logs	Min for Env		Construction	During construction	C	Shore crossing complete, no impacts to marine turtles recorded
844:M6.2	Marine Fauna	If the pipeline shore crossing is to take place between 1 November and 30 April the proponent shall prepare a MTI MP to the satisfaction of the CEO on advice from the DEC prior to undertaking the shore crossing. The protocol shall include: 1. employment of a suitably qualified marine fauna observer; 2. indicators for determining if and when there is potential for impacts on turtle nesting or hatchling emergence; 3. management responses to evidence of turtle activity; and 4. triggers for stopping construction activities pending further consultation with the DEC; and 5. when resumption of activities can take place, on advice of the DEC.	Prepare MTI MP	Approval of MTI MP	CEO	DEC	Construction	Prior to undertaking the shore crossing, if the pipeline shore crossing is to take place between 1 November and 30 April	CLD	Letter of Approval from CEO of EPA received 31.10.11
844:M6.3	Marine Fauna	The proponent shall implement the MTI MP if undertaking the pipeline shore crossing between 1 November and 30 April.	Implement MTI MP	Marine Fauna Observer logs	Min for Env		Construction	If undertaking the pipeline shore crossing location between 1 November and 30 April	CLD	Pipeline shore crossing complete. MTI MP implemented for shore crossing
844:M6.1A	Pipeline Route – State waters	Subject to complying with the separation distances in condition 7-1, the pipeline within State waters shall be laid/constructed within the corridor delineated by the coordinates specified in Schedule 2.	Install pipeline in corridor delineated in Schedule 2	Pipelay vessel logs, as-built survey of route	Min for Env		Construction	During offshore pipeline construction	CLD	Pipeline installed within corridor

Audit Table continued

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Audit Code	Subject	Action (from Ministerial Statement 844)	How	Evidence	Satisfy	Advice	Phase	When	Status	Further Information
844:M7.1	Benthic Primary Producer Habitat	The proponent shall undertake all works in a manner that ensures that the loss of Benthic Primary Producer Habitat (BPPH) within the Local Assessment Area, as defined in Figure 3, does not exceed 1% for any habitat type and is minimised by maintaining the following separation distances during construction of the marine pipeline and umbilical : (1) pipeline to primary feature – 700 metres; (2) pipeline to secondary feature – 600 metres; (3) vessel movement/anchor to primary feature – 200 metres; and (4) vessel movement/anchor to secondary feature – 100 metres. Note: “loss” is loss that does not recover within 5 years, “primary feature” and “secondary feature” are as defined in Figure 18 of the Final EPS and not a feature for which proposed impacts are described in section 8.4.4.5 of the Final EPS.	Maintain separation distance during offshore pipelay as per Condition 7-1	Pipelay vessel logs, as-built survey of route, BPPH survey and loss calculations	Min for Env		Construction	During offshore pipeline construction	CLD	Letter of Approval from CEO of EPA received 23.09.13
844:M7.2	Benthic Primary Producer Habitat	The proponent shall survey the direct loss of BPPH against the criteria in condition 7-1 starting within one month of completion of the marine pipeline and umbilical.	Survey and calculate loss of BPPH	Post construction as built survey of route, BPPH survey and loss calculations	Min for Env		Overall	Commencing within one month of completion of the marine pipeline and umbilical	CLD	Letter of Approval from CEO of EPA received 23.09.13
844:M7.3	Benthic Primary Producer Habitat	Notwithstanding condition 7-1, if monitoring detects that construction activities have contributed to a loss of greater than 1% in any habitat type within the management unit, as defined in Figure 3, the proponent shall notify the CEO of the strategies to be implemented to enhance recovery and rehabilitate the impacted BPPH.	Develop strategies for recovery and rehabilitation of BPPH	Post construction as-built survey, strategies	CEO		Overall	If monitoring detects that construction activities have contributed to a loss greater than 1% in any habitat type within the management unit, as defined in Figure 3	C	No excedance of loss >1% in any habitat type

Audit Table continued

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Audit Code	Subject	Action (from Ministerial Statement 844)	How	Evidence	Satisfy	Advice	Phase	When	Status	Further Information
844:M8.1	Terrestrial Vegetation	Within two months following completion of construction of the gas plant and associated pipelines, the proponent shall commence rehabilitation of the temporarily cleared areas of the site that are no longer being utilised to achieve re-establishment of vegetation, such that the following criteria are met across the distribution of the disturbance footprint within three years of commencement of rehabilitation: (1) Species diversity is not less than 60 percent of the known original species diversity; (2) Weed coverage is equal to or less than that of pre-cleared levels. Note: The original species diversity and weed coverage must be determined prior to clearing or from analogue sites approved by the CEO on advice from the DEC.	Undertake rehabilitation of temporarily cleared areas (gas plant and pipelines) as per Condition 8-1	Rehabilitation monitoring reports, rehabilitation completion criteria: - Species diversity greater than 60%of pre-disturbance - Weed coverage less than pre-disturbance levels	CEO	DEC	Overall	Commence rehabilitation within two months following completion of construction of the gas plant and associated pipelines and meet criteria within three years of commencement of rehabilitation	C	Rehabilitation has been completed of temporary disturbed areas
844:M8.2	Terrestrial Vegetation	In liaison with the DEC, the proponent shall monitor progressively the performance of rehabilitation for a range of sites against the criteria in condition 8-1 based on appropriately timed surveys after rain, until the completion criteria are met. The surveys shall be conducted annually unless otherwise agreed by the CEO.	Monitor rehabilitation success against rehabilitation completion criteria, conduct surveys in accordance with Condition 8-2	Rehabilitation monitoring report, rehabilitation completion criteria: - Species diversity greater than 60%of pre-disturbance - Weed coverage less than pre-disturbance levels Correspondence with DEC	CEO	DEC	Overall	Appropriately timed after rain on an annual basis unless otherwise agreed by the CEO until the completion criteria are met	C	First monitoring conducted in 2013. Letter of compliance for 2013 Rehabilitation Report from OEPA received 23.9.13 Second monitoring survey conducted in 2014
844:M8.3	Terrestrial Vegetation	The proponent shall include a rehabilitation monitoring report in the CAR referred to in condition 4-6 commencing from the date rehabilitation was commenced. The report shall address in the report the following: 1. The progress made towards meeting the criteria required by condition 8-1; and 2. Contingency management measures in the event that the criteria required by condition 8-1 are unlikely to be met.	Submit rehabilitation monitoring report	Rehabilitation monitoring report, rehabilitation completion criteria: - Species diversity greater than 60%of pre-disturbance - Weed coverage less than pre-disturbance levels	Min for Env		Overall	Commencing from the date rehabilitation was commenced and on an annual basis	C	2014 CAR (this document)

Audit Table continued

Audit Code	Subject	Action (from Ministerial Statement 844)	How	Evidence	Satisfy	Advice	Phase	When	Status	Further Information
844:M9.1	Terrestrial Fauna	The proponent shall prevent the death of fauna that becomes entrapped in the onshore pipeline trenches by employing a fauna clearing person or persons to remove trapped fauna from any open pipeline trench.	Fauna clearing person(s) to remove fauna from open pipeline trench	Employment of fauna clearing person(s), daily logs	Min for Env		Construction	Until all trenching is completed and no open pipeline trenches remain	CLD	Trenching complete
844:M9.2	Terrestrial Fauna	The length of open trenches shall not exceed a length capable of being inspected and cleared by a fauna clearing person within the time frame specified in condition 9-4.	Clear open trench within identified timeframes specified in Condition 9-4	Employment of fauna clearing person(s), daily logs	Min for Env		Construction	Until all trenching is completed and no open pipeline trenches remain	CLD	Trenching complete
844:M9.3	Terrestrial Fauna	Fauna refuges providing suitable shelter from the sun and predators for trapped fauna shall be placed in the trench at intervals not exceeding 50 metres.	Fauna refuges installed in open trench at intervals < 50m	Daily logs	Min for Env		Construction	Until all trenching is completed and no open pipeline trenches remain	CLD	Trenching complete
844:M9.4	Terrestrial Fauna	Inspection and clearing of fauna from trenches by a fauna clearing person shall occur twice daily and not more than half an hour prior to the backfilling of trenches, with the first daily inspection and clearing to be undertaken no later than 3.5 hours after sunrise, and the second inspection and clearing to be undertaken daily between the hours of 3:00 pm and 6:00 pm.	Clear open trench within identified timeframes	Employment of fauna clearing person(s), daily logs	Min for Env		Construction	Twice daily and not more than half an hour prior to the backfilling of trenches, with the first daily inspection and clearing to be undertaken no later than 3.5 hours after sunrise, and the second inspection and clearing to be undertaken daily between the hours of 3:00 pm and 6:00 pm	CLD	Trenching complete
844:M9.5	Terrestrial Fauna	In the event of rainfall, the proponent shall, following the clearing of fauna from the trench, pump out significant pooled water in the open trench (with the exception of groundwater) and discharge it to adjacent vegetated areas in a manner that does not cause erosion.	Pump out significant pooled water in open trench	Daily logs	Min for Env		Construction	In the event of rainfall, following the clearing of fauna from the trench	CLD	Trenching complete. No loss of fauna during pipeline construction. Small losses due to groundwater flooding in trenches.
844:M10.1	Emissions to Air	The proponent shall install equipment and manage ongoing operations such that best practice for a petroleum gas/condensate facility in respect to volatile organic compounds and oxides of nitrogen emissions is achieved.	Install equipment as detailed in Air Emissions Best Practice Report (AEBPR) and manage ongoing operations	Approved AEBPR, CAR	Min for Env		Overall	Construction and ongoing operations	C	Equipment identified in AEBPR installed and operated. Emission testing demonstrates effective management of VOC and NO_x

Audit Table continued

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Audit Code	Subject	Action (from Ministerial Statement 844)	How	Evidence	Satisfy	Advice	Phase	When	Status	Further Information
844:M10.2	Emissions to Air	The proponent shall provide reports showing the basis on which 'best practice' was determined, to the satisfaction of the CEO, as follows: 1. for plant and equipment – prior to applying for a Works Approval under Part V of the Act; and 2. for ongoing management of operations – prior to applying for a Licence under Part V of the Act.	Prepare AEBPR for selection of equipment and ongoing management of operations	Approved AEBPR, CAR	CEO		Overall	Prior to applying for a Works Approval (for plant and equipment) and prior to applying for a Part V licence (for ongoing management of operations)	CLD	Approval of AEBPR received from CEO of EPA in letter dated 07.07.11
844:M11.1	Greenhouse Gas Abatement	For the life of the project, the proponent shall include in the CARs referred to in Condition 4-6 the following: 1. annual greenhouse gas emissions and intensity resulting from the operation of the project in comparison to the annual emissions predicted in the Final EPS and reasons for any variance; 2. details of improvements in equipment, technology or procedures investigated by the proponent that would reduce greenhouse gas emissions; and 3. details of improvements in equipment, technology or procedures implemented by the proponent that will reduce greenhouse gas emissions.	CAR to include GHG emissions and intensity (including comparison to annual emissions predicted in the Final EPS and reasons for any variance) and proposed and implemented GHG reduction methods	CAR	Min for Env		Operation	For the life of the project	C	2014 CAR (this document, see Section 3.3)
844:M12.1	Decommissioning	At least six months prior to the anticipated date of closure, the proponent shall submit a Final Decommissioning Plan designed to ensure that the site is suitable for future land uses, for approval of the CEO. The Final Decommissioning Plan shall set out procedures and measures for: 1. removal or, if appropriate, retention of plant and infrastructure; and 2. remediation or rehabilitation of all disturbed areas to a standard suitable for the agreed new land use(s).	Submit Final Decommissioning Plan	Approval of Final Decommissioning Plan	CEO		Operation	At least six months prior to the anticipated date of closure	NR	
844:M12.2	Decommissioning	The proponent shall implement the Final Decommissioning Plan required by condition 12-1 from the date of closure until such time as the Minister determines, on advice of the CEO, that the proponent's decommissioning responsibilities have been fulfilled.	Implement Final Decommissioning Plan	Decommissioning and rehabilitation monitoring reports	Min for Env	CEO	Decommissioning	From the date of closure until such time as the Minister determines, on advice of the CEO, the proponent's decommissioning responsibilities have been fulfilled	NR	

Audit Table continued

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Audit Code	Subject	Action (from Ministerial Statement 844)	How	Evidence	Satisfy	Advice	Phase	When	Status	Further Information
844:M12.3	Decommissioning	The proponent shall make the Final Decommissioning Plan required by condition 12-1 publicly available in a manner approved by the CEO.	Make Final Decommissioning Plan publicly available	Final Decommissioning Plan available as directed by CEO	CEO		Overall	Within two weeks of receiving approval for the final Decommissioning Plan	NR	

Note:

- Phases that apply in this table = Pre-construction, Construction, Operation, Decommissioning, Overall (several phases)
- This audit table is a summary and timetable of conditions and commitments applying to this project. Refer to the Minister's Statement for full detail/precise wording of individual elements
- Code prefixes: M = Minister's condition; P = Proponent's commitment; A= Audit specification; N= Procedure
- Any elements with status = "Audited by proponent only" are legally binding but are not required to be addressed specifically in compliance reports, if complied with
- Acronyms list:- Min for Env = Minster for the Environment; CEO = Chief Executive Officer of OEPA; OEPA = Office of the Environmental Protection Authority; EPA = Environmental Protection Authority; DEC = Department of Environment and Conservation; DMP = Department of Mines and Petroleum; DoH = Department of Health; DoF = Department of Fisheries
- Status: C – Compliant *(implementation of the proposal has been carried out in accordance with the requirements of the audit element)*; CLD – completed *(A requirement with a finite period of application has been satisfactorily completed)*; NR – Not required at this stage.
- Abbreviations: MTI MP - Marine Turtle Impact Management Plan; IMP MP - Introduced Marine Pest Management Plan; AEBPR - Air Emissions Best Practice Report;

5.0 Non-compliance and Corrective/Preventative Actions

The Operation has been fully compliant during the reporting period.

6.0 Changes to the Compliance Assessment Plan

The following changes are proposed in the Compliance Plan:

1. Change key contact from Ian Sinclair – Field Manager Onshore Gas to Nick Paris – Field Manager Onshore Gas.
2. Change Authority to Endorse to Mr Douglas Handyside – General Manager Australia.

7.0 References

BHP Billiton Petroleum 2010, Macedon Gas Project Environmental Protection Statement, July 2010 – Final. BHP Billiton Petroleum, Perth.

BHP Billiton Petroleum 2014, Macedon Gas Project Compliance Assessment Plan, (PMA-BHP-EN-EIA-0002).

8.0 Appendix 1

Macedon Rehabilitation Monitoring Report

Macedon Gas Development

Pipeline Rehabilitation Monitoring

July 2014

Document No. : PMA-BHP-EN-REP-0006

REV	DATE	Description	ORIGINATOR	CHECKER/REVIEWER	APPROVER
0	15/1/2015	Issued for Use	J Flux	S Jeffcote	B Starkey

Macedon Gas Development
Pipeline Rehabilitation Monitoring

July 2014

Prepared for
BHP Billiton Petroleum Pty Ltd (Australia)

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Report Reference: 3930-14-BISR-1Rev0_140919

Macedon Gas Development
Pipeline Rehabilitation Monitoring

Prepared for
BHP Billiton Petroleum Pty Ltd (Australia)

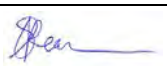
Job Number: 3930-14

Reference: 3930-14-BISR-1Rev0_140919

Revision Status

Rev	Date	Description	Author(s)	Reviewer
A	08/08/2014	Draft Issued for Client Review	N. Cadd M. Matsuki	V. Clarke
B	18/08/2014	Revised Draft Issued for Client Review	N. Cadd M. Matsuki	V. Clarke
C	19/08/2014	Revised Draft Issued for Client Review	N. Cadd M. Matsuki	M. Johnston
0	19/09/2014	Final Issued for Information	N. Cadd M. Matsuki	V. Clarke

Approval

Rev	Date	Issued to	Authorised by	
			Name	Signature
A	08/08/2014	Jill Regazzo	Stuart Pearse	
B	18/08/2014	Jill Regazzo	Stuart Pearse	
C	19/08/2014	Jill Regazzo	Stuart Pearse	
0	19/09/2014	Jill Regazzo	Stuart Pearse	

astron environmental services

Abbreviations

Abbreviation	Definition
Astron	Astron Environmental Services
BHP Billiton	BHP Billiton Petroleum Australia Pty Ltd
BOM	Bureau of Meteorology
DBNGP	Dampier to Bunbury Natural Gas Pipeline
DEC	Department of Environment and Conservation (now Department of Parks and Wildlife)
EPA	Environmental Protection Authority
ha	Hectare
km	Kilometre
m	Metre
mm	Millimetre
MS 844	Ministerial Statement 844
PERMANOVA	Permutation-Based Multivariate Analysis Of Variance
SD	Standard Deviation
spp.	Species (plural)
'the project'	The Macedon Gas Development, located near Onslow, Western Australia.
vs.	Versus
°C	Degrees Celsius

Executive Summary

In March 2012, BHP Billiton Petroleum Pty Ltd commenced rehabilitation of 285 hectares of an area that had been approved for clearing. The temporary clearing was to facilitate installation of gas pipelines associated with the Macedon Gas Development near Onslow, Western Australia. Monitoring of this rehabilitation is required to demonstrate that, within three years of commencement of rehabilitation, the reinstated vegetation has at least 60 per cent of pre-clearing species diversity and no more than the pre-clearing levels of weed cover (Condition 8 of Ministerial Statement 844).

Post-rehabilitation monitoring was commenced in May 2013, involving the assessment of 56, 20 metre line-intercept transects. Thirty-one of these transects are installed in the rehabilitated pipeline corridor, with the remaining 25 transects acting as analogue sites in nearby vegetation located outside of the clearing footprint. These transects were again monitored in July 2014.

The 2014 monitoring showed:

- Species diversity in rehabilitated transects exceeded 60% of that found in paired analogues in 19 out of 23 pairs of transects. Since 2013, two analogue transects have been destroyed due to development for another project.
- Distribution range and cover of weed species may be increasing. The number of rehabilitated transects with greater than 100% increase in weed cover since 2010 was three in 2013 but has increased to eight in 2014.
- No new weed species have been introduced.

The results of July 2014 monitoring indicated that one of the two completion criteria in Condition 8 of Ministerial Statement 844 was likely to be satisfied. By the time the 2015 monitoring is completed, species diversity in rehabilitated areas is likely to be at least 60% of that in analogue areas. However, the weed coverage is likely to be greater than that of pre-cleared levels.

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1 Introduction

1.1 Project Background

The Macedon Gas Development ('the project') is a BHP Billiton Petroleum Pty Ltd (BHP Billiton) natural gas development project. The subsea Macedon Gas Field is located 100 kilometres (km) west of the Pilbara coastal town of Onslow. The key components of the project consist of:

- a subsea pipeline and umbilical to bring gas ashore
- a 15 km buried wet gas pipeline to transport gas from the shoreline crossing to the gas treatment plant
- a single train domestic gas treatment and compression plant plus gas storage facilities at Ashburton North, approximately 15 km south-east of Onslow
- a 67 km buried domestic gas sales pipeline connecting the gas treatment plant to the existing Dampier to Bunbury Natural Gas Pipeline (DBNGP) (Figure 1).

The project was assessed by the Environmental Protection Authority (EPA) under Part IV of the *Environmental Protection Act 1986* and Ministerial approval for the project was granted on 28 October 2010. The EPA recognised that, although there would be an ongoing requirement for a pipeline access and maintenance track, the majority of vegetation cleared during pipeline installation would be rehabilitated. The EPA's advice to the Minister for Environment therefore stated that the objective for flora and vegetation would be met provided that adequate rehabilitation was commenced at the earliest opportunity. Condition 8 of the Macedon Gas Development Ministerial Statement 844 (MS 844) requires:

> ***8 Terrestrial Vegetation***
>
> *8-1 Within two months following completion of construction of the gas plant and associated pipelines, the proponent shall commence rehabilitation of the temporarily cleared areas of the site that are no longer being utilized to achieve re-establishment of vegetation, such that the following criteria are met across the distribution of the disturbance footprint within three years of commencement of rehabilitation:*
>
> *(1) Species diversity is not less than 60 percent of the known original species diversity;*
>
> *(2) Weed coverage is equal to or less than that of pre-cleared levels.*
>
> *Note: The original species diversity and weed coverage must be determined prior to clearing or from analogue sites approved by the CEO on advice from the DEC.*
>
> *8-2 In liaison with the DEC, the proponent shall monitor progressively the performance of rehabilitation for a range of sites against the criteria in condition 8-1 based on appropriately timed surveys after rain, until the completion criteria are met. The surveys shall be conducted annually unless otherwise agreed by the CEO.*

8-3 The proponent shall include a rehabilitation monitoring report in the compliance assessment report referred to in condition 4-6 commencing from the date rehabilitation was commenced. The report shall address the following:

1. *The progress made towards meeting the criteria required by condition 8-1; and*
2. *Contingency management measures in the event that the criteria required by condition 8-1 are unlikely to be met.*

In response to Condition 8.2, a methodology to progressively monitor the rehabilitation was developed. The *BHP Billiton Macedon Gas Project Pipeline Rehabilitation Monitoring and Evaluation Plan* (Astron 2012) outlines:

- a management evaluation framework to measure the effectiveness of BHP Billiton Macedon Gas Pipeline vegetation rehabilitation
- measurement procedures and tools, including statistical analyses, to determine trends towards predetermined management targets.

Only the two buried onshore pipelines were monitored in this scope of work. The wet gas pipeline between the shoreline crossing and the gas processing plant required the clearing of a 30 metre (m) wide and 15 km long corridor, with 60 hectares (ha) of vegetation clearing approved. The sales gas pipeline between the gas processing plant and the DBNGP connection required the clearing of a 30 m wide and 67 km long corridor, with 225 ha of vegetation clearing approved.

The pipeline installation was completed in March 2012, at which time pipeline rehabilitation was commenced. This involved the ripping of the compacted areas and spreading of stockpiled topsoil over the disturbed surfaces.

This report provides the framework for the rehabilitation monitoring carried out in this scope of works.

1.2 Scope and Objectives

Astron Environmental Services (Astron) was commissioned by BHP Billiton to commence annual vegetation rehabilitation monitoring to be conducted over a three year period. The first post-rainfall survey was conducted in May 2013, with annual monitoring for 2014 conducted in July. The scope of the rehabilitation monitoring surveys addresses the following objective:

- Using methodology outlined in the *BHP Billiton Macedon Gas Project Pipeline Rehabilitation Monitoring and Evaluation Plan* (Astron 2012), measure spatial and temporal changes of rehabilitated vegetation. Specifically, monitoring is required to demonstrate that the reinstated vegetation has at least 60 per cent (%) of pre-clearing or analogue diversity levels and no more than the pre-clearing or analogue levels of weed cover.

BHP Billiton Petroleum Pty Ltd

Macedon Gas Development Pipeline Rehabilitation Monitoring

Figure 1: Survey Area Location.

astron environmental services

Author: N. Cadd	Date: 18-09-2014
Drawn: C. Dyde	Figure Ref: 3930-14-BIDR-1Rev0_140918_Fig01_Locn

Datum: GDA 1994 - Projection: MGA Zone 50

0 5 10 15 20 25 30 35 40 Km

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2 Environmental Context

2.1 Climate

The climate of the Pilbara region of Western Australia is classified as arid tropical with two distinct seasons: a hot wet summer (October to April) and a mild dry winter (May to September). Much of the annual precipitation for this region results from local thunderstorms and cyclonic events, with high rainfall variability often occurring across relatively small distances (Van Vreeswyk et al. 2004).

Based on long-term climatic data from the nearest weather station at Onslow Airport (Station 5017), which is approximately 15 km north-east of the survey area, the mean annual rainfall since 1940 is 319.2 millimetres (mm) (Bureau of Meteorology (BOM) 2014) (Figure 2).

The mean maximum daily temperatures range between 25.3 degrees Celsius (°C) and 36.4°C, and range above 30°C for much of the year (BOM 2014) (Figure 2).

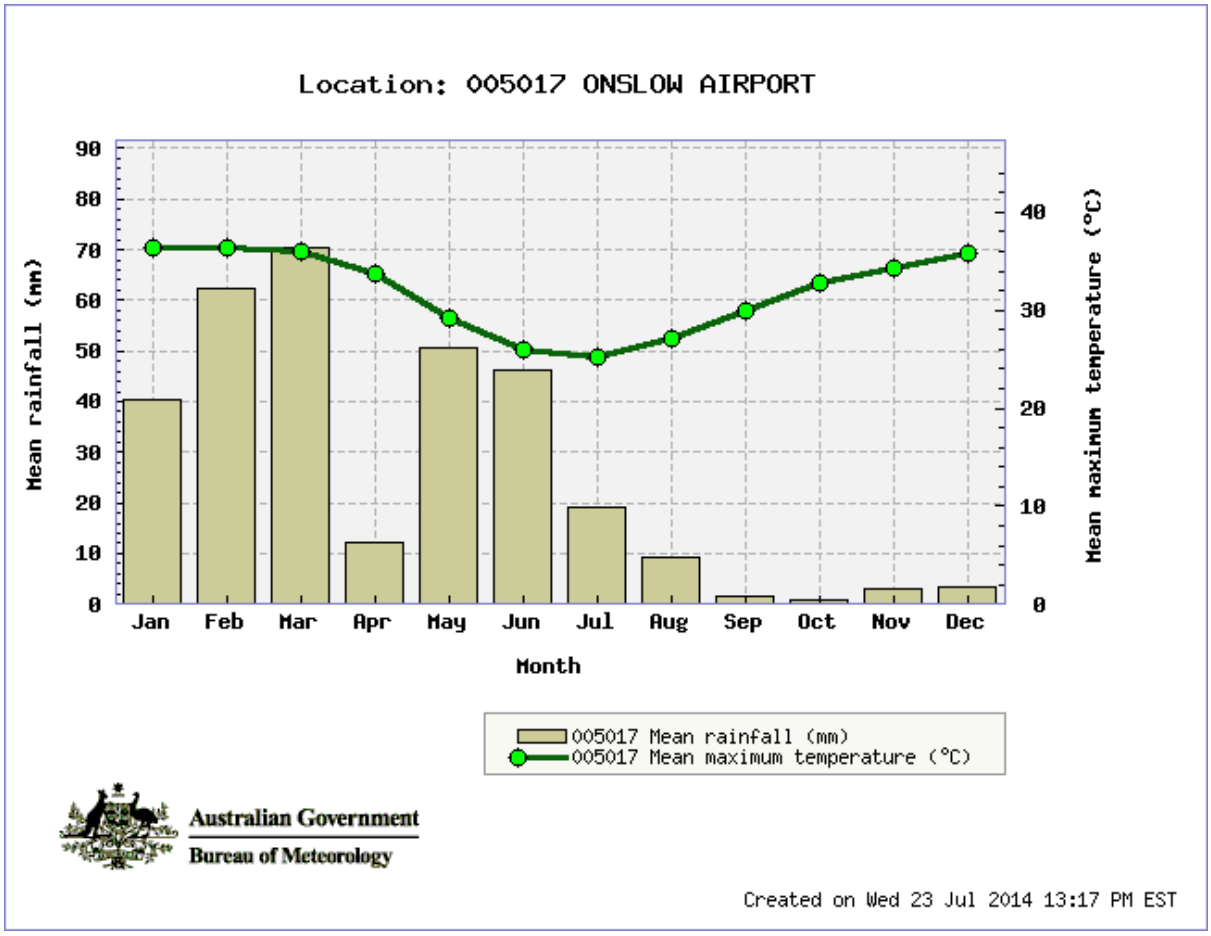


Figure 2: Climate data for Onslow Airport (Station 5017). Mean annual rainfall and mean maximum temperature data has been calculated from 1940 – 2014 (BOM 2014).

2.2 Geology and Soils

The Macedon Gas Development is located over sedimentary rocks of the Northern Carnarvon Basin. The area is dominated by an extensive coastal floodplain. Sandplain areas have low relief and are characterised by longitudinal north trending dunes. Numerous bare clay pans and circular grassy depressions occur on the clay plains (Payne et al. 1988).

The survey area is mapped as soil landscape zone 201 – Onslow Plain of the Exmouth Province. This soil unit is described as coastal mudflats (with some sandplains and coastal dunes) on coastal deposits over Cretaceous sedimentary rocks of the Carnarvon Basin. Red deep sands with red/brown non-cracking clays and red deep sandy duplexes predominate (Tille 2006).

2.3 Vegetation and Flora

Vegetation of the Onslow area is a mosaic of saline alluvial plains with samphire and saltbush shrublands, snakewood (*Acacia xiphophylla*) scrub on clay flats, and tree to shrub steppe over hummock grasslands on and between red sand dune fields (Kendrick and Mau 2002).

Vegetation of the survey area was described and mapped by Astron (2009) and largely reflects the combination of vegetation described above.

Previous surveys undertaken in the Onslow area have identified a diverse suite of native flora, as well as a number of introduced flora species (Mattiske 2013, ENV 2011, Biota 2010, Astron 2009).

3 Methodology

3.1 Monitoring Design and Field Assessment

In 2010, 56 line-intercept transects were established and initially assessed to provide baseline monitoring data. Thirty-one of the transects were originally established within the 30 m wide pipeline construction corridor, with the remaining 25 transects located outside the pipeline corridor. Each transect, 20 m in length, was installed perpendicular to the pipeline construction corridor and permanently marked with a fence dropper at each end (0 and 20 m). Transects were spaced across eight geomorphic units, along the length of the wet gas and sales gas pipeline. The distribution of transects among the geomorphic units is summarised in Table 1.

The 31 transects established within the 30 m wide pipeline construction corridor were removed during pipeline installation, however all of these transects were re-established as close to their original locations as possible during the 2013 monitoring visit (Appendix A, Figures A1 and A2). These transects are referred to as 'rehabilitation transects'.

The remaining 25 transects located outside the pipeline corridor are considered to be analogue, or control, transects (Appendix A, Figures A1 and A2). These were established within intact vegetation types that best matched the vegetation of the transects located within the pipeline construction corridor approved for clearing. They provide an undisturbed 'reference' to monitor the progress of rehabilitation against.

In 2013, all 56 rehabilitation and analogue transects were monitored. In addition, a 1 x 20 m fixed-point strip transect was monitored for each transect to ensure uncommon species were detected, particularly in the rehabilitated transects which often have considerable bare ground. This strip transect was positioned along the left side of each line-intercept transect, from the 0 m start point.

During the 2014 monitoring visit, all of the rehabilitation transects and 23 of the analogue transects were monitored. Two analogue transects (BHPPA-08 and BHPPA-09) had been removed due to the construction of an unrelated project's pipeline. Both of these transects were located within the Floodplain geomorphic unit of the Onslow land system. The current distribution of transects among geomorphic units is summarised in Table 1.

Table 1: Distribution of monitoring sites within geomorphic units, current as at July 2014.

Geomorphic unit	Broad habitat types used for statistical analysis	Number of rehabilitation transects	Number of analogue transects
Clay pans	Clay pan/floodplain	4	4
Floodplain, depressions and wide drainages and river banks (combined)	Clay pan/floodplain	5	2
Lower (stony) plains	Open plain	4	3
Undulating sandy plains	Open plain	2	1
Near level sandy/loamy plains	Open plain	5	3
Mid and lower sandy slopes	Sand dune	10	9
Crests and upper slopes of inland sand dunes	Sand dune	1	1
TOTAL		**31**	**23**

3.1.1 Data Collection

Monitoring was conducted using line-intercept transects, each with an additional adjacent 1 m x 20 m fixed-point strip transect extending the length of the transect. The following data was collected at each transect:

- **flora species** – all vascular plant species present along the transect and within the 1 m x 20 m fixed-point strip transect (including weed species)
- **transect intercept length** – the length of intercept for each flora species present along the transect
- **photographs** – two photographs were taken of each transect, one from each end (0 m and 20 m) oriented along the length of the transect (Appendix B).

3.1.2 Timing and Field Team

Two Astron ecologists undertook the monitoring, which was conducted over five days from 8 to 12 July 2014. Natalie Cadd (Senior Environmental Scientist) and Janelle Atkinson (Senior Environmental Scientist) have extensive previous experience in monitoring, botanical surveys, and plant identification in the Pilbara region. Natalie Cadd participated in both the 2010 and 2013 monitoring surveys.

3.2 Data Analysis

The use of the terms "species diversity" in MS 844 Condition 8-1 (1) is not defined and can have several different interpretations in ecology. The two most commonly used definitions are: 1) species richness or total number of species, and 2) similarity of composition (species and their relative abundance or cover: species diversity in the ecological literature (Magurran 1988)). The first definition is adopted for this project because species diversity is used interchangeably with species richness by the regulator. However, the similarity of composition was also examined to supplement results based only on the number of species.

Data on weed cover were analysed using permutation-based multivariate analysis of variance (PERMANOVA) (Anderson et al. 2008) in Primer v6 (Clarke and Gorley 2006).

Detailed descriptions of statistical data analysis can be found in Appendix C.

3.3 Limitations

The following limitation should be considered when interpreting the data presented in the report:

- Disturbance – fire history, weed infestation and cattle grazing have impacted large areas of the pipeline easement. These disturbances may have some influence on the presence and abundance of both native and introduced species.

4 Results

4.1 Rainfall (2010 – 2014)

Long-term rainfall data indicates that Onslow receives the majority of its rainfall between December and March, and May/June each year, with rainfall generally peaking in February and March (BOM 2014). Since the commencement of monitoring in 2010, the following significant rainfall events have included:

- Significantly below average rainfall for 2010.
- Above average rainfall for 2011, with peak rainfall recorded in February (284.2 mm in comparison to the long-term average of 62.3 mm).
- Significantly below average rainfall records for March 2012, 2013 and 2014, with 6.0 mm, 0 mm and 0.4 mm recorded respectively, in comparison to a long-term average of 70.4 mm.
- Above average rainfall for June 2013, with 118.4 mm received.

In the 12 months prior to the 2014 annual monitoring, 99.8 mm of rainfall was recorded at Onslow Airport in comparison with the long-term average annual rainfall of 318.9 mm. Rainfall received during the 2013/2014 wet season (October to April) was well below average; however 83.2 mm of rainfall was recorded in the three months preceding the 2014 annual monitoring (Figure 3) (BOM 2014).

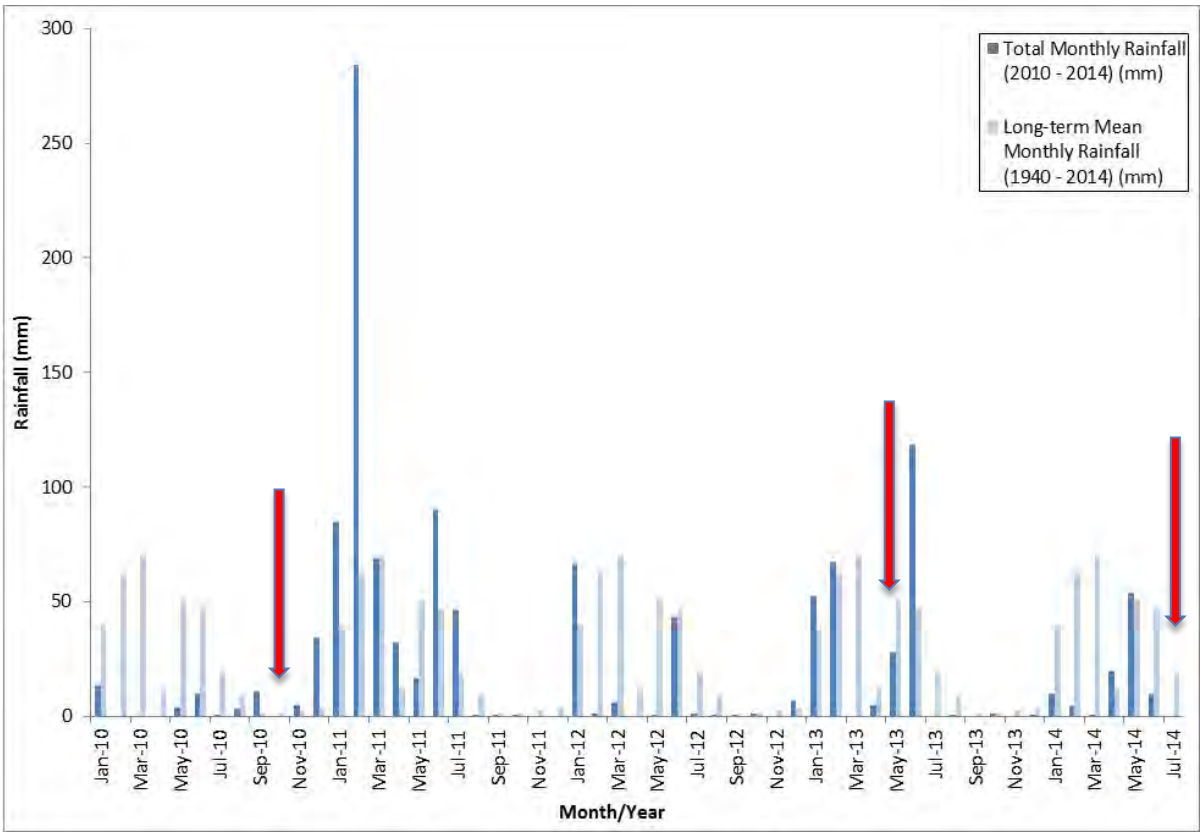


Figure 3: Long-term average and total monthly rainfall for Onslow Airport between January 2013 and July 2014 (BOM 2014). Red arrows indicate monitoring events.

4.2 Native Vegetation

4.2.1 Diversity (species richness)

In 2010, 41 species of native flora were recorded across all monitoring transects (Appendix D). Of those, 32 species were recorded in analogue transects, and 38 species were recorded in rehabilitated transects (Table 2).

In 2014, 144 species of native flora were recorded across all monitoring transects (Appendix D). Seventy species were recorded in analogue transects and 124 species were recorded in rehabilitated transects (Table 2). The number of species in line-intercept transects increased from 32 species in analogue and 38 species in rehabilitated transects in 2010 to 37 and 62 species, respectively, in 2014. Therefore, species richness increased by 63% in rehabilitated transects, while species richness remained relatively constant (16% increase) in analogue transects.

Table 2: Summary of native species richness in analogue and rehabilitated transects.

		Total	Average[1]	SD[2]	Range (min – max)[3]
Line-intercept transects only					
2010	Analogue	32	2.4	1.4	1 – 6
	Rehabilitated	38	3.0	1.4	1 – 6
2013	Analogue	30	2.4	1.2	1 – 6
	Rehabilitated	62	4.3	2.7	0 – 9
2014	Analogue	37	2.8	1.7	0 – 6
	Rehabilitated	62	3.8	2.8	0 – 12
Line-intercept transects and 1 m wide fixed-point strip transect					
2013	Analogue	46	3.2	1.7	1 – 8
	Rehabilitated	101	8.6	4.8	1 – 20
2014	Analogue	70	5.6	2.3	1 – 9
	Rehabilitated	124	9.8	5.3	1 – 23

[1] average number of species per transect

[2] standard deviation around the average number of species per transect

[3] the minimum and maximum number of species per transect

The number of annual species recorded in analogue line-intercept transects has not changed greatly across monitoring years, with two species (6% of total) recorded in 2010, one species (3% of total) in 2013 and four species (11% of total) in 2014. In rehabilitated line-intercept transects annual species increased from none in 2010, to 14 species (23% of total) in 2013 and 11 species (18% of total) in 2014.

The number of perennial species recorded in analogue line-intercept transects does not significantly differ across monitoring years. In 2010, 30 perennial species were recorded, in 2013 29 species were recorded. In 2014, 33 species were recorded. The number of perennial species in rehabilitated line-intercept transects has increased from 38 in 2010, to 48 in 2013 and 51 in 2014.

These results indicate that the increased number of annual and perennial species in rehabilitated transects in 2013 was likely to be due to the temporary disturbance and subsequent rehabilitation.

In 2010, prior to disturbance and rehabilitation, the total and average species richness per transect (i.e. the number of species) did not differ greatly between the analogue and rehabilitation transects (Table 2). In contrast, species richness was approximately twice as high in rehabilitated transects as in analogue transects in 2013 and 2014, after rehabilitation.

The general pattern of increased species richness from 2010 to 2013/2014 was also observed when the rehabilitated and matched analogue transects were compared at each site. In 2010, species richness (inclusive of both annual and perennial species) was similar between the rehabilitated and matched analogue transects in each transect pair (Figure 4: green bars). In this graph, 100% species richness means that species richness in the rehabilitated and matched analogue transects is the same, while less than 100% species richness means that there are fewer species in the rehabilitated transects than in the matched analogue transect. There was no difference in species richness in 12 pairs of rehabilitated and analogue transects in 2010.

After disturbance and rehabilitation, species richness in rehabilitated transects decreased to less than 60% of the matched analogue transects in five transect pairs in 2013, and four transect pairs in 2014 (using 1 m strip transects) (Figure 4: purple and blue bars with red border). However, 16 pairs in 2013 and nine pairs in 2014 had at least twice as many species in the rehabilitated transects than in the matched analogue transects (i.e. greater than 200% species richness).

The observed increase in the number of species in rehabilitated 1 m wide strip transects between 2013 and 2014 was likely due to idiosyncratic germination of some annual species (e.g. *Trachymene pilbarensis*, *Trichodesma zeylanicum* and *Nicotiana* spp.) and slow germination/colonisation of at least some additional perennial species (e.g. *Ptilotus* spp., *Scaevola parviflora* and *Sida cardiophylla*).

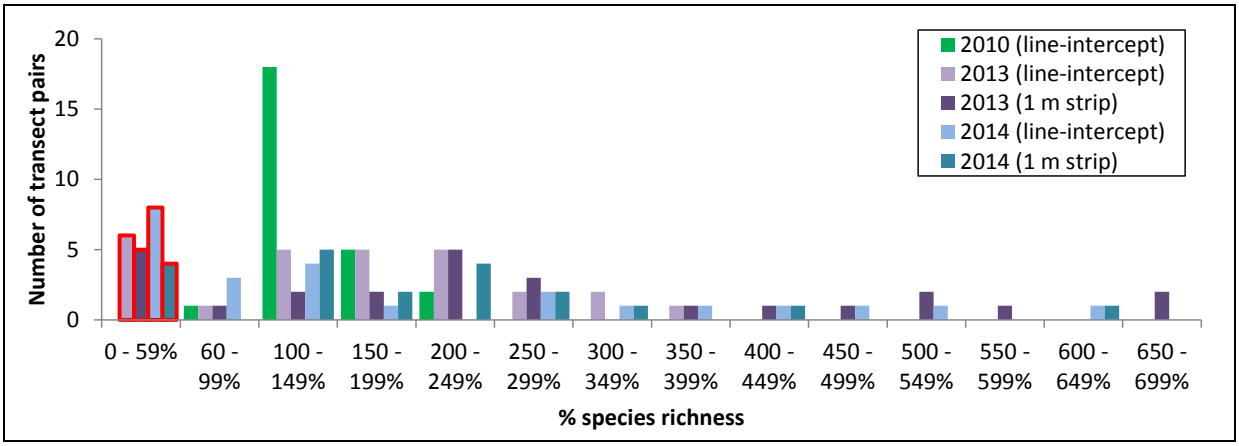


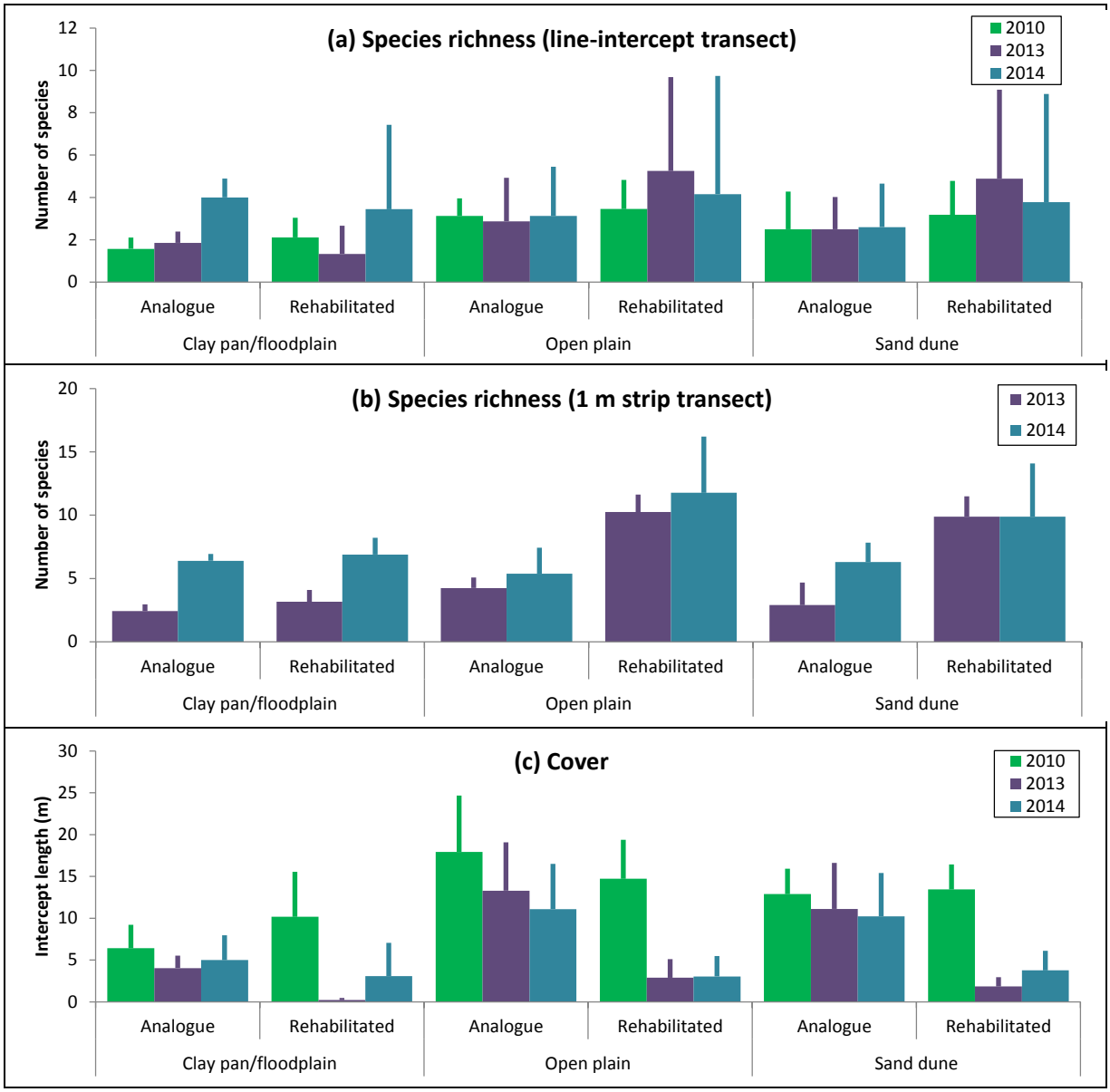
Figure 4: Percentage difference in species richness in rehabilitated transects compared with species richness in paired analogue transects. Red borders indicate that the 60% species richness rehabilitation target has not yet been met.

When changes in species richness were compared between different habitats, there were no clear differences between habitats (Figures 5a and 5b). Also, the mean species richness did not change greatly between years (except for clay pan/floodplain habitat: Figure 5a). However, in rehabilitated transects, error bars (= standard deviation (SD)) were larger in 2013 and 2014 compared with 2010. Therefore, there was much larger spatial variation in species richness after the disturbance and rehabilitation.

4.2.2 Diversity (cover)

When examined in isolation, species richness may indicate that rehabilitation has been largely successful. Changes in cover (as measured by the length of transects intercepted by native plants) provided somewhat different information. Between 2010 and 2013, the intercept length tended to

decrease in both rehabilitated and analogue transects (Figure 5c). The decrease was much greater in rehabilitated transects than in analogue transects. The disturbance and rehabilitation resulted in almost no cover of native vegetation in clay pan/floodplain habitat in 2013. However, at least some cover of native vegetation had returned to those transects in 2014.



Figures 5: Changes in species richness in line-intercept length (a), in 1 m strip transects (b), and the length of transects intercepted by native species in different habitats (c). Mean + SD.

4.2.3 Diversity (similarity of composition)

Similarity of composition can be measured in several ways. A simple index was used to compare proportion of shared species between rehabilitated and analogue transects. The index of species overlap = 1 when all species were shared between a pair of transects, while the index = 0 when no species was in common between the pair. The transects that showed an overlap of less than 0.6 (60%) is indicated by red borders (Figure 6).

In 2010, prior to disturbance and rehabilitation, 48% transect pairs shared 60% of species or greater between the rehabilitated and matched analogue transects (Figure 6: green bars). In 2013, after the

disturbance and rehabilitation, the paired rehabilitated and analogue transects tended to have disparate species composition, and less than 10% of transect pairs shared 60% of species or greater between the rehabilitated and matched analogue transects (Figure 6: purple and mauve bars). In 2014, species composition became even more disparate between the rehabilitated and matched analogue transects: No transect pairs shared 60% of species or greater (Figure 6: blue and pale blue bars). Rehabilitation has so far not re-established vegetation that is equivalent to vegetation prior to disturbance. These results indicated that disturbance and rehabilitation had transformed vegetation in terms of species composition, and at least in the short-term, there was no indication that species composition in rehabilitated transects was becoming similar to the matched analogue transects over time.

In 2010, all species shared between the paired transects were perennials. With disturbance, the perennial species were lost temporarily from the rehabilitated transects. However, some perennial species such as *Triodia* spp. and *Acacia* spp. have already returned to the rehabilitated transects by 2013. In addition to perennials, some annuals such as *Amaranthus undulatus*, *Portulaca oleracea*, *Nicotiana rosulata* and *Gomphrena canescens* have been shared between the paired transects in 2013 and 2014.

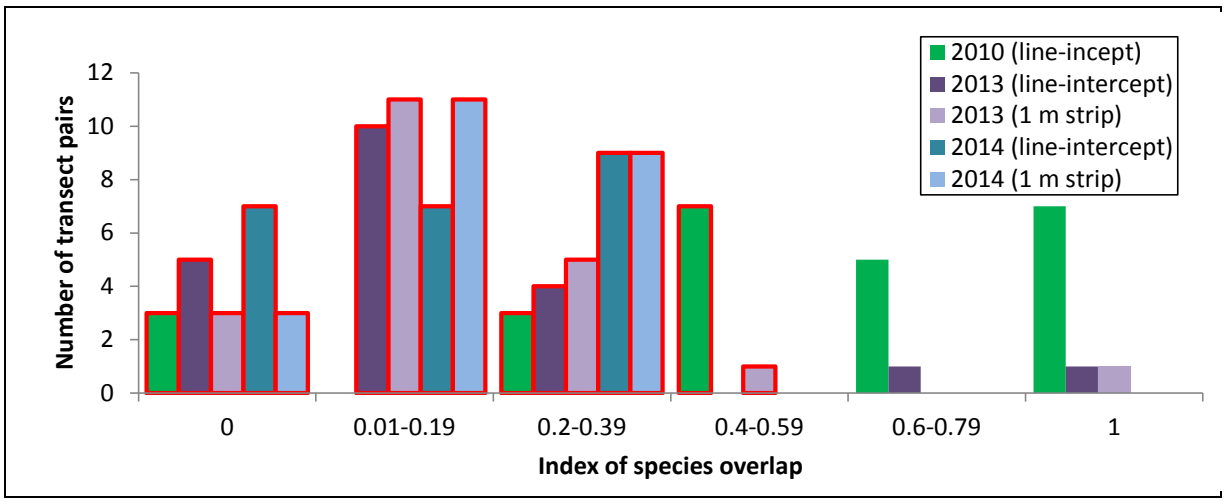


Figure 6: Comparisons of species composition between paired rehabilitated and analogue transects. The number of transects that showed less that 0.6 (60%) overlap in shared species are indicated by red borders.

4.3 Weeds

Three weed species were recorded in monitoring transects in 2010, 2013 and 2014: buffel grass (**Cenchrus ciliaris*), birdwood grass (**C. setiger*) and mimosa bush (**Vachellia farnesiana*). In 2014, buffel grass was recorded in five analogue transects and 18 rehabilitated transects, while birdwood grass was recorded in seven rehabilitated transects. Mimosa bush was recorded in one rehabilitated transect.

Since 2013, weed species distribution and cover has increased. In 2013, weeds were recorded in four analogue and 13 rehabilitated transects. In 2014, the number of transects with weeds recorded in them increased by one analogue transect and five rehabilitated transects. In terms of cover, in 2013, a total of 5.4 m and 5.2 m were intercepted by weeds in analogue and rehabilitated transects, respectively, while in 2014, 2.5 m and 27.5 m were intercepted in analogue and rehabilitated transects, respectively (Table 3). Although the increase in intercepted length by weeds in rehabilitated transects from 2013 to 2014 was five-fold (from 5.2 to 27.5 m), the mean intercept length was still less than 1 m per transects in 2014. Also, the spatial distribution of weeds was still highly patchy.

Between 2010 and 2013, four analogue transects and three rehabilitated transects displayed 100% or greater increase in the intercept length of weed species, while between 2010 and 2014, five analogue transects and eight rehabilitated transects showed 100% or greater increase in the intercept length (Figure 7a).

In four transects pairs, the intercept length in the rehabilitated transects was 100% or greater than that in the matched analogue transect in both 2013 and 2014 (Figure 7b). Although it is not possible to tell from Figures 5, changes in cover of weeds were dynamic. For example, only one of the four transect pairs were in common between 2013 and 2014. In 2013, sites 5, 22, 29 and 30 were the four transect pairs with 100% or greater difference. However, in 2014, sites 1, 4, 5 and 18 were the four transect pairs with 100% or greater difference.

The increases in weed cover were observed in clay pan/floodplain and open plain habitats (Figure 8).

Table 3: Summary of intercepted length by weed species in analogue and rehabilitated line-intercept transects.

Year	Treatment	Total	Average[1]	SD[2]	Range (min – max)[3]	Number of sites with weeds
2010	Analogue	5.7	0.23	1.14	0 – 5.7	4
	Rehabilitated	6.7	0.22	0.57	0 – 2.5	1
2013	Analogue	5.4	0.22	0.75	0 – 3.0	4[4,5]
	Rehabilitated	5.2	0.19	0.40	0 – 1.4	12[4,5]
2014	Analogue	2.5	0.10	0.48	0 – 2.4	4[6,7]
	Rehabilitated	27.5	0.89	1.57	0 – 6.5	18[6,7]

[1] average intercepted length per transect

[2] standard deviation around the average intercepted length per transect

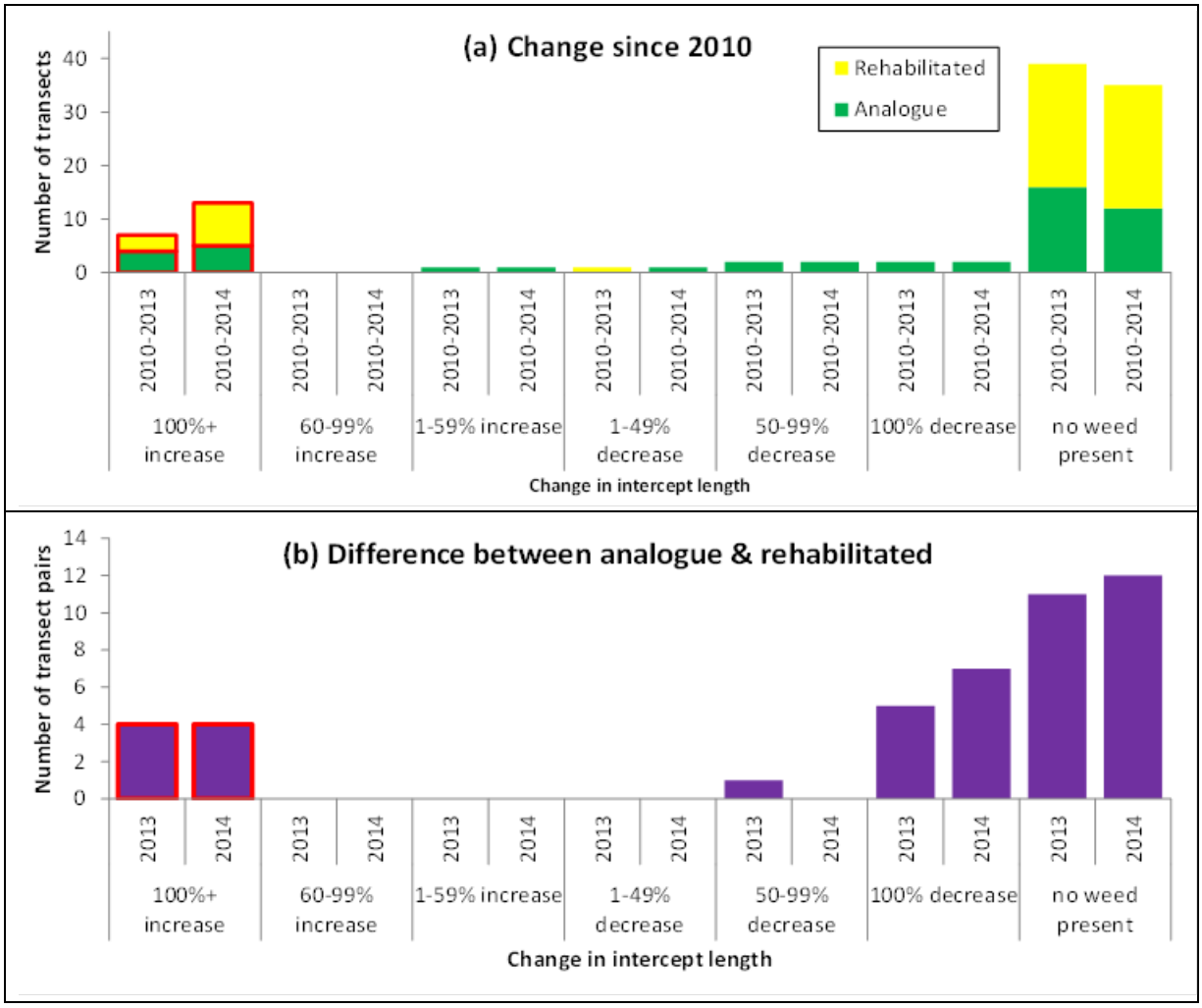
[3] the minimum and maximum intercepted length per transect

[4] list of 2014 sites with weed species (Analogue: 9 &10; Rehabilitated: 8, 9, 10, 11, 15, 18, 23, 29, 30 & 31)

[5] **Cenchrus ciliaris* was found in four additional transects in 1 m wide strip in analogue sites (12 & 29) and rehabilitated sites (5 & 19).

[6] list of 2013 sites with weed species (Analogue: 1 &3; Rehabilitated: 5, 6, 8, 9, 10, 11, 12, 13, 15, 16, 18, 23, 29, 30 & 31)

[7] **Cenchrus ciliaris* was found in five additional transects in 1 m wide strip in analogue sites (12 & 29) and rehabilitated sites (14, 17 & 19).



Figures 7: Comparison of changes in the intercepted length by weed species since 2010 (a) and differences between analogue and rehabilitated transects (b). The number of transects that showed a 100% or greater increase in the intercepted length are indicated by red borders.

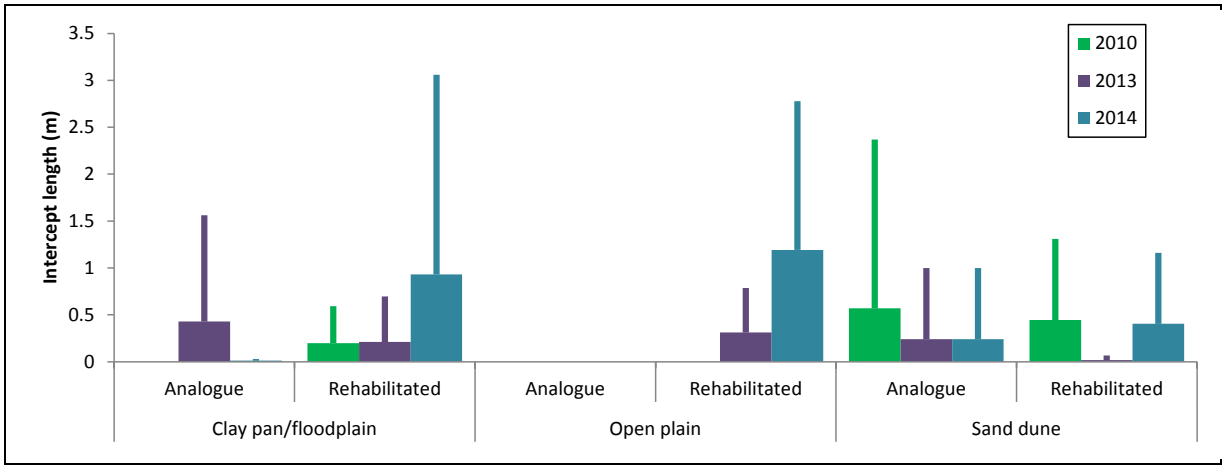


Figure 8: Changes in the length of transects intercepted by weeds in different habitats. Mean + SD.

5 Discussion

5.1 Short-term Progress of Rehabilitation

Monitoring results for May 2013 and July 2014 display a number of consistent patterns between the years, indicating that results of monitoring are unlikely to be entirely due to between-year variation in rainfall.

These consistent patterns can be described as:

- In general, rehabilitation increased species richness of both native annual and perennial species compared with the matched analogue.
- Distribution range and cover of weed species had increased. The number of rehabilitated transects with weeds has increased from 2013 to 2014, indicating that distribution range of weeds are increasing spatially in rehabilitated areas. Moreover, in 2014, weeds have been recorded in analogue transects where no weed was recorded in 2013, indicating that weeds may be spreading from rehabilitated areas into adjacent undisturbed areas. Also, the total intercept length by weeds increased from 2013 to 2014, indicating that where weeds have been present, the local cover of weeds has also been increasing.
- No new weed species have been introduced.

5.2 Medium-term Outlook

On the basis of monitoring results to date, the following tentative predictions can be made:

- Species richness is likely to fluctuate over time, especially in rehabilitated transects, due to idiosyncratic appearance and disappearance of annual species in response to between-year variation and seasonal changes in rainfall. However, species richness of native species in rehabilitated transects as a whole is unlikely to be less than 60% of that in analogue transects in 2015.
- Distribution range and cover of weed species are likely to increase over time. In 2015, it is likely that weed cover in rehabilitated transects will be greater than that in analogue transects.

Of particular note is the progress of rehabilitation of clay pan/floodplain habitats. No vegetation was found in five rehabilitated transects in 2013; four of these were clay pan/floodplain habitats dominated either by *Eriachne benthamii* or *Tecticornia* spp. Of these five transects, at least some vegetation has returned to four transects in 2014. However, *Tecticornia indica* was found in only one of the four transects, and other species present were either weeds or short-lived native species. Contingency management measures should be considered to remediate lack of appropriate vegetation in clay pan/floodplain habitats. Samphire communities in particular have long been recognised as difficult to rehabilitate and require intensive intervention (e.g. Buitenhuis 2010).

Another potentially important issue is the spread of weeds. If the data collected for monitoring along the transects are true representation of the rehabilitated areas and adjacent analogue area, then distribution of weeds are still spatially limited in the rehabilitated area. However, if the current trend (though observed over a very short period of time) continues, weeds may spread readily, especially considering that vegetation cover is generally sparse in the rehabilitated area. Implementing a weed management action as one of contingency management measures at this early stage may prove to be more cost-effective than trying to control weeds when weeds are more widespread.

The weed management plan may include at least some investigations as to why weeds are increasing, planning for which areas should (and can effectively) be treated and how, and planning for further annual monitoring (in fulfilment of MS Condition 8-2). The plan for additional monitoring should indicate whether the whole or only selected sections of the corridor (i.e. the non-compliant parts) need to be monitored.

Priority areas for revegetation are indicated in Figure 9. Transects indicated in red colour are high priority for revegetation (the length of intercept by vegetation is less than 1 m), while yellow transects indicate areas which may require future management action (the length of intercept is between 1 and 1.5 m). Green transects indicate areas that do not require revegetation (the length of intercept is greater than 1.5 m). One half of monitoring sites from the coast to the processing plant were classified as high priority for revegetation. In contrast, 36% of monitoring sites from the processing plant to the end of pipeline easement were classified as high priority.

Priority areas for weed management are indicated in Figure 10. Transects indicated in red colour are high priority for revegetation (weeds were present in 2014), while yellow transects indicate areas which may require future management action (weeds were present in 2013 but absent in 2014). Green transects indicate areas that do not require weed management (weeds were absent in 2013 and 2014). As with the revegetation sites, one half of monitoring sites from the coast to the processing plant were classified as high priority for weed management and again, 36% of monitoring sites from the processing plant to the end of pipeline easement were classified as high priority. These values are exactly the same as the values for revegetation, however, different sets of monitoring sites were classified as high priority for revegetation or for weed management.

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280000 290000 300000 310000 320000 330000 340000

7590000 7580000 7570000 7560000

ASHBURTON RIVER

CANE RIVER

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

Legend

- Tracks
- River
- Gas Plant Site
- Macedon Gas Pipeline Easement

Transects (*schematic purposes only)

- Priority For Management - A
- Priority For Management - R
- May Require Management - A
- May Require Management - R
- No Action Required - A
- No Action Required - R

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Macedon Gas Development Pipeline Rehabilitation Monitoring

Figure 9: Priority areas for revegetation.

Datum: GDA 1994 - Projection: MGA Zone 50

0 1 2 3 4 5 6 7 8 9 10 Kilometres

N

astron environmental services

Author: M. Matsuki | Drawn: C. Dyde | Date: 18-09-2014 | Figure Ref: 3930-14-BIDR-1Rev0_140918_Fig09

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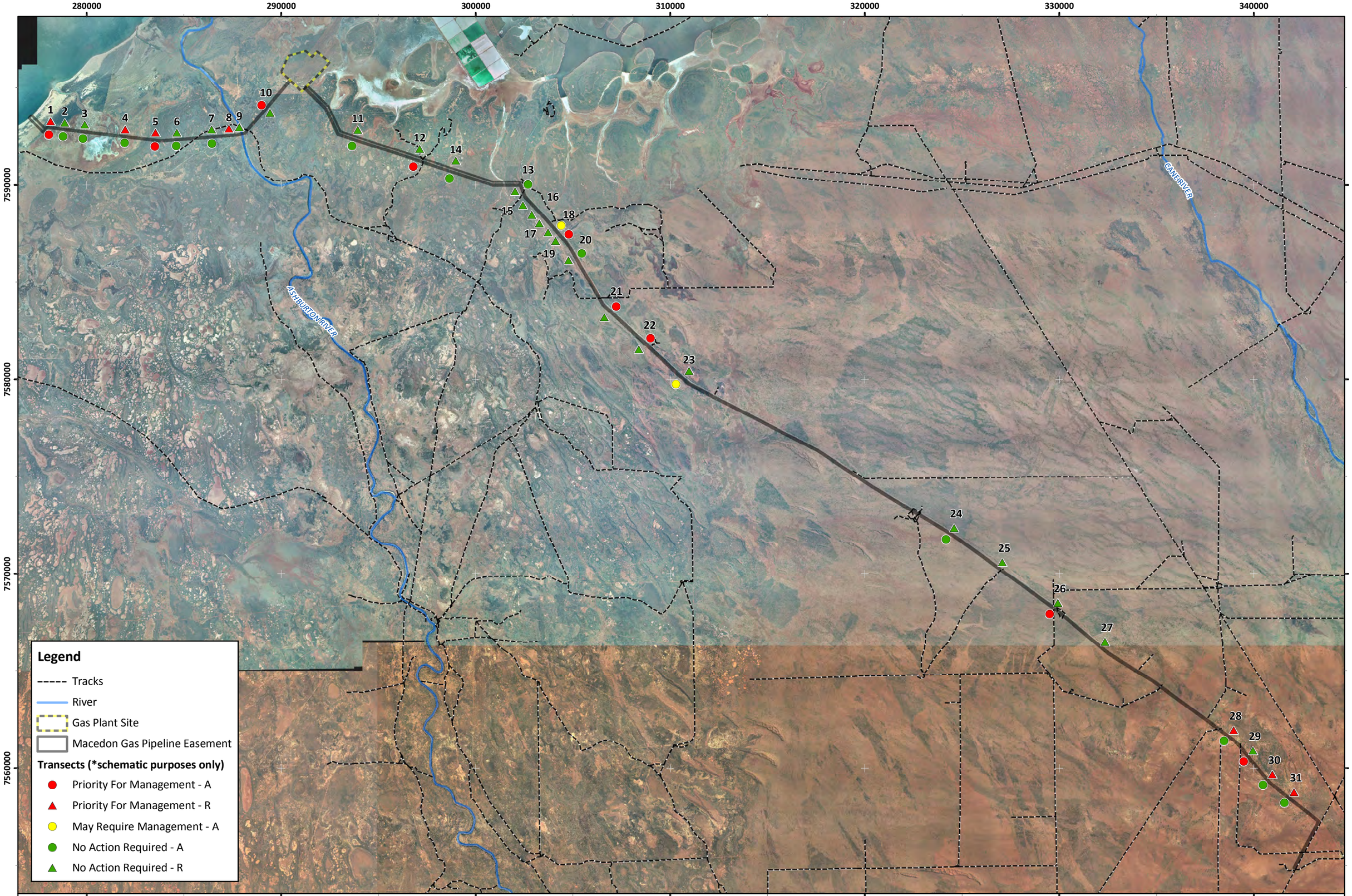

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Figure 10: Priority areas for weed management.

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Author: M. Matsuki | Drawn: C. Dyde | Date: 18-09-2014 | Figure Ref: 3930-14-BIDR-1Rev0_140918_Fig10

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6 Conclusions

The second year of monitoring since the rehabilitation of the onshore gas pipelines in March 2012, has demonstrated some progress in most areas towards meeting the completion criteria outlined in Condition 8.1 of MS 844. Overall, the reinstated vegetation is likely to have at least 60% of pre-clearing or analogue diversity levels. Native vegetation appears to be following a successional trajectory that will result in diverse communities. These communities will help stabilise disturbed soil, and the disturbed areas should eventually be integrated into the surrounding environment. The exception to this progress is clay pan/flood plain habitats which have little establishment of vegetation. Contingency management measures should be considered to remediate this.

While current data indicates that weed cover is still low in rehabilitated areas; future intervention may be necessary as weeds mature and spread. Implementing a weed management program as a contingency management measure at this early stage may prove to be more cost-effective than trying to control weeds after they have already become widespread.

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Appendix A: Transect Locations

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280000 290000 300000 310000

7600000 7590000 7580000

SEAVIEW DR
CANE RIVER
A.1
A.2
ASHBURTON RIVER
URALA RD
ASHBURTON RIVER
OLD ONSLOW RD
ONSLOW - PEEDAMULLA RD
ONSLOW RD
TWITCHIN RD

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

Legend

- Roads
- Tracks
- River
- Gas Plant Site
- Macedon Gas Pipeline Easement

Transect Location

- Rehabilitation and Analogue
- Rehabilitation

BHPB

Macedon Gas Development Pipeline Rehabilitation Monitoring

Figure A.1: Transect Locations.

Datum: GDA 1994 - Projection: MGA Zone 50

0 1 2 3 4 5 Kilometres

N

astron environmental services

Author: N. Cadd | Drawn: C. Dyde | Date: 18-09-2014 | Figure Ref: 3930-14-BIDR-1Rev0_140918_FigA1

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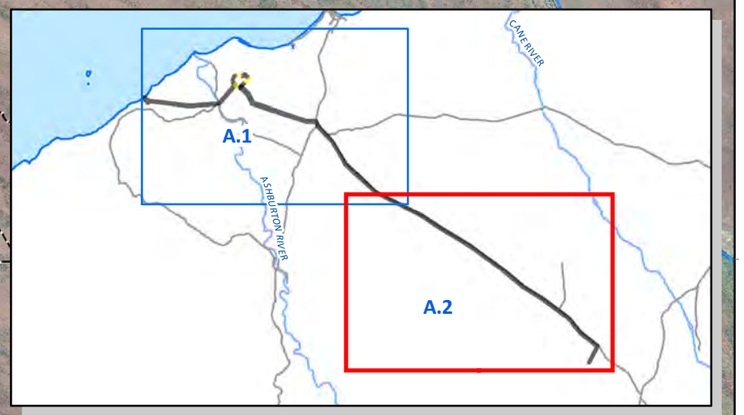
310000 320000 330000 340000

7570000

7560000



24 25 26 27 28 29 30 31

ONSLOW RD

MT MINNIE STATION RD

Legend

- Roads
- Tracks
- River
- Gas Plant Site
- Macedon Gas Pipeline Easement

Transect Location

- Rehabilitation and Analogue
- Rehabilitation

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Macedon Gas Development Pipeline Rehabilitation Monitoring

Figure A.2: Transect Locations.

Datum: GDA 1994 - Projection: MGA Zone 50

0 1 2 3 4 5 Kilometres

N

astron environmental services

Author: N. Cadd | Drawn: C. Dyde | Date: 18-09-2014 | Figure Ref: 3930-14-BIDR-1Rev0_1400918_FigA2

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Appendix B: Transect Photographs

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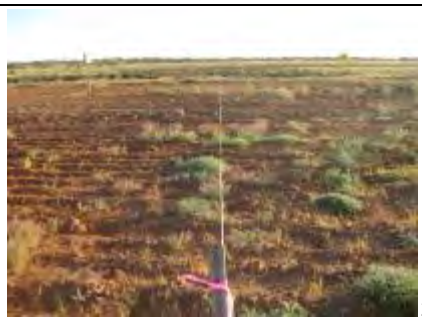
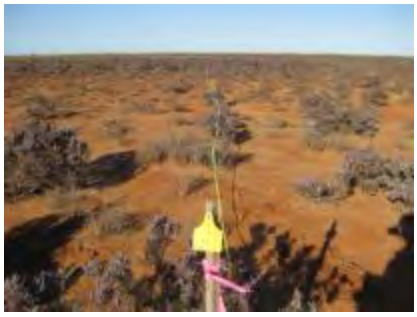
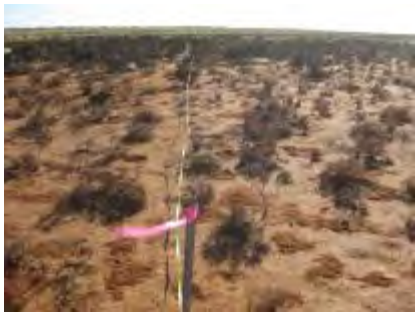
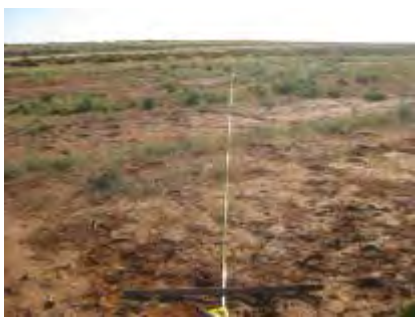
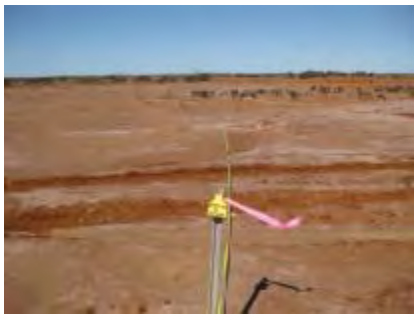
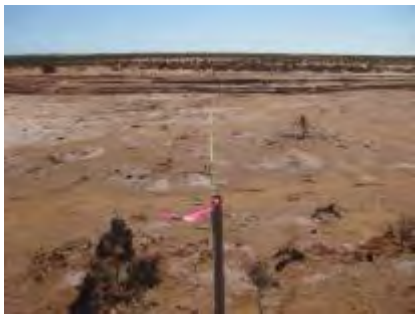
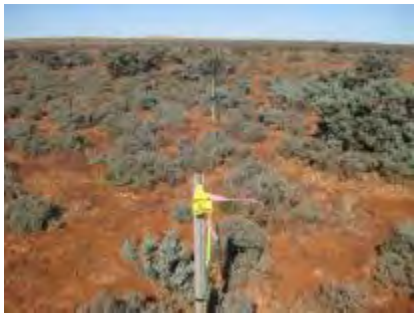
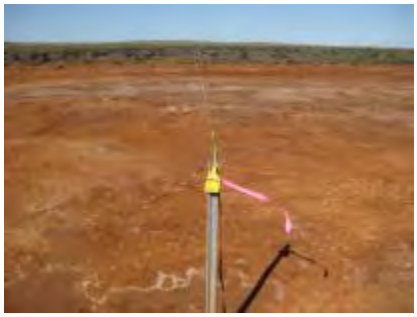
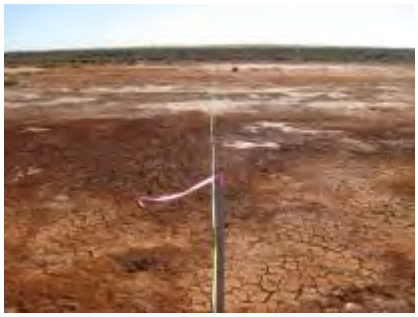
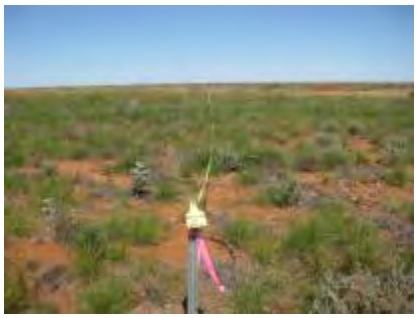
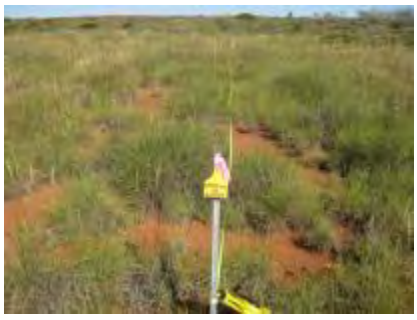
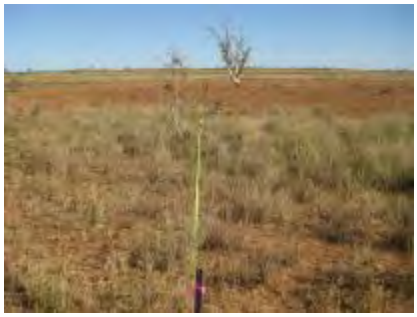
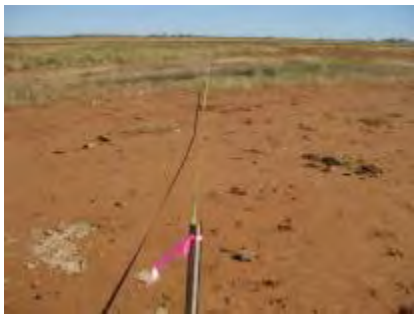
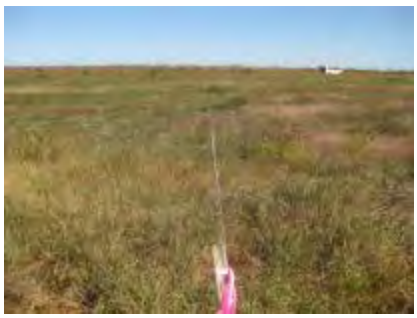
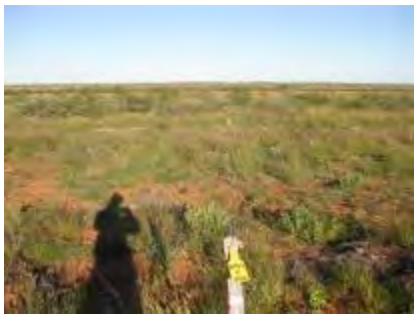
Table B.1: Rehabilitation and analogue transect photographs.

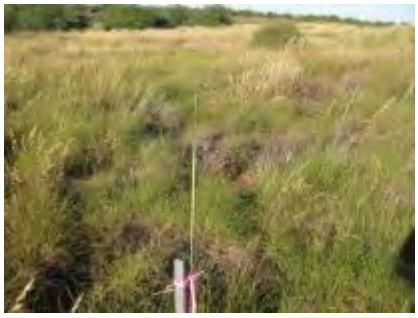
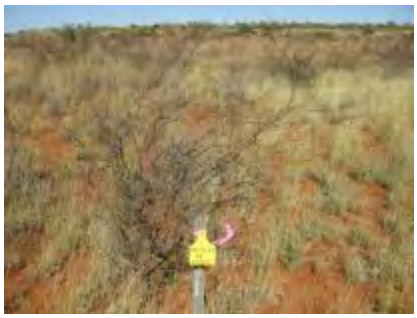
Transect: BHPPA-01 (A)			
Land System: Onslow		**Geomorphic Unit: Clay pans**	
 0 m		 20 m	
Easting (0 m): 283534	**Northing (0 m):** 7592268	**Easting (20 m):** 283534	**Northing (20 m):** 7592252
Transect: BHPPD-01 (R)			
Land System: Onslow		**Geomorphic Unit: Clay pans**	
 0 m		 20 m	
Easting (0 m): 278303	**Northing (0 m):** 7592913	**Easting (20 m):** 278305	**Northing (20 m):** 7592896
Transect: BHPPA-02 (A)			
Land System: Onslow		**Geomorphic Unit: Clay pans**	
 0 m		 20 m	
Easting (0 m): 278672	**Northing (0 m):**7592831	**Easting (20 m):** 278662	**Northing (20 m):** 7592814
Transect: BHPPD-02 (R)			
Land System: Onslow		**Geomorphic Unit: Clay pans**	
 0 m		 20 m	
Easting (0 m): 278684	**Northing (0 m):** 7592879	**Easting (20 m):** 278670	**Northing (20 m):** 7592863

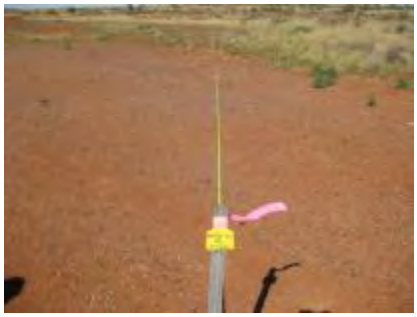
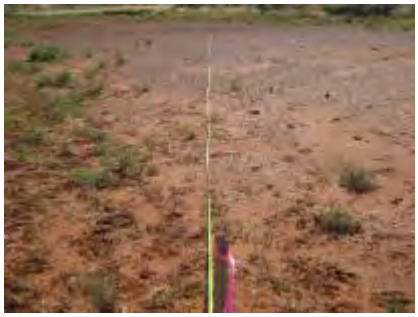
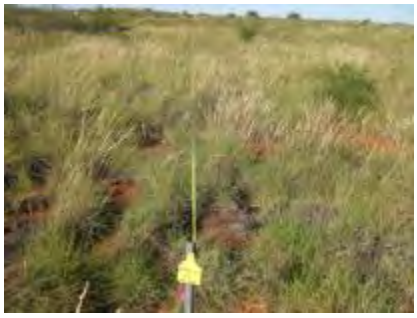
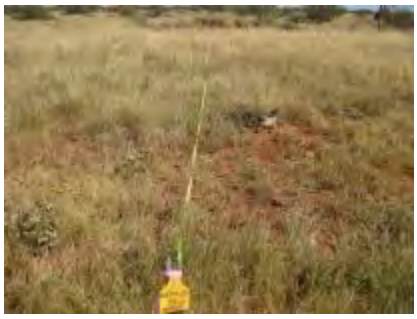
Transect: BHPPA-03 (A)			
Land System: Littoral		**Geomorphic Unit: Clay pans**	
 0 m		 20 m	
Easting (0 m): 279808	**Northing (0 m):** 7592694	**Easting (20 m):** 279797	**Northing (20 m):** 7592676
Transect: BHPPD-03 (R)			
Land System: Littoral		**Geomorphic Unit: Clay pans**	
 0 m		 20 m	
Easting (0 m): 279826	**Northing (0 m):** 7592738	**Easting (20 m):** 279816	**Northing (20 m):** 7592724
Transect: BHPPA-04 (A)			
Land System: Littoral		**Geomorphic Unit: Clay pans**	
 0 m		 20 m	
Easting (0 m): 281952	**Northing (0 m):** 7592437	**Easting (20 m):** 281940	**Northing (20 m):** 7592419
Transect: BHPPD-04 (R)			
Land System: Littoral		**Geomorphic Unit: Clay pans**	
 0 m		 20 m	
Easting (0 m): 281965	**Northing (0 m):** 7592490	**Easting (20 m):** 281963	**Northing (20 m):** 7592470

Transect: BHPPA-05 (A)			
Land System: Dune		**Geomorphic Unit: Clay pans**	
 0 m		 20 m	
Easting (0 m): 283534	**Northing (0 m):** 7592271	**Easting (20 m):** 283537	**Northing (20 m):** 7592253
Transect: BHPPD-05 (R)			
Land System: Dune		**Geomorphic Unit: Crests/ upper slopes of inland sand dunes**	
 0 m		 20 m	
Easting (0 m): 283529	**Northing (0 m):** 7592321	**Easting (20 m):** 283522	**Northing (20 m):** 7592305
Transect: BHPPA-06 (A)			
Land System: Dune		**Geomorphic Unit: Clay pans**	
 0 m		 20 m	
Easting (0 m): 284704	**Northing (0 m):** 7592395	**Easting (20 m):** 284707	**Northing (20 m):** 7592376
Transect: BHPPD-06 (R)			
Land System: Dune		**Geomorphic Unit: Mid and lower sandy slopes**	
 0 m		 20 m	
Easting (0 m): 284703	**Northing (0 m):** 7592347	**Easting (20 m):** 284715	**Northing (20 m):** 7592330

Transect: BHPPA-07 (A)			
Land System: Dune		**Geomorphic Unit: Clay pans**	
 0 m		 20 m	
Easting (0 m): 286541	**Northing (0 m):** 7592535	**Easting (20 m):** 286536	**Northing (20 m):** 7592516
Transect: BHPPD-07 (R)			
Land System: Onslow		**Geomorphic Unit: Floodplain depressions/wide drainage**	
 0 m		 20 m	
Easting (0 m): 286478	**Northing (0 m):** 7592492	**Easting (20 m):** 286468	**Northing (20 m):** 7592475
Transect: BHPPA-08 (A) – transect no longer exists. Has been removed due to adjacent pipeline installation.			
Transect: BHPPD-08 (R)			
Land System: Nanyarra		**Geomorphic Unit: Floodplain depressions/wide drainage**	
 0 m		 20 m	
Easting (0 m): 287555	**Northing (0 m):** 7592577	**Easting (20 m):** 287548	**Northing (20 m):** 7592558

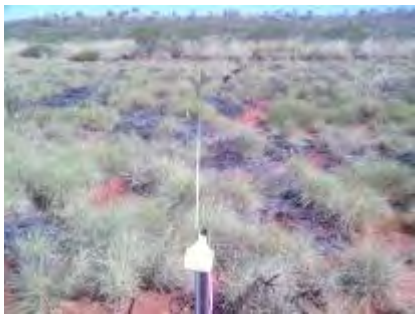
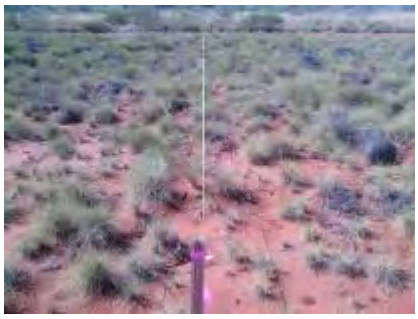
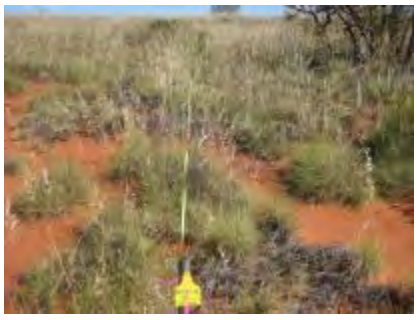
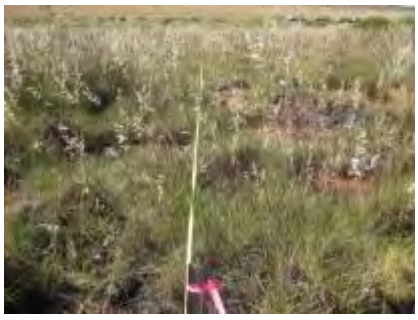
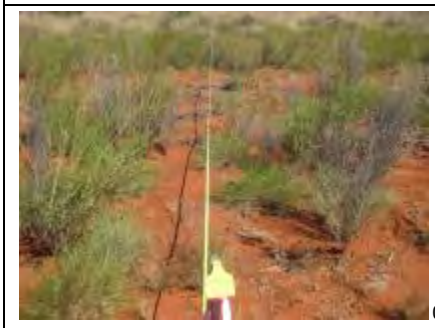
Transect: BHPPA-09 (A) – transect no longer exists. Has been removed due to adjacent pipeline installation.			
Transect: BHPPD-09 (R)			
Land System: Nanyarra		**Geomorphic Unit: Mid and lower sandy slopes**	
 0 m		 20 m	
Easting (0 m): 287687	**Northing (0 m):** 7592585	**Easting (20 m):** 287685	**Northing (20 m):** 7592565
Transect: BHPPA-10 (A)			
Land System: Onslow		**Geomorphic Unit: Crests/upper slopes of inland sand dunes**	
 0 m		 20 m	
Easting (0 m): 289230	**Northing (0 m):** 7593855	**Easting (20 m):** 289228	**Northing (20 m):** 7593836
Transect: BHPPD-10 (R)			
Land System: Onslow		**Geomorphic Unit: Mid and lower sandy slopes**	
 0 m		 20 m	
Easting (0 m): 289198	**Northing (0 m):** 7593901	**Easting (20 m):** 289216	**Northing (20 m):** 7593890
Transect: BHPPA-11 (A)			
Land System: Onslow		**Geomorphic Unit: Mid and lower sandy slopes**	
 0 m		 20 m	
Easting (0 m): 294303	**Northing (0 m):** 7592388	**Easting (20 m):** 294298	**Northing (20 m):** 7592369

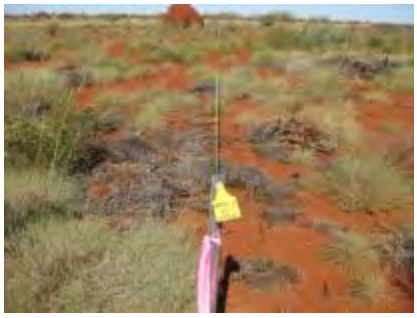
Transect: BHPPD-11 (R)			
Land System: Onslow		**Geomorphic Unit: Mid and lower sandy slopes**	
 0 m		 20 m	
Easting (0 m): 293798	**Northing (0 m):** 7592338	**Easting (20 m):** 293797	**Northing (20 m):** 7592319
Transect: BHPPA-12 (A)			
Land System: Onslow		**Geomorphic Unit: Mid and lower sandy slopes**	
 0 m		 20 m	
Easting (0 m): 297024	**Northing (0 m):** 7591488	**Easting (20 m):** 297031	**Northing (20 m):** 7591506
Transect: BHPPD-12 (R)			
Land System: Onslow		**Geomorphic Unit: Mid and lower sandy slopes**	
 0 m		 20 m	
Easting (0 m): 296942	**Northing (0 m):** 7591296	**Easting (20 m):** 296929	**Northing (20 m):** 7591284
Transect: BHPPA-13 (A)			
Land System: Dune		**Geomorphic Unit: Floodplain depressions/ wide drainage**	
 0 m		 20 m	
Easting (0 m): 302313	**Northing (0 m):** 7589813	**Easting (20 m):** 302300	**Northing (20 m):** 7589796

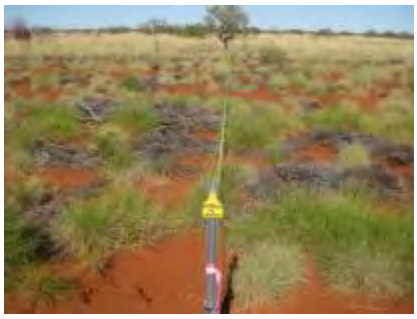
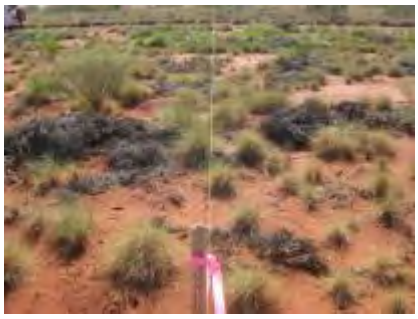
Transect: BHPPD-13 (R)			
Land System: Dune		**Geomorphic Unit: Mid and lower sandy slopes**	
 0 m		 20 m	
Easting (0 m): 302352	**Northing (0 m):** 7589883	**Easting (20 m):** 302345	**Northing (20 m):** 7589864
Transect: BHPPA-14 (A)			
Land System: Dune		**Geomorphic Unit: Floodplain depressions/ wide drainage**	
 0 m		 20 m	
Easting (0 m): 298881	**Northing (0 m):** 7590837	**Easting (20 m):** 298877	**Northing (20 m):** 7590813
Transect: BHPPD-14 (R)			
Land System: Dune		**Geomorphic Unit: Mid and lower sandy slopes**	
 0 m		 20 m	
Easting (0 m): 298799	**Northing (0 m):** 7590685	**Easting (20 m):** 298787	**Northing (20 m):** 7590673
Transect: BHPPD-15 (R)			
Land System: Onslow		**Geomorphic Unit: Mid and lower sandy slopes**	
 0 m		 20 m	
Easting (0 m): 302763	**Northing (0 m):** 7589168	**Easting (20 m):** 302753	**Northing (20 m):** 7589164

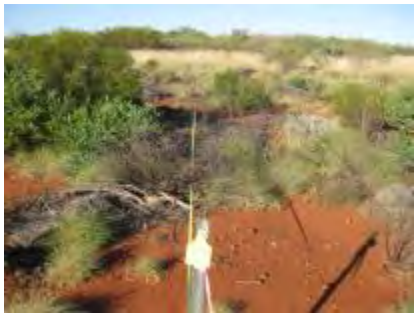
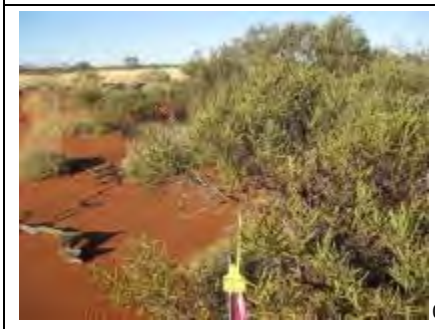
Transect: BHPPD-16 (R)			
Land System: Onslow		**Geomorphic Unit: Mid and lower sandy slopes**	
 0 m		 20 m	
Easting (0 m): 303221	**Northing (0 m):** 7588680	**Easting (20 m):** 303206	**Northing (20 m):** 7588665
Transect: BHPPD-17 (R)			
Land System: Onslow		**Geomorphic Unit: Near level sandy/loamy plains**	
 0 m		 20 m	
Easting (0 m): 303612	**Northing (0 m):** 7588247	**Easting (20 m):** 303601	**Northing (20 m):** 7588234
Transect: BHPPA-18 (A)			
Land System: Dune		**Geomorphic Unit: Floodplain depressions/wide drainage**	
 0 m		 20 m	
Easting (0 m): 303970	**Northing (0 m):** 7587732	**Easting (20 m):** 303956	**Northing (20 m):** 7587718
Transect: BHPPD-18 (R)			
Land System: Onslow		**Geomorphic Unit: Near level sandy/loamy plains**	
 0 m		 20 m	
Easting (0 m): 304048	**Northing (0 m):** 7587760	**Easting (20 m):** 304038	**Northing (20 m):** 7587748

Transect: BHPPA-19 (A)			
Land System: Onslow		**Geomorphic Unit: Floodplain depressions/wide drainage**	
 0 m		 20 m	
Easting (0 m): 304421	**Northing (0 m):** 7587249	**Easting (20 m):** 304412	**Northing (20 m):** 7587231
Transect: BHPPD-19 (R)			
Land System: Onslow		**Geomorphic Unit: Near level sandy/loamy plains**	
 0 m		 20 m	
Easting (0 m): 304436	**Northing (0 m):** 7587320	**Easting (20 m):** 304432	**Northing (20 m):** 7587302
Transect: BHPPA-20 (A)			
Land System: Giralia		**Geomorphic Unit: Floodplain depressions/wide drainage**	
 0 m		 20 m	
Easting (0 m): 305056	**Northing (0 m):** 7586326	**Easting (20 m):** 305039	**Northing (20 m):** 7586316
Transect: BHPPD-20 (R)			
Land System: Giralia		**Geomorphic Unit: Near level sandy/loamy plains**	
 0 m		 20 m	
Easting (0 m): 305113	**Northing (0 m):** 7586339	**Easting (20 m):** 305102	**Northing (20 m):** 7586329

Transect: BHPPA-21 (A)			
Land System: Giralia		**Geomorphic Unit: Floodplain depressions/wide drainage**	
 0 m		 20 m	
Easting (0 m): 306946	**Northing (0 m):** 7583418	**Easting (20 m):** 306925	**Northing (20 m):** 7583411
Transect: BHPPD-21 (R)			
Land System: Giralia		**Geomorphic Unit: Near level sandy/loamy plains**	
 0 m		 20 m	
Easting (0 m): 306992	**Northing (0 m):** 7583465	**Easting (20 m):** 306986	**Northing (20 m):** 7583446
Transect: BHPPA-22 (A)			
Land System: Giralia		**Geomorphic Unit: Mid and lower sandy slopes**	
 0 m		 20 m	
Easting (0 m): 308722	**Northing (0 m):** 7581767	**Easting (20 m):** 308707	**Northing (20 m):** 7581757
Transect: BHPPD-22 (R)			
Land System: Giralia		**Geomorphic Unit: Near level sandy/loamy plains**	
 0 m		 20 m	
Easting (0 m): 308753	**Northing (0 m):** 7581829	**Easting (20 m):** 308743	**Northing (20 m):** 7581814

Transect: BHPPA-23			
Land System: Giralia		**Geomorphic Unit: Mid and lower sandy slopes**	
 0 m		 20 m	
Easting (0 m): 310680	**Northing (0 m):** 7579965	**Easting (20 m):** 310663	**Northing (20 m):** 7579949
Transect: BHPPD-23 (R)			
Land System: Giralia		**Geomorphic Unit: Near level sandy/loamy plains**	
 0 m		 20 m	
Easting (0 m): 310693	**Northing (0 m):** 7580026	**Easting (20 m):** 310681	**Northing (20 m):** 7580010
Transect: BHPPA-24 (A)			
Land System: Uaroo		**Geomorphic Unit: Mid and lower sandy slopes**	
 0 m		 20 m	
Easting (0 m): 324359	**Northing (0 m):** 7572037	**Easting (20 m):** 324352	**Northing (20 m):** 7572018
Transect: BHPPD-24 (R)			
Land System: Uaroo		**Geomorphic Unit: Near level sandy/loamy plains**	
 0 m		 20 m	
Easting (0 m): 324437	**Northing (0 m):** 7572060	**Easting (20 m):** 324428	**Northing (20 m):** 7572043

Transect: BHPPD-25 (R)			
Land System: Uaroo		**Geomorphic Unit: Near level sandy/loamy plains**	
 0 m		 20 m	
Easting (0 m): 326911	**Northing (0 m):** 7570292	**Easting (20 m):** 326903	**Northing (20 m):** 7570273
Transect: BHPPA-26 (A)			
Land System: Uaroo		**Geomorphic Unit: Mid and lower sandy slopes**	
 0 m		 20 m	
Easting (0 m): 329727	**Northing (0 m):** 7568156	**Easting (20 m):** 329716	**Northing (20 m):** 7568139
Transect: BHPPD-26 (R)			
Land System: Uaroo		**Geomorphic Unit: Lower (stony) plains**	
 0 m		 20 m	
Easting (0 m): 329764	**Northing (0 m):** 7568214	**Easting (20 m):** 329760	**Northing (20 m):** 7568195
Transect: BHPPD-27 (R)			
Land System: Uaroo		**Geomorphic Unit: Lower (stony) plains**	
 0 m		 20 m	
Easting (0 m): 332180	**Northing (0 m):** 7566205	**Easting (20 m):** 332173	**Northing (20 m):** 7566188

Transect: BHPPA-28 (A)			
Land System: Stuart		**Geomorphic Unit: Mid and lower sandy slopes**	
 0 m		 20 m	
Easting (0 m): 338649	**Northing (0 m):** 7561624	**Easting (20 m):** 338638	**Northing (20 m):** 7561607
Transect: BHPPD-28 (R)			
Land System: Stuart		**Geomorphic Unit: Lower (stony) plains**	
 0 m		 20 m	
Easting (0 m): 338709	**Northing (0 m):** 7561652	**Easting (20 m):** 338704	**Northing (20 m):** 7561632
Transect: BHPPA-29 (A)			
Land System: Stuart		**Geomorphic Unit: Mid and lower sandy slopes**	
 0 m		 20 m	
Easting (0 m): 339668	**Northing (0 m):** 7560530	**Easting (20 m):** 339663	**Northing (20 m):** 7560510
Transect: BHPPD-29 (R)			
Land System: Stuart		**Geomorphic Unit: Lower (stony) plains**	
 0 m		 20 m	
Easting (0 m): 339711	**Northing (0 m):** 7560604	**Easting (20 m):** 339703	**Northing (20 m):** 7560590

Transect: BHPPA-30 (A)			
Land System: Stuart		**Geomorphic Unit: Mid and lower sandy slopes**	
 0 m		 20 m	
Easting (0 m): 340703	**Northing (0 m):** 7559306	**Easting (20 m):** 340696	**Northing (20 m):** 7559287
Transect: BHPPD-30 (R)			
Land System: Stuart		**Geomorphic Unit: Lower (stony) plains**	
 0 m		 20 m	
Easting (0 m): 340706	**Northing (0 m):** 7559391	**Easting (20 m):** 340699	**Northing (20 m):** 7559379
Transect: BHPPD-31 (R)			
Land System: Stuart		**Geomorphic Unit: Lower (stony) plains**	
 0 m		 20 m	
Easting (0 m): 341811	**Northing (0 m):** 7558474	**Easting (20 m):** 341800	**Northing (20 m):** 7558458

Appendix C: Statistical Analysis Supporting Documentation

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Section 1 - Transect Data Included in Analyses

For mostly technical reasons, some transect data had to be excluded from the analyses. The following explains which transects have been excluded and the reason for exclusion.

In the following transect data are specified by the site number (between 1 and 31), A (= analogue) or R (= rehabilitated) and year (2010 or 2013). For example 15R 2010 specifies the following: site 15, rehabilitated transect and data collected in 2010.

PERMANOVA

For PEMANOVA, data from transects 8R 2014, 9R 2014, 15R 2010, 2013 & 2014, 16R 2010, 2013 & 2014, 17R 2010, 2013 & 2014, 25R 2010, 2013 & 2014, 27R 2010, 2013 & 2014, and 31R 2010, 2013 & 2014 were excluded from all analyses because these transects did not have matched analogue transects.

Figure and Table Formulation

For generating Tables 2 and 4, all transects were used.

For the analysis for generating Figures 4 and 5b, data from transects 15R 2010, 2013 & 2014, 16R 2010, 2013 & 2014, 17R 2010, 2013 & 2014, 25R 2010, 2013 & 2014, 27R 2010, 2013 & 2014, and 31R 2010, 2013 & 2014 were excluded because these transects did not have matched analogue transects. 8A 2014 and 9A 2014 were also excluded because these transects had been destroyed by disturbance since the 2013 field visit.

For the analysis for generating Figure 5a, sites 8, 9, 15, 16, 17, 25, 27, and 31 were excluded because these sites had only rehabilitated transects.

Section 2 – Detailed Descriptions of Data Analysis

Whether the management targets have been met was examined by differences between rehabilitated transects and analogue transects. Two response variables were used in the analysis: 1) species diversity (i.e. the number of species) and 2) total length of transect intercepted by all weed species. For species diversity, whether the number of species in rehabilitated transects was greater than or equal to 60% of the number of species in analogue transects in each year. For the total length of transects intercepted by all weed species, whether the intercept length in rehabilitated transects was less than or equal to that in analogue transects in each year.

The permutation-based multivariate analysis of variance (PERMANOVA; Anderson et al. 2008) was used to examine whether the two rehabilitation management targets have been met. The two response variables did not meet the normality assumption of analysis of variance, and hence the analysis using the usual analysis of variance was not appropriate. PERMANOVA allows one to analyse data that do not meet the normality assumption. For analysis of the two response variables, the same statistical model was used: analysis of variance for randomised block design with the fixed-factor treatment (rehabilitation vs. analogue) and sites as the random factor block. Each year was analysed separately. Analysis of variance for randomised block design is the most appropriate way to analyse data for this project because at each site, each rehabilitated transects has a matched analogue transect. Therefore, the site in this project is equivalent to the block in randomised block

design. The analysis using randomised block design allows one to differences between treatments (i.e. rehabilitated vs. analogue) after factoring out variation between blocks (i.e. sites).

Prior to analysis using PERMANOVA, the number of native species and total length of transect intercepted by all weed species in each transect were converted into similarity/distance matrices by calculating pairwise similarity/distance between all transects. For the number of species, the similarity between each pair of transects was calculated using Gower distance. The Gower distance is a flexible distance measure that can be applied to continuous or categorical variables (Legendre and Legendre 2012). The number of species is a count which can be considered as being in-between continuous and categorical variables. For the intercept data, the similarity between each pair of transects was calculated using Euclidean distance.

Section 3 – Detailed Descriptions of Results of Data Analysis

Species diversity

Results of statistical analysis using PERMANOVA (Table C.1) were generally consistent with the results in Figure 4 and Table 2. The number of species in the rehabilitated transects was significantly different from 60% of the number of species in matched analogue transects. Although results of PERMANOVA do not indicate whether species diversity is higher in the rehabilitated transects than analogue transects, results summarised in Figure 4 and Table 2 showed that species diversity was higher in the rehabilitated transects than analogue transects. Perhaps one thing to note is that in line-intercept transects, differences in species diversity between rehabilitated and analogue transects may be becoming smaller in 2014, as indicated by significant but larger *P*-value (0.012).

Weeds

Results of statistical analysis using PERMANOVA (Table C.1) were consistent with the results in Figure 5 and Table 3. No statistically significant difference was found between the rehabilitated transects and matched analogue transects. However, when the results were examined carefully, the difference was not significant at all in 2010 and 2013 (as indicated by *P*-values that were close to 1), while in 2014, the difference had become marginally significant, as indicated by $P = 0.09$). This is consistent with the increase in the intercept length in rehabilitated transects in 2014.

Table C.1: Summary of statistical analysis using PERMANOVA (*P*-value in parenthesis).

Year	Treatment (analogue vs. rehabilitated)	Site
Species diversity (line-intercept)		
2010	$F_{1,24} = 52.73$ (0.0001)	$F_{25,24} = 5.33$ (0.0001)
2013	$F_{1,20} = 34.00$ (0.0001)	$F_{25,20} = 1.73$ (0.12)
2014	$F_{1,22} = 7.45$ (0.012)	$F_{25,22} = 0.77$ (0.73)
Species diversity (1 m)		
2010	$F_{1,25} = 52.73$ (0.0001)	$F_{24,25} = 5.33$ (0.0002)
2013	$F_{1,20} = 41.63$ (0.0001)	$F_{25,20} = 0.96$ (0.55)
2014	$F_{1,22} = 26.96$ (0.0001)	$F_{25,22} = 0.79$ (0.72)
Intercepted length: weed		
2010	$F_{1,25} = 0.003$ (0.92)	$F_{24,25} = 2.25$ (0.057)
2013	$F_{1,19} = 0.15$ (0.71)	$F_{26,19} = 1.65$ (0.21)
2014	$F_{1,22} = 3.12$ (0.090)	$F_{23,22} = 1.35$ (0.21)

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Appendix D: Flora Species List (2010, 2013 and 2014)

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Family	Species	Life form	Habit	2010		2013		2014	
				Analogue	Rehabilitated	Analogue	Rehabilitated	Analogue	Rehabilitated
Aizoaceae	*Trianthema pilosa*	annual	herb				p		p ^
	Trianthema triquetra	annual	herb			p ^	p	p ^	p ^
	Trianthema turgidifolia	annual	herb	p		p	p		p
Amaranthaceae	*Amaranthus undulatus*	annual	herb			p ^	p ^		p ^
	Gomphrena canescens	annual/perennial	herb			p ^	p ^		p ^
	Ptilotus astrolasius	perennial	shrub				p ^		p ^
	Ptilotus axillaris	perennial	herb				p		p ^
	Ptilotus fusiformis	annual/perennial	herb				p		p
	Ptilotus gomphrenoides	annual	herb				p		
	Ptilotus macrocephalus	annual	herb						p ^
	Ptilotus murrayi	annual	herb						p
	Ptilotus nobilis	perennial	herb/shrub				p ^	p ^	p ^
	Ptilotus polystachyus	annual	herb				p		p
	Ptilotus latifolius	perennial	herb/shrub				p		p
Araliaceae	*Trachymene pilbarensis*	annual	herb					p ^	p ^
Asteraceae	*Pterocaulon sphaeranthoides*	annual	herb						p ^
	Streptoglossa bubakii	perennial	herb				p ^		p ^
	Streptoglossa decurrens	perennial	herb						p
Boraginaceae	*Heliotropium crispatum*	annual/perennial	herb				p	p ^	p
	Heliotropium glanduliferum	annual/perennial	herb				p ^		p ^
	Trichodesma zeylanicum	annual	herb					p ^	p ^
Caryophyllaceae	*Polycarpaea corymbosa*	annual	herb					p ^	p ^
Chenopodiaceae	*Atriplex* sp. indet.	perennial	shrub						p ^

Family	Species	Life form	Habit	2010		2013		2014	
				Analogue	Rehabilitated	Analogue	Rehabilitated	Analogue	Rehabilitated
Chenopodiaceae	*Dysphania kalpari*	annual/perennial	herb					p ^	p ^
	Dysphania rhadinostachya	annual/perennial	herb				p ^		p ^
	Dysphania sp.	annual/perennial	herb				p ^		
	Maireana planifolia	perennial	shrub					p ^	
	Maireana sp. indet.	perennial	shrub			p ^	p		p
	Neobassia astrocarpa	annual	herb						p ^
	Salsola australis	annual	herb	p			p	p ^	p
	Tecticornia halocnemoides	perennial	shrub	p	p	p		p	
	Tecticornia indica	perennial	shrub	p	p	p	p ^	p	p
Convolvulaceae	*Bonamia alatisemina*	perennial	herb						p
	Bonamia erecta	perennial	herb			p	p	p	p
	Cressa australis	annual	herb					p ^	
	Evolvulus alsinoides var. *villosicalyx*	perennial	herb				p ^		p ^
	Ipomoea muelleri	perennial	herb				p		p ^
	Ipomoea sp. indet.	perennial	herb						p ^
	Polymeria ambigua	annual/perennial	herb				p ^		p
	Polymeria lanata	perennial	herb				p		
Cucurbitaceae	*Cucumis maderaspatanus*	annual	herb				p ^		
Cyperaceae	*Bulbostylis barbata*	annual	herb (sedge)				p	p ^	p ^
	Cyperaceae ?sp.						p		
	Cyperus bulbosus	perennial	herb					p	p
Euphorbiaceae	*Adriana tomentosa* var. *tomentosa*	perennial	herb	p	p	p		p	

Family	Species	Life form	Habit	2010		2013		2014	
				Analogue	Rehabilitated	Analogue	Rehabilitated	Analogue	Rehabilitated
	Euphorbia boophthona	perennial	herb					p ^	
	Euphorbia coghlanii	perennial	herb				p		p
Euphorbiaceae	*Euphorbia myrtoides*	perennial	herb						p ^
	Euphorbia sp. indet.		herb				p ^		p ^
	Euphorbia tannensis	annual/perennial	herb						p ^
Fabaceae	**Vachellia farnesiana*	perennial	shrub		p		p		p ^
	Acacia ancistrocarpa	perennial	shrub	p	p	p	p ^	p	p ^
	Acacia bivenosa	perennial	shrub	p	p	p	p ^	p	p
	Acacia coriacea	perennial	shrub		p		p		p
	Acacia gregorii	perennial	shrub		p				
	Acacia inaequilatera	perennial	shrub	p	p	p	p		p
	Acacia stellaticeps	perennial	shrub	p	p	p	p	p	p
	Acacia synchronicia	perennial	shrub	p	p	p		p	p ^
	Acacia tetragonophylla	perennial	shrub	p	p	p		p	
	Acacia trachycarpa	perennial	shrub		p				
	Acacia xiphophylla	perennial	shrub	p	p	p		p	
	Aenictophyton reconditum	perennial	shrub				p		p ^
	Crotalaria cunninghamii	perennial	shrub				p		p
	Crotalaria medicaginea	annual/perennial	herb				p ^		p ^
	Crotalaria ramosissima	perennial	herb						p ^
	Cullen cinereum	perennial	herb				p	p	p
	Cullen leucanthum	perennial	shrub				p ^		
	Cullen martinii	perennial	shrub				p ^		p
	Desmodium ?filiforme	annual/perennial	herb					p ^	p

Family	Species	Life form	Habit	2010		2013		2014	
				Analogue	Rehabilitated	Analogue	Rehabilitated	Analogue	Rehabilitated
	Indigofera ?boviperda	perennial	shrub				p ^		
	Indigofera boviperda	perennial	shrub				p	p ^	p
Fabaceae	*Indigofera colutea*	annual/perennial	herb				p	p	p
	Indigofera linifolia	annual/perennial	herb				p	p ^	p ^
	Isotropis atropurpurea	perennial	shrub					p ^	p ^
	Lotus cruentus	annual	herb					p	p
	Petalostylis cassioides	perennial	shrub				p		p
	Rhynchosia minima	annual	herb			p ^	p ^	p ^	p
	Senna artemisioides subsp. *oligophylla* 'thinly sericeous'	perennial	shrub		p				
	Senna notabilis	perennial	shrub				p		p ^
	Swainsona kingii	perennial	herb					p ^	p
	Swainsona pterostylis	perennial	herb				p ^	p ^	p
	Tephrosia sp. B Kimberley Flora	perennial	shrub				p ^		p ^
	Tephrosia uniovulata	perennial	shrub				p		p ^
Frankeniaceae	*Frankenia pauciflora*	perennial	shrub	p	p	p		p ^	p
Geraniaceae	*Erodium cygnorum*	annual/perennial	herb						p
Goodeniaceae	*Goodenia forrestii*	perennial	herb			p ^		p ^	p ^
	Goodenia microptera	perennial	herb				p		p
	Goodenia tenuiloba	perennial	herb				p ^	p ^	p ^
	Scaevola parviflora	perennial	shrub						p ^
	Scaevola sericophylla	perennial	shrub	p	p	p		p	
	Scaevola spinescens	perennial	shrub			p ^	p ^		p

Family	Species	Life form	Habit	2010		2013		2014	
				Analogue	Rehabilitated	Analogue	Rehabilitated	Analogue	Rehabilitated
Haloragaceae	*Haloragis gossei*	annual/perennial	herb				p ^	p ^	p
Lamiaceae	*Dicrastylis cordifolia*	perennial	shrub	p	p	p	p	p	p ^
	Quoya paniculata	perennial	shrub		p	p ^		p	
Lauraceae	*Cassytha capillaris*	perennial	creeper	p	p				
	Cassytha sp. indet.	perennial	creeper	p	p	p		p	
Malvaceae	*?Triumfetta sp.*	perennial	shrub				p ^		
	Abutilon lepidum	perennial	shrub				p		p ^
	Abutilon otocarpum	perennial	shrub				p		
	Abutilon sp. indet	perennial	shrub				p ^		p
	Alyogyne pinoniana	perennial	shrub		p				
	Corchorus sidoides	perennial	shrub			p	p ^	p	p
	Hannafordia quadrivalvis	perennial	shrub						p ^
	Hibiscus sp. indet.	perennial	shrub				p ^		p ^
	Hibiscus sturtii	perennial	shrub				p ^		p ^
	Hibiscus sturtii var. *platycalyx*	perennial	shrub						p ^
	Lawrencia viridigrisea	perennial	shrub						p
	Melhania oblongifolia	perennial	shrub						p ^
	Sida cardiophylla	perennial	shrub						p
	Sida fibulifera	perennial	shrub				p		p
	Sida rohlenae subsp. *rohlenae*	perennial	shrub				p		p
	Sida sp.?intricata	perennial	shrub				p ^		
	Sida sp. indet.	perennial	shrub				p ^		p ^
	Sida sp. Pilbara	perennial	shrub			p ^	p ^	p ^	

Family	Species	Life form	Habit	2010		2013		2014	
				Analogue	Rehabilitated	Analogue	Rehabilitated	Analogue	Rehabilitated
	Triumfetta ramosa	perennial	shrub				p		p
Molluginaceae	*Mollugo molluginea*	perennial	herb				p ^		p
Myrtaceae	*Corymbia hamersleyana*	perennial	shrub	p	p	p		p	
	Eucalyptus ?victrix	perennial	tree		p				
Myrtaceae	*Eucalyptus victrix*	perennial	tree	p	p	p		p	
	Eucalyptus xerothermica	perennial	tree		p				
Nyctaginaceae	*Boerhavia coccinea*	perennial	herb				p		p ^
	Boerhavia sp. indet.	perennial	herb						p ^
Phyllanthaceae	*Phyllanthus maderaspatensis*	annual/perennial	herb					p ^	
Plantaginaceae	*Stemodia grossa*	perennial	herb				p ^		p ^
Poaceae	**Cenchrus ciliaris*	perennial	grass	p	p	p	p	p	p
	**Cenchrus setiger*	perennial	grass			p ^	p ^		p
	Aristida contorta	perennial	grass			p ^	p		p ^
	Aristida holathera var. *holathera*	perennial	grass				p	p	p
	Brachyachne prostrata	annual	grass			p ^	p	p ^	p ^
	Chloris pumilio	annual	grass				p	p	p
	Chrysopogon fallax	annual	grass					p ^	
	Dactyloctenium radulans	annual	grass				p	p ^	p
	Dichanthium sericeum	annual	grass				p		p
	Enneapogon caerulescens	perennial	grass				p ^		p ^
	Eragrostis ?sp. indet.	perennial	grass	p	p				
	Eragrostis dielsii	perennial	grass				p		
	Eragrostis eriopoda	perennial	grass				p		p

Family	Species	Life form	Habit	2010		2013		2014	
				Analogue	Rehabilitated	Analogue	Rehabilitated	Analogue	Rehabilitated
Poaceae	*Eragrostis pergracilis*	perennial	grass			p ^	p	p	p
	Eriachne ?sp. indet.	perennial	grass	p	p				
	Eriachne aristidea	perennial	grass			p ^	p		p
	Eriachne benthamii	perennial	grass	p		p		p	
	Eriachne obtusa	perennial	grass					p ^	
	Eriachne pulchella var. *pulchella*	perennial	grass				p ^		p ^
	Eulalia aurea	perennial	grass	p	p	p		p	
	Grass ?sp. indet.		grass		p				
	Iseilema vaginiflorum	annual	grass				p ^	p	p
	Paractaenum refractum	annual	grass				p		p ^
	Paspalidium clementii	annual	grass				p		
	Paspalidium sp. indet.	annual	grass				p		p ^
	Sorghum plumosum	perennial	grass				p		p
	Sporobolus australasicus	perennial	grass			p ^	p		p ^
	Sporobolus mitchellii	perennial	grass			p	p	p	p
Poaceae	*Triodia ?epactia/pungens*	perennial	grass	p	p				
	Triodia ?lanigera	perennial	grass		p				
	Triodia ?schinzii	perennial	grass	p	p				
	Triodia epactia	perennial	grass	p	p	p	p	p	p
	Triodia lanigera	perennial	grass	p	p	p	p	p	p
	Triodia schinzii	perennial	grass	p		p		p	p
	Triodia wiseana	perennial	grass			p	p	p	p
	Yakirra australiensis	perennial	grass				p ^		

Family	Species	Life form	Habit	2010		2013		2014	
				Analogue	Rehabilitated	Analogue	Rehabilitated	Analogue	Rehabilitated
Polygalaceae	*Polygala isingii*	annual	herb					p ^	
Portulacaceae	*Calandrinia* sp. indet.	annual	herb						p ^
	Portulaca oleracea	annual	herb			p ^	p	p ^	p ^
Proteaceae	*Grevillea eriostachya*	perennial	shrub	p	p	p		p	
	Grevillea stenobotrya	perennial	shrub	p	p	p	p ^	p	p ^
Sapindaceae	*Diplopeltis eriocarpa*	perennial	shrub	p	p	p	p	p	p
Solanaceae	*Nicotiana occidentalis*	annual	herb						p ^
	Nicotiana rosulata	annual	herb					p	p
	Solanum horridum	perennial	shrub						p ^
Solanaceae	*Solanum lasiophyllum*	perennial	shrub			p ^	p	p ^	p
Zygophyllaceae	*Tribulus hirsutus*	perennial	herb				p		p
	Tribulus sp. indet.	perennial	herb				p	p ^	
	Zygophyllum retivalve	annual	herb						p ^

* = Introduced species (weeds)

^ = Species that were found in 1 m wide strip but not recorded in line-intercept transect

p = Present