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WESTERN AUSTRALIA

NorthLinkWA
Perth-Darwin National Highway

Ioppolo Road Site Land Acquisition and Management Plan

Perth-Darwin National Highway (Swan Valley Section)

JANUARY 2017





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Document Control						
Revision	Date	Description	Prepared	Reviewed	Approved	
A	12/08/2016	Draft (Coffey v1)	T. Vu	E. Waterhouse	E. Waterhouse	
B	15/09/2016	Draft for consultation (Coffey v2)	T. Vu / M. Holliday	E. Waterhouse	E. Waterhouse	
0	06/10/2016	Final for submission to OEPA (Coffey v3)	T. Vu	D. Morley	D. Morley	
1	22/12/2016	Addressed OEPA comments (Coffey v4)	M. Holliday	D. Morley	D. Morley	
2	12/01/2017	Addressed OEPA comments (Coffey v5)	T. Vu	D. Morley	D. Morley	

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EP2016/051

1 SUMMARY

This Ippolo Road Site Land Acquisition and Management Plan (this plan) is submitted in accordance with Ministerial Statement No. 1036 conditions 16-2 to 16-7 for the Perth–Darwin National Highway (Swan Valley Section) by Main Roads Western Australia (MRWA).

Table 1 presents a summary of this plan including the proposal-specific completion criteria against which the environmental objective are measured.

Table 1 Ippolo Road Site Land Acquisition and Management Plan summary

Item	Details
Title of proposal	Perth-Darwin National Highway (Swan Valley Section)
Proponent name	Commissioner for Main Roads Western Australia
Ministerial Statement No.	1036
Purpose of this Plan	This plan is submitted to fulfil the requirements of conditions 16-2 to 16-7 of the above Ministerial Statement.
Environmental objective	To counterbalance the significant residual impact to: <ul style="list-style-type: none">• 7.65 ha of A Class Nature Reserves.• 202 ha of Carnaby's Cockatoo (<i>Calyptorhynchus latirostris</i>) foraging habitat.• 99.1 ha of Forest Red-tailed Black Cockatoo (<i>Calyptorhynchus banksii naso</i>) foraging habitat.
Completion criteria	
Full funding by MRWA for the acquisition of Lot 2091 Ippolo Road.	<ul style="list-style-type: none">• MRWA has fully funded the acquisition of Lot 2091 Ippolo Road.
Agreement and funding for initial and ongoing management.	<ul style="list-style-type: none">• MRWA and Department of Parks and Wildlife has developed a Memorandum of Understanding (MoU) and agreed the arrangements and funding for the upfront works associated with establishing the conservation reserve and ongoing management. The MoU was signed on 28 November 2016.• MRWA provides funds in accordance with MoU.
Management actions completed by DPAW.	<ul style="list-style-type: none">• MRWA has assessed management actions completed by DPAW, upon review of DPAW's report on the completion of actions.



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2 CONTEXT AND SCOPE

2.1 Description of the Proposal

MRWA proposes to construct a new 38 km section of the Perth–Darwin National Highway (PDNH) between Malaga and Muchea in Western Australia (the proposal). The proposal is a dual carriageway highway and will connect the intersection of Tonkin Highway and Reid Highway in the south with Great Northern Highway and Brand Highway in the north.

2.2 Background

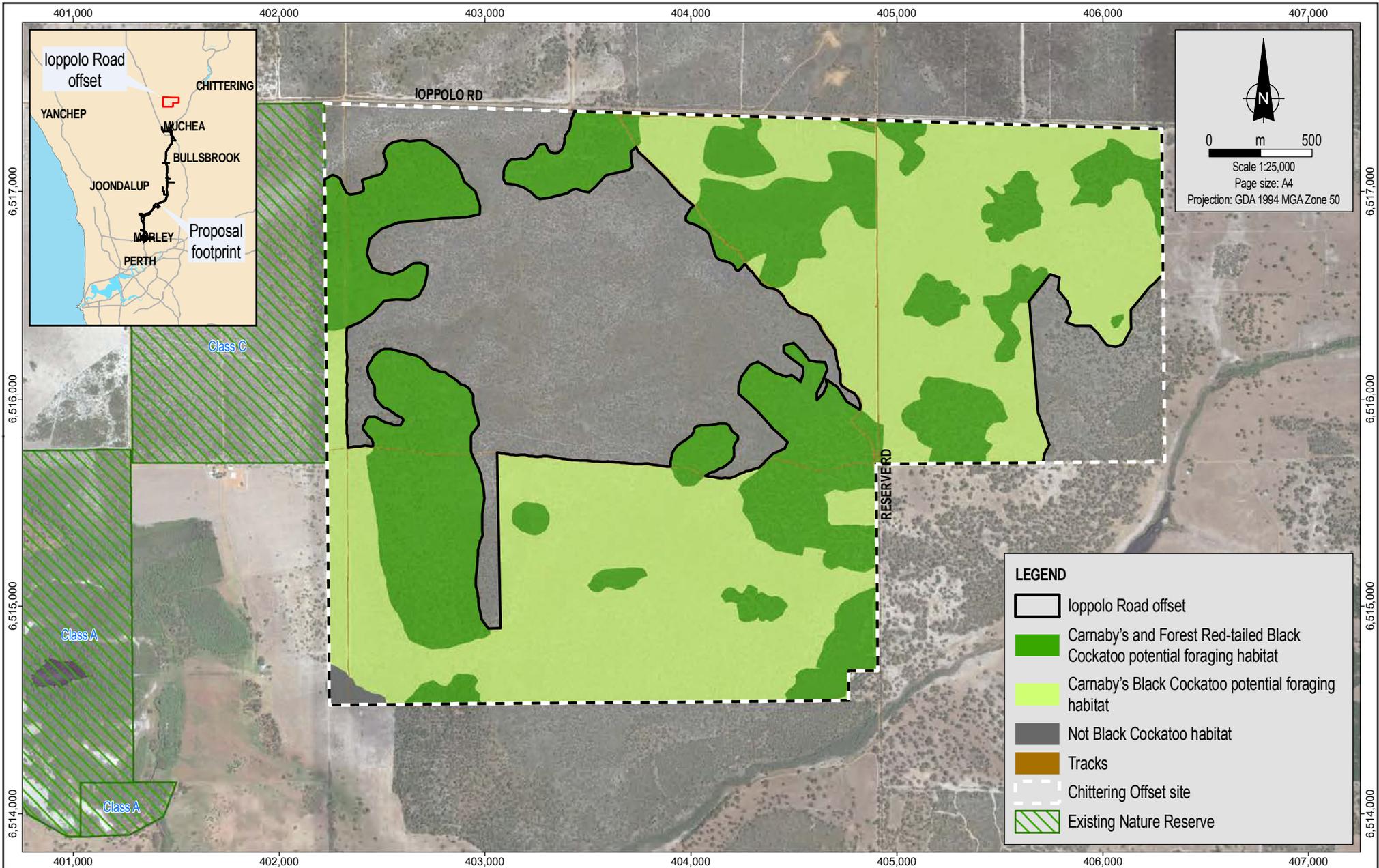
The Public Environmental Review (PER) (Coffey, 2015a) and Response to Submissions (Coffey, 2015b) identified Lot M2091 (Plan 6457) Ippolo Road, Chittering (Lot 2091) as a site containing appropriate values to counterbalance significant residual impacts to A Class Nature Reserves and foraging habitat for two Black Cockatoo species, *Calyptorhynchus latirostris* (Carnaby's Black Cockatoo) and *Calyptorhynchus banksii naso* (Forest Red-tailed Black Cockatoo). This plan nominates the 681.7 ha portion of the 986 ha Lot 2091 labelled 'Ippolo Road offset' on Figure 1 as the offset containing the environmental attributes identified in condition 16-3(1) and otherwise referred to by conditions 16-2 to 16-7. This offset is hereafter referred to in this plan as 'Ippolo Road'.

Ippolo Road is surrounded by private land, with the exception of an existing C Class Nature Reserve managed by Department of Parks and Wildlife (DPAW) to the west. Ippolo Road is currently zoned 'Agriculture Resource' under the Shire of Chittering Town Planning Scheme No. 6.

Field assessments and consultation with the Environment Protection Authority (EPA), Department of the Environment and Energy (DOTEE) and DPAW determined Ippolo Road to be in line with the State and Commonwealth governments' advice on the suitability of an offset site. Ippolo Road was endorsed by DPAW and DOTEE as a suitable offset site with the potential to deliver an overall conservation outcome that improves or maintains the viability of A Class Nature Reserves and Black Cockatoo habitat.

In consultation with DPAW and DOTEE, Lot 2091 has been acquired to be vested with the Conservation and Parks Commission to establish a conservation reserve, with subsequent management by DPAW to offset the loss to A Class Nature Reserves and Black Cockatoo habitat as part of the proposal.

Portions of Lot 2091 not forming part of the Ippolo Road offset may be used as offsets for impacts to Black Cockatoo habitat from other Main Roads projects, including the Tonkin Grade Separations project approved by DOTEE on 7 December 2015 (reference: EPBC 2014/7385).



Source & Notes
 Significant vegetation and broad habitat mapping from Coffey (February 2015).
 Existing Nature Reserves from DPAW (January 2015).
 Roads from MRWA (2012).
 Aerial Imagery from Google Earth Pro (10 January 2015).



Date: 21.12.2016
 MXD: 4483AA_65_GIS002_4
 File Name: 4483AA_65_F001_GIS

Main Roads WA
 Ioppolo Road Site Land Acquisition
 and Management Plan

Ioppolo Road Offset Site

Figure No:
 1

2.3 Requirements of the Condition

This plan is submitted in accordance with conditions 16-2 to 16-7 of Ministerial Statement No. 1036.

Condition requirements and in-plan section references are provided in Table 2.

The objective of this plan is to counterbalance the significant residual impact to 7.65 ha of A Class Nature Reserves, 202 ha of Carnaby's Cockatoo (*Calyptorhynchus latirostris*) foraging habitat and 99.1 ha of Forest Red-tailed Black Cockatoo (*Calyptorhynchus banksii naso*) foraging habitat through implementation of the management activities detailed in Section 4.

Table 2 Requirements of Ministerial Statement No. 1036

Condition number	Condition	Section of this plan
16-2	<p>Prior to the commencement of ground disturbing activities, or as otherwise agreed in writing by the CEO, the proponent shall submit an Ippolo Road Site Land Acquisition and Management Plan to the requirements of the CEO, with the objective of counterbalancing the significant residual impact to:</p> <ol style="list-style-type: none"> 1. 7.65 ha of A Class Nature Reserves. 2. 202 ha of <i>Calyptorhynchus latirostris</i> (Carnaby's black cockatoo) foraging habitat. 3. 99.1 ha of <i>Calyptorhynchus banksii naso</i> (forest red-tailed black cockatoo) foraging habitat. 	Section 1
16-3	<p>The Ippolo Road Site Land Acquisition and Management Plan shall:</p> <ol style="list-style-type: none"> 1. Identify the environmental attributes of the land to be acquired which must contain: <ol style="list-style-type: none"> a) At least 673.5 ha of <i>Calyptorhynchus latirostris</i> (Carnaby's Black Cockatoo) potential foraging habitat. b) At least 279 ha of <i>Calyptorhynchus banksii naso</i> (Forest Red-tailed Black Cockatoo) potential foraging habitat. 2. Detail the arrangements and funding for the upfront works associated with establishing the conservation reserve and ongoing management of the land acquired on advice from the Department of Parks and Wildlife. 3. Identify activities to be undertaken including improvement actions for areas identified as being in a degraded condition or cleared areas requiring rehabilitation. 4. Detail timeframes for undertaking improvement actions and management activities. 5. Identify roles and responsibilities of the proponent and any agreements with third parties. 6. Detail completion criteria. 7. Include monitoring and reporting requirements. 	<p>Section 3</p> <p>Section 4.1</p> <p>Section 4.2</p> <p>Section 4.3</p> <p>Section 4.4</p> <p>Section 4.5</p> <p>Sections 4.6 and 5</p>



Condition number	Condition	Section of this plan
16-4	<p>After receiving notice in writing from the CEO that the Ioppolo Road Site Land Acquisition and Management Plan satisfies the requirements of condition 16-3, the proponent shall:</p> <ol style="list-style-type: none"> 1. Prior to the commencement of ground disturbing activities, commence the implementation of the actions in accordance with the requirements of the approved Ioppolo Road Site Land Acquisition and Management Plan. 2. Continue to implement the approved Ioppolo Road Site Land Acquisition and Management Plan until the CEO has confirmed by notice in writing that it has been demonstrated that the completion criteria in the Ioppolo Road Site Land Acquisition and Management Plan have been met and therefore the implementation of the actions is no longer required. 	Compliance Assessment Plan (see Section 5)
16-5	<p>Prior to the commencement of ground disturbing activities, or as otherwise agreed in writing by the CEO, the proponent shall acquire, or fully fund the acquisition of, the land identified in the approved Ioppolo Road Site Land Acquisition and Management Plan, as required by condition 16-2, for the purpose of conservation. The land identified in the approved Ioppolo Road Site Land Acquisition and Management Plan shall be vested to the Conservation and Parks Commission for the purpose of conservation of flora and fauna</p>	Section 4
16-6	<p>The proponent shall review and revise the Ioppolo Road Site Land Acquisition and Management Plan as and when directed by the CEO.</p>	Section 5
16-7	<p>The proponent shall implement the latest revision of the Ioppolo Road Site Land Acquisition and Management Plan, which the CEO has confirmed by notice in writing, satisfies the requirements of condition 16-2.</p>	Section 5

3 ENVIRONMENTAL ATTRIBUTES

Field surveys and assessments were undertaken to determine the environmental attributes of loppolo Road (Coffey, 2015c, d; Terratree, 2014 – Appendix A). These are summarised below.

3.1 General Attributes

loppolo Road is unfenced with tracks and unsealed roads running through the site that are accessible by the public for exploration and agricultural activities.

Vegetation condition was assessed as very good to excellent. No areas of degraded or cleared vegetation were recorded during the field surveys.

3.2 Black Cockatoo Habitat

At least 673.5 ha of Carnaby's Black Cockatoo foraging habitat was identified in loppolo Road (see Figure 1) associated with Eucalypt Woodland (279.2 ha) and Banksia Woodland (394.4 ha). The site contains 17 species of foraging resources, including the following dominant species: *Eucalyptus marginata*, *E. todtiana*, *Corymbia calophylla*, *Allocasuarina humilis*, *Banksia menziesii* and *B. attenuata*.

At least 279 ha of Forest Red-tailed Black Cockatoo foraging habitat was identified in loppolo Road (see Figure 1) associated with Eucalypt Woodland containing *E. marginata* and *C. calophylla*, both of which are the main constituents of this species' diet, and Banksia woodland containing *Hakea* spp., which provides potential foraging habitat (Johnstone et al., 2013).

Eucalypt Woodland habitat (specifically the stands of tall *E. marginata*, *E. todtiana* and *C. calophylla*) in loppolo Road also represent breeding and roosting habitat for both species of Black Cockatoo. An estimated 6,300 potential breeding trees of sufficient age to produce large hollows are present within this habitat, based on an average tree density of 20 trees per hectare. The site is within the current modelled breeding and non-breeding range of Carnaby's Black Cockatoo (DSEWPAC, 2012) and is within 16 km of a number of significant roost sites at Gingin town site (Finn et al., 2014).

DPAW has confirmed that there have been regular sightings of Forest Red-tailed Black Cockatoos in the surrounding area including as far north as Bindoon (Errington, pers. comm.). This is supported by Forest Red-tailed Black Cockatoo distribution contained in the Perth and Peel Green Growth Plan for 3.5 million (DPC, 2015), which shows the species' range extending some 100 km further north of loppolo Road.

3.3 Dieback and Weeds

Terratree Pty Ltd (Terratree, 2014) conducted a *Phytophthora cinnamomi* (dieback) risk assessment on 119.2 ha of linear corridor (tracks, unsealed roads) within loppolo Road. The vegetation disease risk was low for 73.5% of the site area, medium for 10.2% and high for 16.3%. The potential for spreading dieback within the loppolo Road site was assessed as low.

High risk areas recorded a positive sample result or symptoms consistent with dieback. Two of the positive samples were located outside loppolo Road and are a potential vector for spreading the disease into the site. The power line track in the north western corner of loppolo Road is 'infested' but does not extend beyond about 50 to 100 m either side of the track. Moderate risk areas recorded deaths of indicator species. No positive samples results were recorded in these areas. Low risk areas are 'uninfested'.



Coffey (2015d) identified six weed species within Ioppolo Road. None of these species is a weed of national significance (WONS). The Arum Lily was identified in the south western corner of Ioppolo Road. This species is a declared pest under the *Biosecurity and Agriculture Management Act 2007* (BAM Act) and is a C3 category weed that requires management under the BAM Act.

4 FUNDING ARRANGEMENTS AND MANAGEMENT PLAN

4.1 Funding Arrangements

4.1.1 Land Acquisition

MRWA has fully funded the acquisition of Lot 2091, including Ioppolo Road (DPAW and MRWA, 2016).

4.1.2 Upfront Works and Ongoing Management

MRWA and DPAW have agreed to the works plan listed in Table 3. The agreement, including costs for the listed actions, has been formalised through a MoU between the two departments and was signed on 28 November 2016. The MoU (and the works plan) is in accordance with DPAW's Corporate Guideline for proponent management contributions to the management of offset sites. Note that this publicly available plan does not contain the commercial information regarding the transfer of funds to DPAW.

4.2 Reserve Management Activities

A works plan proposed for the establishment and maintenance tasks of Ioppolo Road is detailed as management activities in Table 3. The works plan is proposed for seven years and covers management activities highlighted during the meeting with DPAW at Ioppolo Road.

Table 3 MRWA Ioppolo Road management activities (2017 to 2023)

Management activities	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
Nature reserve signage x 10.	X						
<i>Phytophthora cinnamomi</i> Dieback signage x 20.	X						
Track closures – barriers/ ripping/mounding and maintenance.	X	X	X	X	X	X	X
Gates x 10 – maintenance.	X						
Rubbish removal – old machinery, dumped scrap metal etc.	X						
Pest animal control (wild deer and feral pigs) – monitoring and control actions.	X	X	X	X	X	X	X
Survey and control of feral bee site in Black Cockatoo habitat areas.	X		X		X		X
<i>Phytophthora cinnamomi</i> Dieback re-survey and treatment.		X			X		

Note: Management activities extend over a seven-year program. Improvement actions are not required – refer to Section 4.2.1.

Year 1 contains the majority of the outlay of establishment and management projects. The successive years set out the ongoing projects and costs that once completed should see Ioppolo Road well established by way of:

1. Physical infrastructure:
 - a) Reserve signage implemented.

- 
- b) Tracks permanently closed.
 - c) Gates established.
 - d) *Phytophthora cinnamomi* Dieback hygiene signage implemented.
 - e) Old farm machinery/rubbish dump cleaned up.
2. Conservation management attention:
- a) Control of feral animals well established.
 - b) *Phytophthora cinnamomi* Dieback survey and treatment well understood and treated.
 - c) Feral bee hives located (surveyed) and substantially reduced/eliminated from Black Cockatoo habitat areas (Marri Woodland areas).

Once these activities have been completed the loppolo Road will be left in an improved condition where upon the DPAW District responsible for the area will be able to manage any ongoing issues.

4.2.1 Improvement Actions

All areas within the loppolo Road offset site are considered to be better than degraded or cleared condition. No activities are required to improve any areas of the proposed areas. No improvement actions are proposed in accordance with condition 16-3(3).

4.3 Timeframes

MRWA will provide funding to DPAW in accordance with MoU between the two agencies within six months of construction commencing.

Timeframes for undertaking upfront works and ongoing management actions are shown in Table 3. The works plan will be implemented for seven years (2017 to 2023).

In accordance with condition 16-4(2), this plan will continue to be implemented until the CEO of OPEA has been confirmed that the completion criteria have been met and the management actions are no longer required.

MRWA will report annually in the compliance assessment report (CAR) on the activities undertaken by DPAW at loppolo Road.

4.4 Roles and Responsibilities

4.4.1 Main Roads Western Australia

MRWA will be responsible for the following in relation to loppolo Road:

- Fund the acquisition of Lot 2091 (including loppolo Road) – completed.
- Reach an agreement with DPAW for the arrangement and funding for upfront works associated with establishing the conserve reserve and ongoing management of land acquired through a MoU – completed.
- Provide funding to DPAW in a single payment for the agreed costs of the seven year works plan within six months of construction commencing.
- Provide the completed MoU and evidence of the funds transfer to the CEO of the OEPA once the MoU has been signed and the funds transferred.

- Report on activities undertaken under the works plan in the annual CAR.

4.4.2 Department of Parks and Wildlife

DPAW will be responsible for the following activities, subject to the conditions of the MoU:

- Invoice MRWA for the agreed funds once the MoU takes effect.
- Prepare an operational works plan to undertake the tasks in Table 3.
- Allocate the funds provided by MRWA to agreed tasks and activities over the timeframe of the works plan.
- Provide an annual update of works activities completed, expenditure incurred and proposed actions to MRWA by 20 October, during the lifetime of the works plan.
- Keep MRWA informed of activities and works pursuant to this MoU that might affect or have implications for MRWA projects and proposals.

4.5 Completion Criteria

Table 4 details this plan’s completion criteria.

Table 4 Completion criteria

Completion criteria	Description
Full funding by MRWA for the acquisition of Lot 2091 Ioppolo Road.	<ul style="list-style-type: none"> • MRWA has fully funded the acquisition of Lot 2091 Ioppolo Road.
Agreement and funding for initial and ongoing management.	<ul style="list-style-type: none"> • MRWA and DPAW has developed MoU and agreed the arrangements and funding for the upfront works associated with establishing the conservation reserve and ongoing management. The MoU was signed on 28 November 2016. • MRWA provides funds in accordance with MoU.
Management actions completed by DPAW.	<ul style="list-style-type: none"> • MRWA will assess management actions completed by DPAW, upon review of DPAW’s report on the completion of actions.

4.6 Monitoring

MRWA will monitor whether the management actions were undertaken by DPAW, once the reports have been provided to MRWA.



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5 REVIEW AND REPORTING

5.1 Review of this Plan

This plan will be implemented until the CEO of OEPA advises implementation may cease.

This plan will be reviewed and revised as and when directed by the CEO.

5.2 Reporting

Details of MRWA's reporting to the CEO of the OEPA is in Table 5.

Table 5 Reporting requirements to the CEO

Reporting requirement	Timeframe
Funding of acquisition of Lot 2091.	Complete.
MoU between MRWA and DPAW.	Complete.
Funding of management actions in accordance with the MoU.	As required in the MoU.
Providing the completed MoU to the CEO of the OEPA.	Within 3 months of the MoU being signed and funds have been transferred.
Reporting on management actions.	Annually.

The annual compliance assessment report (CAR) will include:

- A summary of compliance against the management plan.
- An evaluation of the results of monitoring and survey actions to identify progress on meeting the completion criteria detailed in Table 4.
- DPAW's report to MRWA on the completion of actions.

Any revisions (undertaken in accordance with Section 4.1) will also be highlighted in the CAR. The CAR will be submitted in accordance with condition 4-6.

5.3 Vesting of Land

MRWA is unable to vest Lot 2091 (including Ippolo Road) with the Conservation and Parks Commission for the following reasons:

- Lot 2091 is a freehold title, currently owned by the State of WA.
- Land cannot be vested to a body unless the land is a reserve.
- MRWA cannot create a conservation reserve, even on land that it owns.
- The Department of Lands and DPAW are responsible for creating a reserve and vesting the land with the Conservation and Parks Commission. This action is outside the control of MRWA.

MRWA has provided funding to DPAW for the acquisition Lot 2091, including Ippolo Road. MRWA has completed all actions under its control to ensure compliance with condition 16-5.



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6 STAKEHOLDER CONSULTATION

MWRA consulted with stakeholders while developing this plan. This section provides a summary of consultation that occurred. The comments raised during consultations with stakeholders were considered in developing the plan.

DPAW was consulted in accordance with condition 16-3(2).

Table 6 presents a summary of consultation and MRWA's response.

Table 6 Stakeholders consulted, comments and responses

Date	Organisation	Summary of consultation	MRWA response to comments/concerns
11 July 2016	DPAW (Office of the Director General)	MRWA met with DPAW to discuss proponent land management contributions for offset properties in accordance with DPAW's Corporate Guideline No.14.	MRWA to contact DPAW Swan Region to meet on site at Lot 2091 and discuss management actions and costs.
29 July 2016	DPAW (Swan Region)	MRWA met with DPAW's Swan Region on site.	DPAW to provide MRWA a list of proposed actions and costs. MRWA to draft MoU.
2 August 2016	DPAW	MRWA met with DPAW on-site at loppolo Road, to discuss arrangements and funding for upfront works associated with establishing the conservation reserve and ongoing management of the land by DPAW.	General agreement that the works proposed were acceptable in principle and DPAW would cost the works plan.



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7 REFERENCES

Publications

- Coffey. 2015a. Public Environmental Review: Perth-Darwin National Highway (Swan Valley Section). Volume 1: Main text. September. Report prepared for NorthLink WA by Coffey Environments Pty Ltd, Burswood, Western Australia.
- Coffey. 2015b. Response to Submissions: Perth-Darwin National Highway (Swan Valley Section). September. Report prepared for NorthLink WA by Coffey Environments Pty Ltd, Burswood, Western Australia.
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- DSEWPAC. 2012. EPBC Act referral guidelines for three threatened black cockatoo species. Department of Sustainability, Environment, Water, Population and Communities.
- Finn, H., Barrett, G., Groom, C., Blythmann, M. and Williams, M. 2014. The 2014 Great Cocky Count: a community-based survey for Carnaby's Black Cockatoos (*Calyptorhynchus latirostris*) and Forest Red-tailed Black Cockatoos (*Calyptorhynchus banksii naso*). June. Report prepared by Birdlife Australia and Department of Parks and Wildlife, Western Australia.
- Johnstone, R. E., Kirkby, T. and Sarti, K. 2013. The breeding biology of the Forest Red-tailed Black Cockatoo *Calyptorhynchus banksii naso* Gould in south-western Australia. II. Breeding behaviour and diet. *Pacific Conservation Biology* 19:143-155.
- Terratree. 2014. Linear Phytophthora Dieback Risk Assessment of M2091 Ippolo Road, Chittering. December. Prepared for Report prepared for Coffey Environments Pty Ltd by Terratree Pty Ltd, Fremantle, Western Australia.

Personal Communications

- Errington, A. Land Tenure Project Officer, Department of Parks and Wildlife, Perth, Western Australia. Email. 25 August 2015.



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APPENDIX A

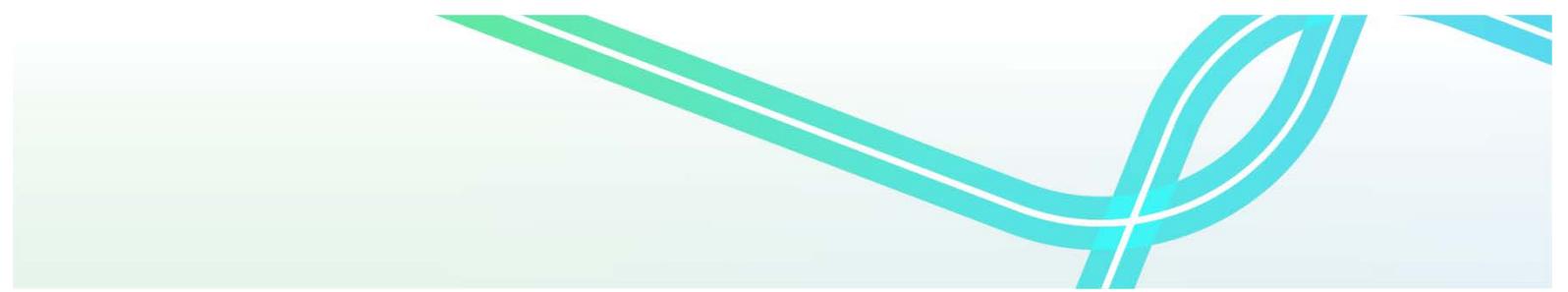
Linear

Phytophthora

Dieback Risk

Assessment of

Ioppolo Road



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**Linear *Phytophthora* Dieback Risk Assessment of
M2091 Ioppolo Road, Chittering**

Prepared for Coffey Environments Australia Pty Ltd

Ref: T14008

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Document Control

Version	Date	Author	Reviewer
Draft	13/10/2014	J. Grehan	C. McGary C. Van Den Bergh
Final	16/12/14	J. Grehan	C. Van Den Bergh



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DISCLAIMER

This document is prepared in accordance with and subject to an agreement between Terratree Pty Ltd (“Terratree”) and the client for whom it has been prepared (“Coffey Environments Australia Pty Ltd”) and is restricted to those issues that have been raised by the client in its engagement of Terratree and prepared using the standard of skill and care ordinarily exercised by Environmental Scientists in the preparation of such documents.

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Terratree Pty Ltd

Executive Summary

Coffey Environments Australia Pty Ltd commissioned Terratree Pty Ltd to undertake a linear *Phytophthora* Dieback assessment of tracks and other potential disease vectors within and surrounding a block of native vegetation. The site is located in the Shire of Chittering approximately 80 km north of Perth. The site is 983 ha and mainly comprised of Banksia woodland with some areas of Marri (*Corymbia calophylla*) open forest.

The assessment was conducted in accordance with the Department of Parks and Wildlife's (DPaW) *Manual for detecting Phytophthora Dieback disease* (Procedures for DPaW managed lands) (DPaW 2013). Tracks, water courses and hard-hooved feral animals are considered to be the most likely vectors of disease into the study area. A linear Dieback assessment was determined to be an appropriate method for assessing the risk and likelihood of Dieback presence within and adjacent to the site.

Vegetation within the study area was categorised according to three different levels of risk:

1. High Risk: Areas where *P. cinnamomi* has been recovered from samples and disease symptoms are consistent with the presence of Dieback.

2. Moderate Risk: Areas exhibiting past or current disturbances (logging, grazing, dumping etc.) which has altered vegetation structure and composition and areas downslope of confirmed infestations, or vegetation exhibiting disease symptoms but have not returned positive results for *P. cinnamomi*.

3. Low Risk: Areas of protectable uninfested vegetation (as determined by a registered Dieback interpreter), which exhibit multiple healthy indicator species, vegetation in Pristine to Very Good condition (Keighery scale 1-3), no disease pattern or chronology, and no significant risks from disease vectors or current land use.

The total study area, in terms of the linear corridor that was assessed, is 119.2ha. This is comprised of 19.4 ha of High Risk (16.3 %), 12.2 ha of Moderate Risk (10.2 %) and 87.6 ha (73.5 %) of Low Risk vegetation

In total, 11 soil and tissue samples were taken from recently dead and dying disease indicator species. Two positive results for *P. cinnamomi* were reported. In addition, a tissue sample was taken to test for canker and this returned a positive result for *Cytospora* sp.

In conclusion, the linear assessment determined that the majority of the study area (linear assessment corridor) is uninfested and therefore presented a low risk of spreading Dieback into areas outside the study corridor. While it is likely that the majority of the 983 ha site is uninfested, caution must be exercised when extrapolating the disease status and/or risk to vegetation that has not been assessed outside the study area.

Terratree makes the following recommendations in relation to assessment and management of Dieback at the site:

- A comprehensive Dieback assessment of the site should be completed in accordance with current Department of Parks and Wildlife standards (DPaW 2013).
- Protectable areas should be clearly demarcated and signposted.
- Additional sampling should be done in moderate risk areas.
- A Dieback management plan, including an access management strategy, should be developed for the site.

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Appendix 2: Sample Results from the Vegetation Health Services laboratory

1 Introduction

Coffey International (Coffey) commissioned Terratree Pty Ltd (Terratree) to undertake a linear *Phytophthora* Dieback (Dieback) assessment of tracks and other potential disease vectors within and surrounding a 983 ha block of native vegetation ('the site') in the Shire of Chittering. The linear assessment corridor includes a 25 m area either side of tracks and unsealed roads within and adjacent to the site, watercourses and other potential disease vectors (hereafter referred to as the 'study area').

1.1 Background

Phytophthora Dieback ('Dieback') is a soil borne pathogen with a range of plant hosts in the southwest of Western Australia. These predominantly belong to the Proteaceae, Ericaceae, Myrtaceae, Xanthorrhoeaceae and Fabaceae plant families. While some plant species are resistant, others are susceptible to the disease caused by the pathogen resulting in chlorosis, dieback and usually death.

According to the most recent Western Australian (WA) State of the Environment Report (Environmental Protection Authority 2007) *Phytophthora* Dieback, a Priority 1 Threat, is the third greatest threat to biodiversity after salinity and climate change. It is a more serious threat than weeds, native vegetation clearing, acid sulphate soils and soil erosion. It is significant in WA because:

- Over 40% (2,300) of the native plant species and half of the endangered plant species in the southwest of WA are susceptible to the pathogen
- The changes in plant community composition and structure that Dieback causes has impacts throughout the whole ecosystem, including on the indigenous fauna
- Dieback can lead to significant soil erosion as a result of the loss of susceptible vegetation

The Dieback pathogen is widespread in areas with greater than 800 mm of annual rainfall, less extensive in areas that receive between 600–800 mm and mainly restricted to water-gaining sites in areas that receive 400–600 mm. The pathogen does not occur in areas that receive less than 400 mm of annual rainfall. In WA, Dieback is a significant environmental issue for projects between Geraldton in the Midwest and Esperance on the South Coast and is widespread in the Southwest region.

1.2 Project Location and Description

The study area is located in the Shire of Chittering approximately 80 km north of Perth, approximately 15 km north of Muchea (**Figure 1**). The 960 ha site is mainly comprised of Banksia woodland with some Marri (*Corymbia calophylla*) open forest.

1.3 Regulatory Context

Phytophthora Dieback management is required under the following regulatory mechanisms in WA:

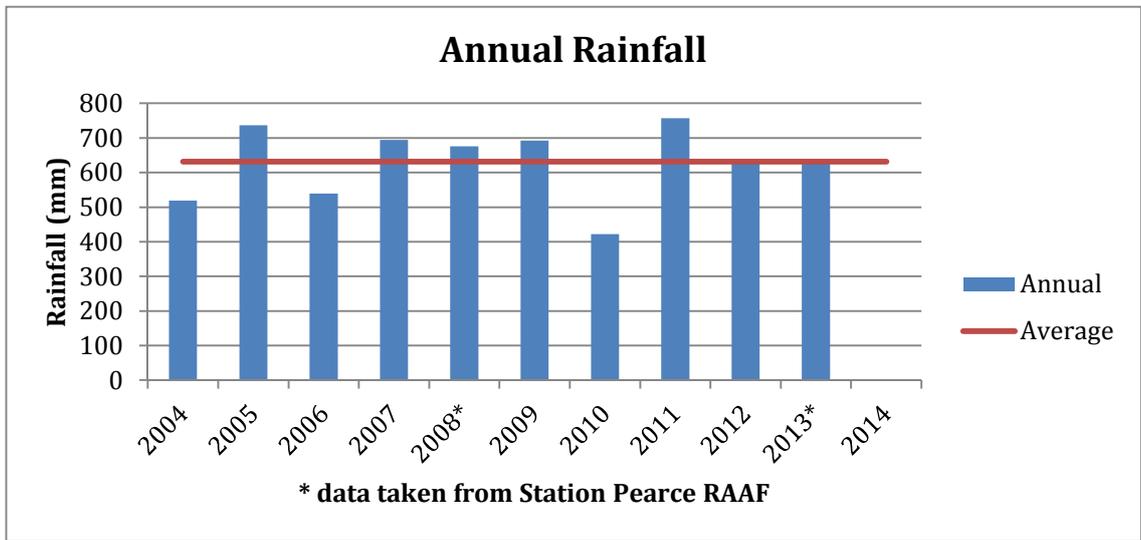
- *Phytophthora* Dieback is listed as a Key Threatening Process with the Federal Government under the *Environmental Protection and Biodiversity Conservation Act (1999)*
- *Environmental Protection Act (1986)* Part V S.50A "Serious Environmental Harm" provisions

2 Existing Environment

2.1 Climate

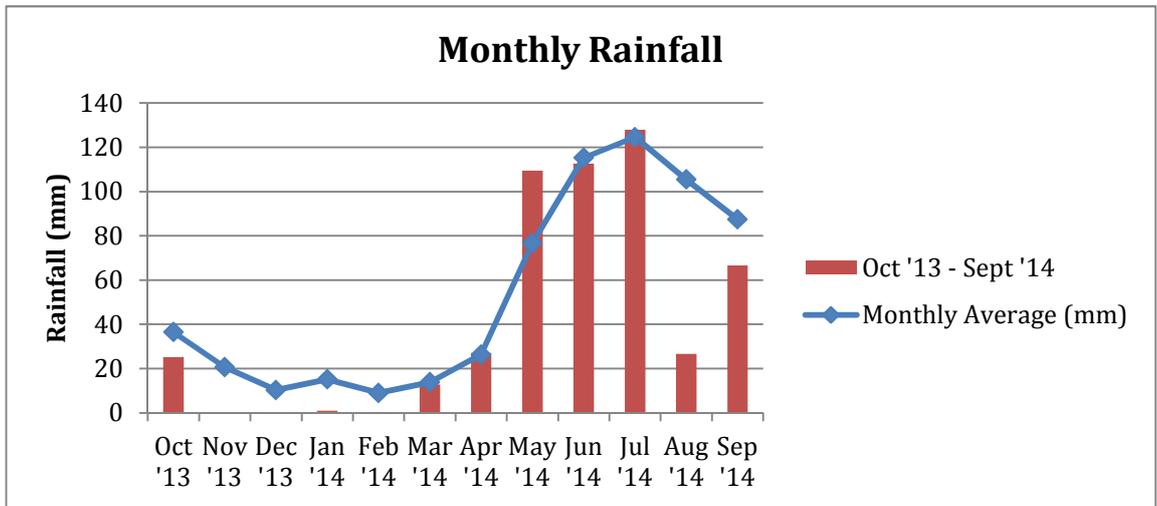
The Swan Coastal Plain region has a Mediterranean type climate with hot dry summers and cool wet winters. The warmest month is February, with an average monthly temperature of 30.4°C. The coolest month is July, with an average temperature of 18.3 °C.

Based on data from the Gingin Aero station (# 9178), the average annual rainfall for Muchea is 631.7 mm. The seasonal rainfall pattern for Muchea indicates an overall reduction in rainfall compared to historical averages, but exhibits variability in this trend, with years of significantly reduced rainfall interspersed with years of average to slightly above average rainfall (**Graph 1**). Significantly, the rainfall for 2010 was only 422 mm, which is 33% below average annual rainfall.



Graph 1: Annual rainfall at Gingin Aero station # 9178 (BoM, 2014)

Most rain falls in the cooler months of June-August. During winter 2014, this station received average or above-average rainfall until July, but a significant drop in rainfall was recorded during August and September compared to the long-term average.



Graph 2: Monthly rainfall at Gingin Aero station (# 9178) (2013-14) (BOM, 2014)

2.2 Biogeography

The study area is located in the Swan Coastal Plain Interim Biogeographic Regionalisation of Australia (IBRA) Bioregion, Perth Sub-Region (SWA02). This sub-region is dominated by woodlands of *Banksia* and Tuart on sandy soils, Sheoak on outwash plains, and paperbark in swampy areas. The colluvial and aeolian sand areas represent three phases of Quaternary marine sand dune development (which provide relief), and include a complex series of seasonal fresh water wetlands, alluvial river flats, coastal limestone and several off-shore islands. Younger sandy areas and limestone are dominated by heath and/or Tuart woodlands, while *Banksia* and Jarrah–*Banksia* woodlands are found on the older dune systems (Mitchell *et. al*, 2002).

2.3 Flora and Vegetation

Five vegetation complexes (Hedde *et. al* 1980) have been identified within the site. Descriptions of these vegetation complexes along with their interpretability for the presence of Dieback are presented below:

Moondah - supports predominantly a low closed to low open forest of *Banksia attenuata*, *B. menziesii*, *B. prionotes* and *Eucalyptus todtiana* on the slopes; and an open-woodland of Marri-*Banksia* in the valleys. Along the water courses, the vegetation is dominated by woodland of *E. rudis*, *Melaleuca raphiophylla* with some mixture of *M. preissiana* and thickets of *Kunzea vestita* in the understorey. One of the distinctive features of the Moondah vegetation complex is the presence of large number of *B. prionotes*. In other respects, due to the sandy soils, the vegetation has affinities with Mogumber, Cullala and Reagan complexes. Upland areas of the Moondah vegetation complex are highly interpretable for the presence of Dieback; however, the wetland areas are generally uninterpretable.

Reagan - supports vegetation ranging from low open-woodland of *B. attenuata*, *B. menziesii* and *E. todtiana* to closed heath depending on the depth of the soil. The composition of the understorey varies slightly depending on the proportion of sand and gravel. Plant species include *Adenanthos cygnorum*, *Petrophile linearis*, *Mesomelaena tetragona*, *Casuarina humilis*, *Mesomelaena stygia*, *Hakea trifurcata*, *Daviesia juncea* and species of *Hibbertia*, *Eremaea*, *Conospermum* and *Conostephium*. The Reagan complex is generally highly interpretable for the presence of Dieback.

Karamel South - is dominated by an open forest of Jarrah-Marri with a definite second storey of *B. grandis* on the gravelly soils with *B. attenuata* and *B. menziesii* on the sandier soils. Elsewhere on the Dandaragan Plateau, *B. grandis* is restricted mainly to the Gingin complex. Small areas of Wandoo occur in pockets on Karamal South. Other species in the open forest of Jarrah-Marri include *Stirlingia latifolia*, *B. sessilis*, *B. nivea*, *Hakea ruscifolia*, *Petrophile linearis*, *Jacksonia floribunda* and species of *Calytrix*, *Conostephium* and *Hakea*. The Karamel South complex is generally highly interpretable for the presence of Dieback.

Mogumber South - is dominated by an open-woodland of Marri with a well-defined second storey of Pricklybark-*Banksia* (*E. todtiana*, *B. attenuata*, *B. menziesii* and *B. ilicifolia*) The same pattern of Marri extending further north than Jarrah, seen of on the northern Swan Coastal Plain, is repeated in this area. Although localised patches of Jarrah are to be found, they are restricted in size and number. As one goes from the higher rainfall in the south to the lower rainfall in the north, Jarrah disappears first, then Marri. The intermingling of Pricklybark and Jarrah evident on the Bassendean sand dunes near Perth and Gnangara is repeated in the Mogumber complex. Understorey species vary considerably depending on proportion of sand and gravel, depth of sand and moisture levels, but include such species as *Nuytsia floribunda*, *Stirlingia latifolia*, *Petrophile linearis*, *Daviesia pectinata*, *Calothamnus sanguineus*, *Mesomelaena tetragona*, *Baeckea camphorosmae*, *Hypocalymma angustifolium*, *Leptocarpus scariosus*, *Casuarina humilis*, *Lyginia tenax* and *Bossiaea eriocarpa*. The Mogumber South complex is generally highly interpretable for the presence of Dieback.

Coonambidgee complex –this vegetation ranges from a low open forest to low woodland of *E. todtiana*, *Banksia attenuata*, *B. ilicifolia* with local admixtures of *B. prionotes*, to an open woodland of *Corymbia calophylla* and *Banksia* species. The Coonambidgee complex is generally highly interpretable for the presence of Dieback.

3 Methods

The Dieback assessment was done by DPAW registered Dieback Interpreter Joseph Grehan and Field Assistant Kelby Jennings in August 27th and 28th, 2014. While the assessment occurred during the optimal time of the year, sampling conditions were sub-optimal due to the lower than average winter rainfall.

The linear Dieback assessment was conducted in accordance with the *Manual for detecting Phytophthora Dieback disease* (Procedures for DPaW managed lands) (DPaW 2013). These recently updated Dieback Interpreters' guidelines now categorise land that has been cleared of native vegetation (such as farmland) as 'excluded' from assessment. Non-vegetated areas that are 'excluded' from assessment include pasture, pits, easements, development, large roads (sealed and unsealed) permanent flooding and parkland tree stands. Excluded areas are distinguished from unmappable areas by the fact that unmappable areas retain the ability to regenerate and eventually become mappable. **Table 1** presents the *Phytophthora* occurrence categories, impacts and syndromes (DPaW 2013), which include the unmappable category.

The unmappable category is allocated to areas of native vegetation which have been disturbed, but native vegetation will recover over time and may become interpretable and therefore mappable. Examples of unmappable areas include vegetation that has been impacted by fire, timber harvesting, flooding or mining with subsequent rehabilitation. The recovery time for unmappable areas may take longer than 3 years (DPaW 2013). **Table 1** presents details of the different Dieback occurrence categories as defined in DPaW's draft Dieback interpreter's guidelines (DPaW 2013).

Table 1: *Phytophthora* occurrence categories, impacts and syndromes (as cited in DPaW 2013)

<i>Phytophthora</i> occurrence mapping	Impact Rating	Syndrome	Comment
Infested: Impacts of <i>Phytophthora</i> Dieback are visible	High	Endemic or Extremely destructive Epidemic	
	Moderate	Commonly a variable epidemic but may also exist as or be progressing to an extremely destructive epidemic	This syndrome may not have reached full destructive potential, depending on the age of infestation. It might be progressing to High Impact, epidemic syndrome
	Low None of the susceptible overstorey is affected by disease	Variable epidemic Disease apparent	Although overall impact is low, it is not low enough to be given 'no apparent disease' syndrome
			May consist of very low level endemic disease in an environment not favourable to the pathogen
Uninfested: Areas of natural undisturbed or low disturbance vegetation free of symptoms that Indicate <i>Phytophthora</i> Dieback	Nil	No apparent disease	
Uninterpretable: Areas of natural undisturbed vegetation where susceptible plants are too few for interpretation of <i>Phytophthora</i> Dieback	None, or none perceptible	No apparent disease	May consist of very low level endemic disease in an environment not favourable to the pathogen
Unmappable: Keighery disturbance rating 4 or greater	Predicted impact rating may be forecast based using landform and vegetation types	Not assessable	

The Keighery vegetation disturbance scale (DPaW 2013) presented in **Table 2** was used to determine the interpretability of the vegetation. Areas with a vegetation condition rating of 1-3 (Pristine - Very Good) are considered to be mappable. In addition, there must be enough disease indicator species present to enable a diagnosis of the disease status. An area with a vegetation condition rating of 4 (Good) is possibly mappable; however, it is up to the interpreter's discretion. Unmappable and excluded areas are given a condition rating of 5 or 6 (Degraded or Completely Degraded).

Table 2: Keighery (1994) Vegetation Disturbance Scale and Assessability (as cited in DPaW 2013)

Interpretability	Scale		Condition
Mappable	1	Pristine	Pristine or nearly so, no obvious signs of disturbance
	2	Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species
	3	Very Good	Vegetation structure altered, obvious signs of disturbance. For example, disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing
Possibly Mappable, discretion required	4	Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, Dieback and grazing.
Unmappable or Excluded from assessment	5	Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. For example, disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, Dieback and grazing.
	6	Completely Degraded	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These areas are often described as "parkland cleared" with the flora comprising weed or crop species with isolated native trees or shrubs.

3.1 Linear Assessment

A linear Dieback assessment was done on the tracks and unsealed roads within and adjacent to the study area. During the assessment, visual evidence of disease absence or presence was recorded within a 50 m wide corridor, 25m either side of the track or unsealed road. Other potential disease vectors including watercourses and disturbed areas in and adjacent to the site were also assessed. Reconnaissance of the study area was completed prior to commencing the linear assessment to determine the following:

- Access
- Identify interpretable vegetation and disease expression if present
- Identify possible disease vectors e.g. tracks, utility corridors, ground disturbance, feral animals etc.
- Determine the location of high risk areas (e.g. areas of high disturbance and water-gaining sites)
- Identify other impacts to vegetation (e.g. drought, cankers, herbivory, *Armillaria luteobubalina*, fire)

The assessment involved driving the tracks and unsealed roads within and surrounding the study area recording evidence of presence or absence of Dieback. When necessary areas outside the linear corridor were assessed, including watercourses and disturbed areas, to determine the broader landscape context and to ensure uninfested areas were protectable.

3.2 Disease Risk Categories

Vegetation within the study area was categorised into three different disease risk categories as described below in **Table 3**.

Table 3: Disease Risk Categories

Disease Risk Category	Description
High	Areas where <i>Phytophthora cinnamomi</i> has been recovered from samples and disease symptoms are consistent with the presence of Dieback.
Medium	Areas exhibiting past or current disturbances (logging, grazing, dumping etc.) which have altered vegetation structure and composition. Also includes areas downslope of confirmed infestations, or which exhibit disease symptoms but have not returned positive results for <i>P. cinnamomi</i> .
Low	Areas of protectable uninfested vegetation (as determined by a registered Dieback interpreter), which exhibit multiple healthy indicator species, vegetation in Pristine to Very Good condition (Keighery scale 1-3), no disease pattern or chronology, and no significant risks from disease vectors or current land use.

3.3 Sampling

Soil and tissue samples of recently dead or dying disease indicator species were collected and lodged with the DPaW's Vegetation Health Services Laboratory (VHS) where diagnostic baiting was conducted. All sample point locations were recorded with a hand-held GPS. The following sampling strategy was applied when determining sample locations:

Initial standards sampling: Initial samples are taken to determine disease behaviour. The results inform the sampling strategy and enable testing of early hypotheses (e.g. are other factors causing the deaths of susceptible species such as *Armillaria luteobubalina* or drought).

Sampling to support infested diagnosis: Recently dead and dying indicator species are sampled to support an infested diagnosis.

Sampling to support an uninfested diagnosis: Recently dead and dying indicator species are sampled to support an uninfested diagnosis. Caution must be exercised when claiming that a negative result means that an area is uninfested, because false negative results can be recorded when inoculum levels are depleted from prolonged unfavourable environmental conditions for the pathogen.

All sampling strictly adheres to the following procedures:

- All tools used in sampling are thoroughly sterilised with a 70:30 mixture of methylated spirits and water before samples are taken. It must be ensured that the tools are dry prior to sampling so that the results are not compromised.
- The area around the base of the plant being sampled is cleared of leaf litter and debris so that this material is not included in the sample.
- The plant sampled is excavated to suitable depth to ensure that adequate plant tissue material can be obtained from the roots and cambium layer around the collar of the plant being sampled.
- Material from all around the plant is taken in addition to any obvious lesions to avoid missing any infected material. All the plant tissue material and a few handfuls of soil from around the roots and other places in the soil profile are placed in a polythene bag.
- Enough distilled water to moisten the soil is poured into the bag to ensure the survival of any inoculum that may be present in the sample.
- All relevant information pertaining to the plant sampled and sample location is recorded on the Sample Information Sheet.
- Two aluminium tags with the date, project name, sample number, species sampled and the name of the interpreter are written. One tag is placed in the sample bag and the other is tied near the sample site which is also flagged with a day-glow orange flagging banner.
- The sample hole is backfilled to prevent fauna from becoming trapped.
- All tools are brushed off (to remove excess soil) and sterilised to prevent contamination of the next sample site and sample.

3.4 Mapping

Field evidence and observations were used to prepare the Dieback risk map (**Figure 2**) within the study area. The information used in mapping includes:

1. Sample results
2. Interpretability determined from vegetation condition and disease indicator present
3. Topography and drainage

3.5 Limitations

The DPaW's draft Dieback interpreters guidelines (DPaW 2013) discuss the limitations of linear assessment (P.88)

While a linear assessment uses the same methods as comprehensive transect assessments, it is often regarded as significantly more difficult to do, because the linear assessment corridor is easily taken out of context from wider landscape units. Phytophthora occurrence assessment boundaries may only briefly intersect linear corridors, giving little relative perspective to the wider landscape unit.

The following limitations were encountered during the assessment:

- The widespread impact of drought on the vegetation made Dieback interpretation more difficult.
- The impacts of canker species on susceptible vegetation, particularly *Banksia* species, made Dieback interpretation more difficult.
- Some areas were uninterpretable due to past disturbance caused by logging and grazing.
- Although the survey was conducted during the optimal time, negative sample results can be due to low inoculum levels for *Phytophthora cinnamomi* and therefore it is possible to obtain false negative results.

4 Results

In total, 11 soil and tissue samples were collected from recently dead and dying disease indicator species. The samples were baited at the VHS laboratory. In addition, a tissue sample was taken to test for canker and this returned a positive result for *Cytospora* sp. *Banksia* species including *Banksia attenuata*, *B. menziesii*, and *B. grandis* were the preferred species to sample because they are highly susceptible to the pathogen (Brandis 1983). The sample results are presented in **Table 4** below.

Table 4: Sample Results

Sample No.	Species	Easting GDA 94, Zone 50	Northing GDA 94, Zone 50	Result
CS01	<i>Banksia attenuata</i>	404805	6514443	<i>P. cinnamomi</i>
CS02	<i>Banksia grandis</i>	404874	6511350	Negative
CS03	<i>Banksia menziesii</i>	405328	6517342	Negative
CS04	<i>Banksia attenuata</i>	406281	6517239	Negative
CS05	<i>Banksia grandis</i>	406273	6516533	Negative
CS06	<i>Banksia menziesii</i> & <i>Banksia attenuata</i>	402347	6517398	<i>P. cinnamomi</i>
CS07	<i>Banksia attenuata</i>	402678	6514603	Negative
CS08	<i>Banksia attenuata</i>	403319	6514552	Negative
CS9	<i>Banksia grandis</i>	404215	6514542	<i>Cytospora</i> sp. (Canker)
CS10	<i>Banksia attenuata</i>	404459	6517350	Negative
CS11	<i>Xanthorrhoea preissii</i>	402356	6516852	Negative

The total study area in terms of the linear corridor that was assessed is 119.2ha. This is comprised of 19.4 ha of High Risk (16.3 %), 12.2 ha of Moderate Risk (10.2 %) and 87.6 ha (73.5 %) of Low risk vegetation (**Figure 2**).

5 Discussion

5.1 High Risk Areas

High risk areas are defined as areas where *Phytophthora cinnamomi* has been recovered and disease symptoms consistent with Dieback have been observed. Depending on disease expression symptoms may include:

- Multiple disease indicator species deaths
- Disease pattern and chronology
- Reduction in species richness and cover
- The presence of a disease vector (e.g. track, watercourse, evidence of animal vectors such as pigs)

The linear assessment identified three high risk areas within and adjacent to the study area:

1. The northern section of the power line track near Ippolo Road is infested with recently dead *Banksia attenuata* and *B. menziesii* returning a positive result for *P. cinnamomi* (sample CS08). The infestation runs down the slope along the power line but doesn't appear to extend further than 50 to 100m either side of the track. This section of the power line track poses a high risk of spreading Dieback through the site (**Plates 1 & 2**).
2. The unsealed road along the western boundary of the unnamed DPaW reserve to the west of the study area boundary is infested with two historical results for *P. cinnamomi* (VHS 2014). This unsealed road poses a high risk of vectoring disease along Ippolo Road and into the study area.
3. A section of vegetation on the northern side of the creek located to the south of site boundary is infested. A recently dead *Banksia attenuata* returned a positive result for *P. cinnamomi* (Sample CS01). It is believed that the disease has been vectored into the riparian zone of the creek by feral pigs (**Plate 3**) because there was no distinct disease pattern along the watercourse. The track crossing the creek into the southern boundary of study area poses a high risk as a disease vector.

5.2 Moderate Risk Areas

Two of the moderate risk areas have past disturbances, including logging and grazing, which have resulted altered vegetation structure and some disease indicator species deaths, but have not yielded positive results for *P. cinnamomi* (**Plate 4**). The other moderate risk area is along the power line track downslope of a confirmed infestation. Although this area did not yield a positive result for *P. cinnamomi* there were multiple disease indicator species deaths and additional sampling may recover a positive result

5.3 Low Risk Areas

Low risk areas are areas that have been determined to be uninfested by a DPaW registered Dieback Interpreter. While an uninfested diagnosis can be supported by negative sample results for *P. cinnamomi*, an area cannot be determined to be uninfested on sample results alone (**Plate 5**). Observable factors which can be used in making an uninfested diagnosis include the following:

- Multiple healthy disease indicator species.
- Vegetation condition is rated as 1-3 on the Keighery vegetation condition scale.
- No evidence of disease pattern or chronology.
- Indicator species deaths can be attributed to other factors i.e. drought, canker or *Armillaria*.

5.4 Other Potential Impacts to Vegetation

There may be other factors that caused the observed deaths of disease indicator species, including drought, other *Phytophthora* species, pathogenic fungi and *Armillaria luteobubalina* (*Armillaria* or Australian Honey Fungus).

5.4.1 Other *Phytophthora* species

Phytophthora arenaria is thought to be a native Australian species of *Phytophthora*, however its centre of diversity is still to be determined (C, Crane. Pers. Comm 16/12/2014). The website 'Phytophthora Database' describes the characteristics of *P. arenaria* as follows:

Phytophthora arenaria A. Rea, M. Stukely & T. Jung has been isolated in Western Australia from kwongan heath-land stands since the early 1980s (Burgess et al. 2009, Rea et al. 2011), but was misidentified as *P. citricola*. With the exception of one isolate from Bunbury (south-west coast) *P. arenaria* has been isolated exclusively from the northern sand plains. Most isolates were associated with dead or dying *Banksia* or *Eucalyptus* species; however, isolates were also recovered in association with asymptomatic *Banksia* and *Eucalyptus* species. The first isolation of this taxon was from soil in native kwongan vegetation near Kalbarri in 1986. *Phytophthora arenaria* has thick oospore walls and physiological characteristics that appear to be adaptations favouring survival in the harsh kwongan ecosystem suggesting that this species may be endemic to Western Australia. However, the most closely related species is *P. alticola* a species described from South Africa and the origin of both species requires further examination (<http://www.phytophthoradb.org>).

Another species, *Phytophthora multivora*, which has often been misdiagnosed for *P. citricola*, can persist in alkaline soil (Scott et al. 2009) which is suppressive to *P. cinnamomi*. The ability of *P. multivora* to survive in alkaline soils has implications for hygiene management because using limestone as a sterilising road-base material, as it has been previously used due to its antagonism to *P. cinnamomi*, may not be effective for managing *P. multivora* spread.

5.4.2 Other Pathogenic Fungi

The impact of cankers caused by pathogenic fungus on Proteaceous species was examined by Crane and Burgess (2013). The study examined the impact that aerial cankers are having on coastal vegetation between Esperance and Cervantes and demonstrated pathogenicity in seven *Banksia* spp. over a wide geographic range. The pathogenic fungus was identified as a new genus and species within the *Cryphonectriaceae* (*Diaporthales*) and is described as *Luteocirrhus shearii* gen. sp. nov. The fungus causes the death of single branches; however, it can lead to multiple branch deaths or cause complete crown dieback as occurred with some of the *Banksia baxteri* and *B. verticillata* sampled (Crane and Burgess 2013).

A tissue sample taken from a recently dead *Banksia grandis* was tested for the presence of canker at VHS. *Cytospora* sp. was recovered from the sample which is likely to indicate an inability of the plant to contain the fungi because this canker species can also be present on healthy plants (**Appendix 1**). *Banksia* species including *Banksia attenuata*, *B. grandis*, *B. prionotes* and *B. menziesii* displaying symptoms consistent with those described by Crane and Burgess, but not characteristic of *P. cinnamomi* disease expression, were observed throughout the study area. Canker impacts were observed throughout the study area and were generally discernible from Dieback symptoms by the death of single branches or lesions emanating above the trunk collar (**Plates 6, 7 & 8**).

5.4.3 Drought

Impacts to vegetation as a result of prolonged drought were differentiated from impacts caused by *P. cinnamomi* by the following characteristics:

- No disease pattern or chronology in the surrounding vegetation.
- The plant had senesced gradually rather than succumbing quickly as is usually the case with deaths attributed to *P. cinnamomi*.

- No visible lesions or mycelium on the roots of the dead or dying plant.
- Re-shooting or epicormic growth visible on dying plants (**Plates 9 & 10**).

The presence of single or multiple dead branches with the remainder of the plant appearing to be healthy may be attributed to drought or pathogenic fungi.

5.4.4 *Armillaria* (Australian Honey Fungus)

Armillaria luteobubalina (Armillaria or Australian Honey Fungus) is a species of mushroom which causes Armillaria root-rot in affected plants. The fungus is widespread in Jarrah (*Eucalyptus marginata*) and Karri (*E. diversicolor*) forests of the southwest of WA, but has also been recorded in coastal vegetation between Cape Arid (120 km east of Esperance) to Cervantes (160 km north-west of Perth) (Shearer *et al* 1997). *Armillaria* is dispersed by spores produced by the mushroom and also reproduces vegetatively through the roots of affected plants. It affects many of the same plant genera as *Phytophthora* in particular members of the Myrtaceae and Proteaceae plant families, such as *Eucalyptus* and *Banksia* species. *Armillaria* forms a quite visible white or yellow leathery mycelial sheath which is visible beneath the bark in the roots or lower stem. Other observable factors that can be applied in the diagnosis of *Armillaria* infection include:

- Clusters of fruiting bodies around or near the base of the plant
- A pungent mushroom smell
- An inverted V shaped scar at the base of the plant
- Yellow-white stringy rot under the bark in the roots and base of affected plants (DEC, 2012)

While some of the mycelium observed may be as a result of *Armillaria*, the assessment occurred at the wrong time of the year to observe fruiting bodies and therefore confirm the presence of the fungus. It is possible that *Armillaria luteobubalina* is present within the study area and contributing to the death of the vegetation.

6 Conclusion and Recommendations

Tracks, water courses and hard-hooved feral animals are considered to be the most likely vectors of disease in the study area. Therefore a linear Dieback assessment was considered an appropriate method for assessing the risk and likelihood of Dieback presence within and adjacent to the study area. The linear assessment determined that the majority of the study area is uninfested and therefore presents a low risk of spreading Dieback into areas outside the study corridor. While it is likely that the majority of the 983 ha site is uninfested, caution should be used when extrapolating the disease status and/or risk to vegetation that has not been assessed outside the study area.

Terratree makes the following recommendations in relation to the linear *Phytophthora* Dieback assessment of the study area:

- A comprehensive Dieback assessment of the site should be completed in accordance with *Manual for detecting and mapping Phytophthora Dieback disease* (Procedures for DPaW managed lands) (DPaW 2013).
- Protectable areas should be clearly demarcated and signposted.
- Additional samples from moderate risk areas should be taken.
- A Dieback management plan, including an access management strategy, should be developed for the site.

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8 Glossary of Terms

Assessment – (*Phytophthora* occurrence) any combination of activities including, detection, diagnosis (interpretation), mapping and demarcation of *Phytophthora* Dieback disease in natural ecosystems.

Assessment Area – An area where *Phytophthora* occurrence assessment is possible, or will be possible in the short to medium term. This area may be larger or smaller than the proponent's project area.

Disease - The combination of a pathogen, host and correct environmental conditions, which results in disease symptoms or death of a host.

Environment - The sum of all external factors which act on an individual organism during its lifetime.

Excluded Area – An area of high disturbance in which native vegetation is unlikely to recover.

Host - means the plant which is invaded by a pathogen and from which the pathogen derives its energy.

Indicator species – Plant species that are more susceptible to *Phytophthora* disease and reliably show symptoms earlier than other species.

Infection – The invasion of a host organism's bodily tissue by disease causing organisms. In relation to Dieback this refers to an individual plant and not the population.

Infested – The state of being invaded or overrun by pests or parasites. In relation to Dieback it refers to a population of plants and not individual plants.

Inoculum – Cells, tissue, or viruses that are used to inoculate a new culture

Pathogen – Any organism or factor causing disease within a host

Pathogenic – Causing or capable of causing disease

***Phytophthora* Dieback** – A term referring to the disease symptoms caused by *Phytophthora* species in susceptible vegetation.

Susceptible – Likely to be influenced or able to be harmed by particular pathogen

Sporulation - a type of reproduction that occurs in fungi, algae, and protozoa and involves the formation of spores by the spontaneous division of a cell into four or more daughter cells, each of which contains a part of the original nucleus.

Symptom – A phenomenon that arises from, and accompanies a particular disease or disorder and serves as an indication of it

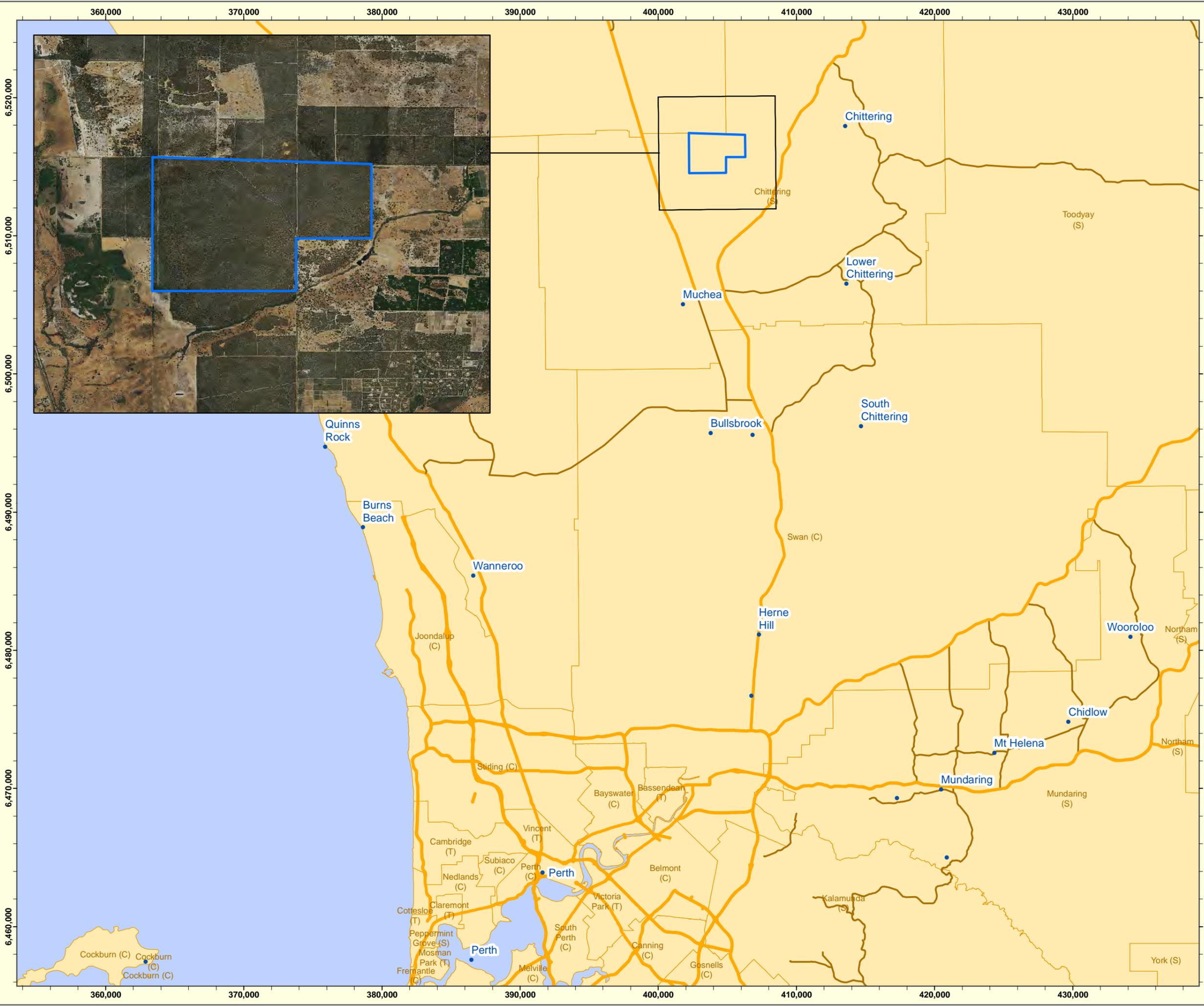
Uninfested – An area that does not contain infected plants or show visible signs of disease

Uninterpretable – a natural area where there are inadequate visible symptoms present to make a diagnosis

Unmappable – A naturally vegetated area that has had disturbance and from which is likely to recover in the short term

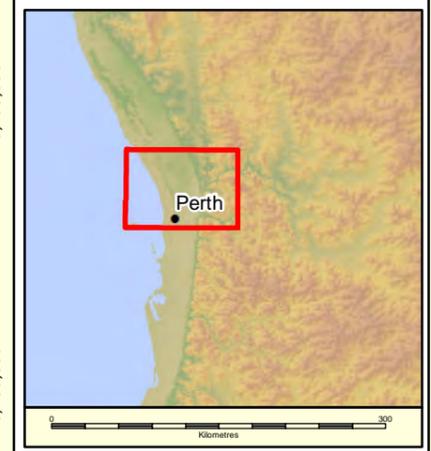
Unprotectable – A disease free area that is likely to become infested within a given time

Figures

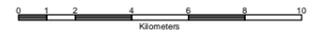


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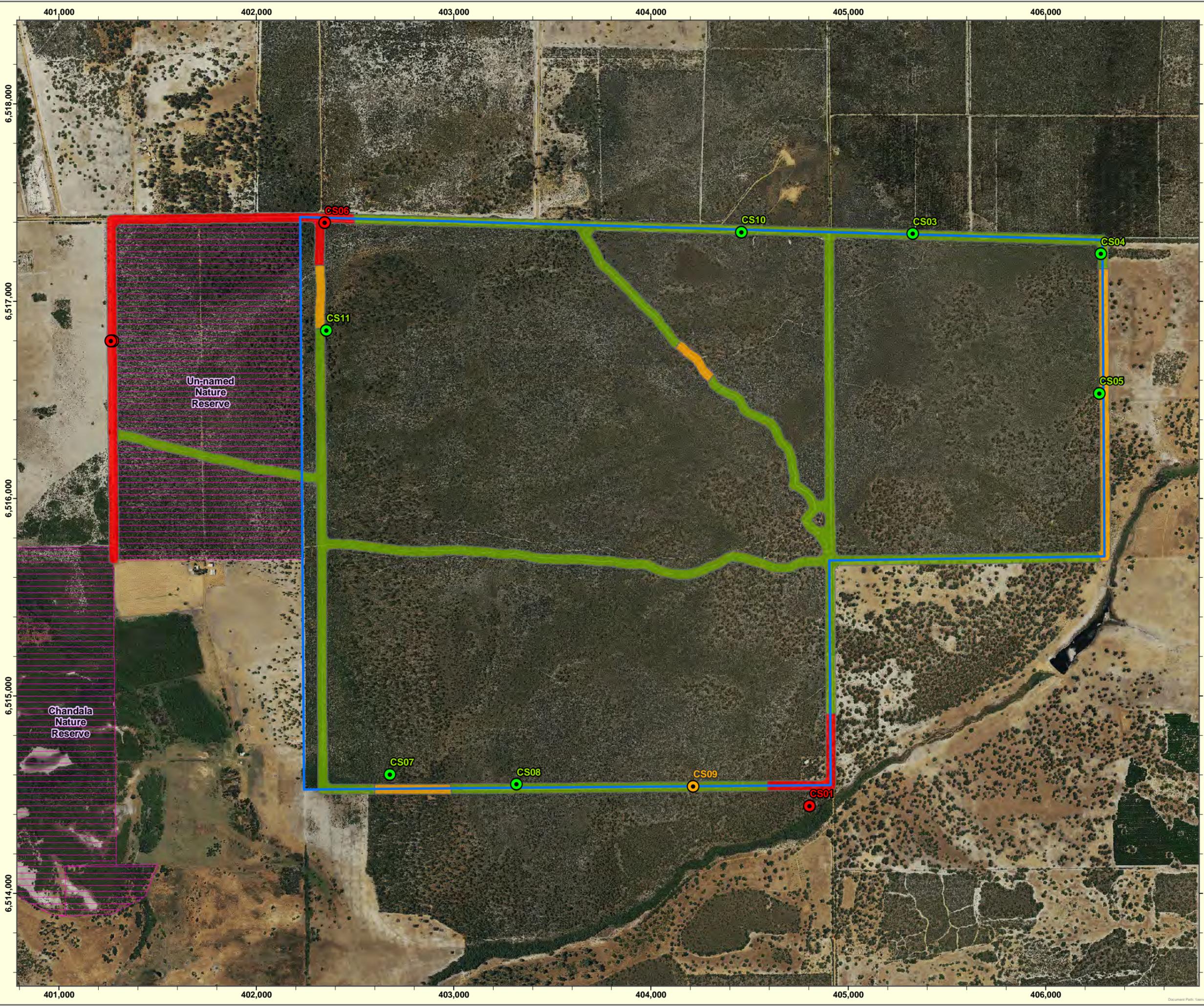
- Site boundary
- Towns
- Road (Primary Distributor)
- Road (Regional Distributor)



SITE LOCALITY
Chittering Dieback
Reconnaissance Survey


 Coordinate System: GDA 1994 MGA Zone 50
 Projection: Transverse Mercator, Datum: GDA 1994, Units: Meter


Scale @ A3: 1:250,000	Figure 01
Date: 22/09/2014	 
Revision: Rev A	
Project No: TS14013	
Prepared: R Cullen	
Checked: J Botterill	
Reviewed: N King	



LEGEND

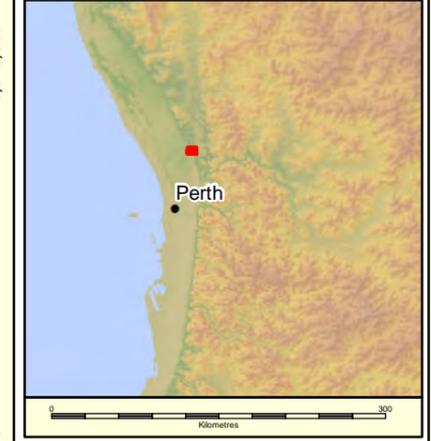
- Site boundary
- DPaW managed lands

Dieback sample results

- Cytospora* sp. (canker)
- P. cinnamomi*
- Negative

Dieback risk assessment

- High
- Moderate
- Low



LINEAR DIEBACK RISK ASSESSMENT AND SAMPLE RESULTS
Chittering Dieback
 Reconnaissance Survey

Coordinate System: GDA 1994 MGA Zone 50
 Projection: Transverse Mercator, Datum: GDA 1994, Units: Meter

Scale @ A3: 1:17,500	Figure 02
Date: 22/09/2014	
Revision: Rev C	
Project No: TS14013	
Prepared: R Cullen	
Checked: J Botterill	
Reviewed: N King	

9 Plates



Plate 1: High risk vegetation: Infested *Banksia* woodland with multiple indicator species deaths, disease pattern and chronology



Plate 2: Dead *Banksia attenuata* adjacent to disease vector (power line access track)



Plate 3: Evidence of feral pig activity, a likely vector for the positive *P. cinnamomi* sample



Plate 4: Medium risk vegetation - Area at risk due to historical disturbance due to logging, nearby areas of Infested vegetation and indicator species deaths.



Plate 5: Low risk vegetation - Uninfested woodland with low levels of disturbance and intact vegetation in Excellent condition



Plate 6: *Banksia grandis* exhibiting canker impacts



Plate 7: *Banksia* trunk exhibiting canker lesions on the cambium layer



Plate 8: *Banksia attenuata* exhibiting partial death due to canker



Plate 9: *Banksia* woodland exhibiting drought impacts



Plate 10: *Banksia attenuata* re-shooting after drought impact

10 Appendices

Appendix 1: Vegetation Health Services Laboratory report on positive identification of *Cytospora* sp. (canker) in CS11

Appendix 2: Sample Results from the Vegetation Health Services laboratory

PLANT DISEASE SAMPLE INFORMATION SHEET

CLIENT NAME Terratree Joe Grehan joeg@terratree.com.au

SAMPLE *Banksia grandis* canker CS 11 (canker) Fig. 1.

DIAGNOSIS A *Cytospora* sp. (Fig 2 & 3) was isolated and most likely indicates some inability of the plant to contain the fungi which can also be present on healthy plants.



Fig. 1 sample

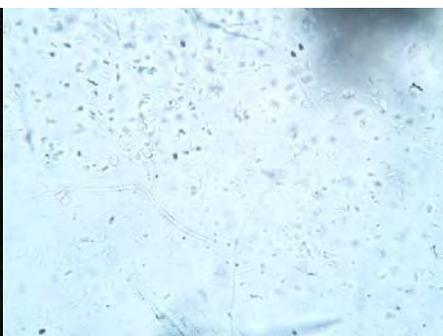


Fig. 2 Curved conidia



Fig.3 Alantoid conidia

THE PATHOGEN *Cytospora* sp. along with other genera in the Valsaceae, are commonly isolated from stem and twig cankers of *Eucalyptus*, *Hakea* and *Banksia* sp. of south-western Australia (Shearer 1994) They have a worldwide reputation as pathogens and cause extensive damage to tree crops. However in south-western Australia they often exist as benign endophytes (present in host tissues asymptotically) or wound pathogens causing disease only when the host is compromised in some way. Trees affected by drought, insect attack, defoliation by fungi, sunscald, herbicides or mechanical injury are predisposed to infection and disease development.

SYMPTOMS Twig and branch death.

HOST RANGE Myrtaceae, Proteaceae and Ericaceae

DISTRIBUTION Ubiquitous across the south-west but can have local high inoculum levels in infection pockets.

CONTROL Really need to trial this first to look at host/pathogen/fungicide response. Unsure? Is it warranted?

LABORATORY SAMPLES CC1721 not retained

SITE CS 11 Chittering

Boulder

MAP REFERENCE E 404215 N 6514542 Zone 50

19/9/2014

Colin Crane

Manager Vegetation Health Service

Department of Parks and Wildlife

Science Division

PH. (08) 9334 0482

Fax.(08) 9334 0327

Email: colin.crane@dpaw.wa.gov.au

Shearer BL (1994) The major plant pathogens occurring in native ecosystems of south-western Australia, *Journal of the Royal Society of Western Australia* 77, 113-122.

VEGETATION HEALTH SERVICE - PHYTOPHTHORA SAMPLE INFORMATION SHEET

SEND TO: Vegetation Health Service, Science Division – D.E.C, 17 Dick Perry Ave KENSINGTON 6151 Phone: (08) 9334 0317 Fax: (08) 9334 0114

CONTACT DETAILS of sender

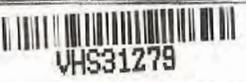
Name Joe Graham Terratree
 Fax No. Ph. 9335 4228 Phone No. 0412003658
 DEC Office or Company Name Terratree Pty Ltd

GDA
(1)
GDA 94

Job Type (Please indicate)
 D.E.C. (C) Alcoa (A)
 Recoup (R) FPC
 Private (P) Other _____

VHS USE ONLY

Date processed 29/9/14
 Date faxed 12/9/14

VHS Identification Number (VHS USE ONLY)	Sample Date	Sample label (Give location, eg. Forest Block or Shire, etc. and sample number)	Plant species sampled	Site Impact (2)	Zone 50 or 51	Map Reference (3)	Land Tenure (4)	RESULT s/s root (5)	RESULT bait (5)
 VHS31279	27/8/14	CS01 (chittering)	<i>Banksia attenuata</i>	M	50	E 404805 N 6514443	P		CIN
 VHS31280	27/8/14	CS02 "	<i>Banksia grandis</i>	M	50	E 404874 N 6571350	P		NEG
 VHS31281	27/8/14	CS03 "	<i>Banksia menziesii</i>	M	50	E 405328 N 6512242	P		NEG
 VHS31282	27/8/14	CS04 "	<i>Banksia attenuata</i>	M	50	E 406281 N 6512232	P		NEG
 VHS31283	27/8/14	CS05 "	<i>Banksia grandis</i>	H	50	E 406273 N 6576522	P		NEG
 VHS31284	27/8/14	CS06 "	<i>B. menziesii</i>	L	50	E 401375 N 6516788	P		SUB
 VHS31285	28/8/14	CS07 "	<i>B. menziesii</i>	AA	50	E 401281 N 6517193	P		AS FOR 31284
 VHS31286	28/8/14	CS08 "	<i>B. menziesii</i> + <i>B. attenuata</i>	H	50	E 402347 N 6517398	P		CIN

NOTES:

1. Please tick this box if your map references are supplied in the GDA 94 standard. If not, please specify the datum used.
2. Site impact - Low, Moderate, or High (as in the Dieback Interpreter's Manual).
3. An MGA map reference with prefixes must be supplied for all samples.
4. Land Tenure - State Forest (SF), National Park (NP), Reserve (R), Westrail (W), Private (P), Gravel Pit (GP), or other. (Other - describe in comments below).
5. Result codes used - CIN = *Phytophthora cinnamomi*, MUL = *P. multivora*, CRY = *P. cryptogea*, PI = *P. inundata*, ARE = *P. arenaria*, ELO = *P. elongata*, THE = *P. thermophila*, PM = *P. megasperma*, PN = *P. nicotianae*, CON = *P. constricta*, NEG = negative, SUB = subcultured for further tests

Please Note: a). NEG results cannot be used to represent a total absence of *Phytophthora* in the sampled area. b). Information from your samples will be incorporated into the VHS database.

COMMENTS:

VEGETATION HEALTH SERVICE - PHYTOPHTHORA SAMPLE INFORMATION SHEET

SEND TO: Vegetation Health Service, Science Division – D.E.C, 17 Dick Perry Ave KENSINGTON 6151 Phone: (08) 9334 0317 Fax: (08) 9334 0114

CONTACT DETAILS of sender

Name JOE Grehun
 Fax No. Mob 040003688 Phone No. 93354228
 DEC Office or Company Name Terrace Pty Ltd

GDA
 (1)
 GDA 94

Job Type (Please indicate)
 D.E.C. (C) Alcoa (A)
 Recoup (R) FPC
 Private (P) Other _____

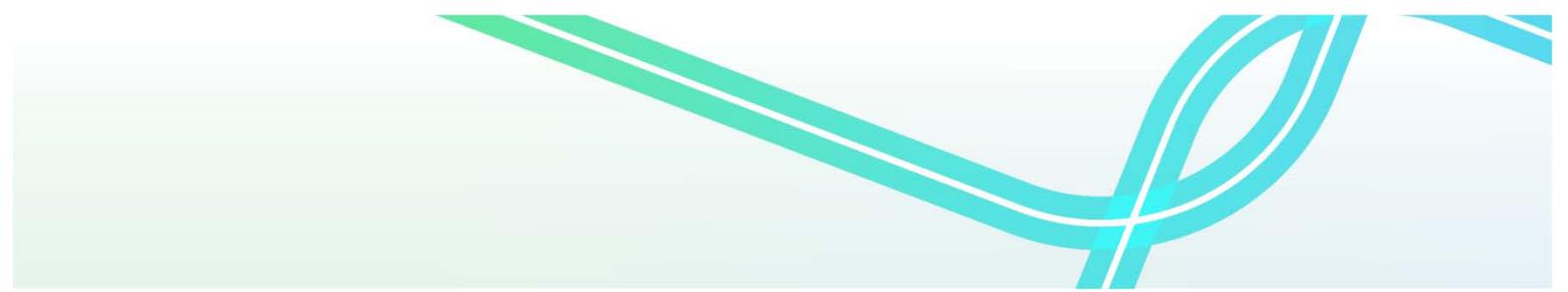
VHS USE ONLY
 Date received 30/8/14
 Date sampled 12/9/14

VHS Identification Number (VHS USE ONLY)	Sample Date	Sample label (Give location, eg. Forest Block or Shire, etc. and sample number)	Plant species sampled	Site Impact (2)	Zone 50 or 51	Map Reference (3)	Land Tenure (4)	RESULT s/s root (5)	RESULT bait (5)
 VHS31287	28/8/14	CS09 (chittering)	<i>Banksia attenuata</i>	M	50	E 402678 N 6574603	P		NEG
 VHS31288	28/8/14	CS10 "	<i>B. attenuata</i>	L	50	E 403319 N 6574552	P		NEG
	28/8/14	CS11 "	CANKER sample <i>B. grandis</i>	M	50	E 404215 N 6574342	P		
 VHS31289	28/8/14	CS12 "	<i>B. attenuata</i>	L	50	E 404459 N 6572350	P		NEG
 VHS31290		CS13 "	<i>Xanthorrhoea preissii</i>	M	50	E 402356 N 6576852	P		NEG
						E ----- N -----			
						E ----- N -----			
						E ----- N -----			

- NOTES:
1. Please tick this box if your map references are supplied in the GDA 94 standard. If not, please specify the datum used
 2. Site impact - Low, Moderate, or High (as in the Dieback Interpreter's Manual).
 3. An MGA map reference with prefixes must be supplied for all samples.
 4. Land Tenure - State Forest (SF), National Park (NP), Reserve (R), Westrail (W), Private (P), Gravel Pit (GP), or other. (Other - describe in comments below).
 5. Result codes used - CIN = *Phytophthora cinnamomi*, MUL = *P. multivora*, CRY = *P. cryptogea*, PI = *P. inundata*, ARE = *P. arenaria*, ELO = *P. elongata*, THE = *P. thermophila*, PM = *P. megasperma*, PN = *P. nicolianae*, CON = *P. constricta*, NEG = negative, SUB = subcultured for further tests

Please Note: a). NEG results cannot be used to represent a total absence of *Phytophthora* in the sampled area. b). Information from your samples will be incorporated into the VHS database.

COMMENTS:



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GPO Box 2776
Cloisters Square
Perth WA 6850



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