Terratree

Phytophthora Dieback Assessment of Proposed Mine Site Remediation Area within Argyle Forest Block, Boyanup State Forest

Prepared for Department of Mines, Industry Regulation and Safety

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Abbreviations and Acronyms

BoM	Bureau of Meteorology
CALM	former Department of Conservation and Land Management (now DBCA)
DAFWA	former Department of Agriculture and Food Western Australia (now DPIRD), WA Government
DAWE	Department of Agriculture, Water and the Environment, Australian Government
DBCA	Department of Biodiversity, Conservation and Attractions, WA Government
DotE	former Department of the Environment, Australian Government (now DAWE)
DEE	former Department of the Environment and Energy, Australian Government (now DAWE)
DIDMS	Dieback Information Data Management System
Dieback Interpreter's Manual	*FEM047 Phytophthora Dieback Interpreter's Manual for lands managed by the Department*
DPIRD	Department of Primary Industries and Regional Development, WA Government
EPA	Environmental Protection Authority
FEMD	Forest and Ecosystem Management Division of DBCA, WA Government
GDA94	Geocentric Datum Australia 1994
GPS	Global Positioning System

Executive Summary

DMIRS commissioned Terratree to undertake a Comprehensive Phytophthora Dieback assessment within the Argyle Forest Block in Donnybrook. The objective of the Dieback assessment was to map the extent of disease occurrence caused by the plant pathogen *Phytophthora cinnamomi*. This will inform hygiene management plans for rehabilitation operations within the forest block.

The Comprehensive Dieback field assessment was conducted on 9th- 18th September and 9th – 11th November 2020 and was completed by Department of Biodiversity Conservation and Attractions-registered Dieback Interpreter Joseph Grehan, along with Trainee Interpreters Aaron Caubo and Jemma Marshal. The assessment was conducted according to the *FEM047 Phytophthora Dieback Interpreter's Manual for lands managed by the* Department produced by the Forest and Ecosystem Management Division.

Eight soil and tissue samples were taken during the Dieback assessment, five of which returned positive results for *Phytophthora cinnamomi* through diagnostic baiting. Two samples (AS03 & AS04) were retested after receiving unexpected negative results, but again returned negative results on re-testing. The AS03 sample is believed to be false negatives as the area show clear evidence of infestation **(Table 8)**. The cause of the false negatives may be due to low inoculum levels in the sandy mid-slope soils. The Dieback Interpreter's Manual states the following in relation to false negative results:

> Interpreters will consider these factors (and factors from 11.2) when analysing negative sample results. At sites where false negatives are suspected, Interpreters can choose to resample – improving the chances of a positive recovery by using a better sample technique. Interpreters may also choose to abandon sampling at a site where a negative result has been achieved if Phytophthora symptoms and observable factors are obvious (FEMD Page 154)

Mapping categorised 23.0 ha (45.4 %) of the assessed area as Infested. A further 22.4 ha (44.3 %) of the assessed area was mapped as Uninfested with 0.3 ha of this also being mapped as Unprotectable. The remaining 5.2 ha (10.3%) of the assessment area was mapped as Uninterpretable. No areas were Excluded from the assessment.

Approximately 23.0 ha (45.4%) of the assessment area was determined to be Infested with *P. cinnamomi*. The infestations occurred in two areas, one in the north-west of the assessment area and the other covers the southern and eastern sides of the assessment area. Large areas of disturbed soil and vegetation caused by the historical construction of mineshafts and costeans were also present.

Two samples (AS03 & AS04) were taken to confirm the Infested statues of the area. However, even after double baiting the samples, they both returned negative results. The AS03 sample is believed to be false

negatives as the area show clear evidence of infestation. The cause of the false negatives is believed to be due to potentially low inoculum levels in the sandy mid-slope soils.

The central and eastern portion of the assessment area was mapped as Uninfested, this is approximately 22.4 ha (44.3%). A small spur of Uninfested vegetation also penetrates into the south eastern section of Infested vegetation. The Uninfested vegetation occurred predominately on a ridge which ran through the centre of the assessment area. This ridge contained significant lateritic outcropping which can hinder the prevalence and impact which the pathogen can have on the vegetation.

There is a small section (0.3ha (0.6%)) of Uninfested vegetation on the eastern boundary of the assessment area which has been mapped as Unprotectable. This is due to the area occurring downslope of an area of Infested vegetation as well as this portion being too small in size and diameter (less then 3ha and 100m respectively) to be protectable from the autonomous spread of the pathogen.

The north-western corner of the assessment area, approximately 5.2 ha (10.3%), was mapped as Uninterpretable. This area was dominated by two vegetation communities which lack sufficient number of primary and secondary disease indicator species to enable this vegetation to be interpretable.

Terratree makes the following recommendations to manage the Argyle Forest Block Assessment area:

- Movement of vehicles and machinery into and out of areas mapped as Infested should be avoided in wet conditions to reduce the chance of spreading the pathogen.
- All vehicles and machinery should be Clean on Exit when leaving the areas mapped as Infested.
- All vehicles and machinery should be Clean on Entry before entering areas mapped as Uninfested.
- All vehicles and machinery should be Clean on Entry and Exit when operating in areas that have been mapped as Uninterpretable.

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1 Introduction

1.1 Background

DMIRS commissioned Terratree Pty Ltd (Terratree) to undertake a Comprehensive Phytophthora Dieback (Dieback) assessment within an old mining area in Argyle forest block within Boyanup State Forest near Donnybrook. The objective of the Dieback assessment was to map the extent of disease occurrence caused by the plant pathogen *Phytophthora cinnamomi*. This will inform hygiene management planning for proposed remediation work within the previously disturbed area of Argyle forest block.

1.2 Project Location and Size

Argyle Forest Block (hereafter referred to as 'the assessment area') is located within Boyanup State Forest approximately 2.1 km south west of Donnybrook, 4.8 km east of Brookhampton and 3.3 km north east of Paynedale (**Figure 1**). The assessment area is enclosed by Goodwood Road on the northern boundary, Upper Capel Road on the south eastern boundary and unnamed tracks on the western, eastern and southern boundaries.

The assessment area is 50.6 ha in total area.

1.3 *Phytophthora* Dieback

Phytophthora Dieback (or Dieback) is a disease caused by the introduced soil-borne pathogen *Phytophthora cinnamomi*. While some plant species are resistant, others are susceptible to the disease caused by the pathogen, which can result in chlorosis, dieback and usually death (Wills and Keighery 1994). The pathogen has a range of hosts in Southwest WA, predominantly from the Ericaceae, Fabaceae, Myrtaceae, Proteaceae, and Xanthorrhoeaceae plant families.

Although several *Phytophthora* species occur in Western Australia, the most virulent and pathogenic is *P. cinnamomi*. References to Phytophthora Dieback refer to the disease caused by this species unless otherwise specified.

The most recent Western Australian State of the Environment Report lists Dieback as a Priority 1 threat to biodiversity (EPA 2007). A recent review of threats to species listed as threatened under the Federal *Environment Protection and Biodiversity Conservation Act 1999* shows that *P. cinnamomi* is the second greatest invasive species threat in Australia after rabbits (Kearney *et al*. 2019).

Dieback has a significant effect in WA for the following reasons:

- 40 % of native plant species in Southwest WA (over 2,200 species), including almost half the listed federally listed Endangered species, are susceptible to the pathogen (Shearer *et al*. 2004). This includes 49 % of WA listed Threatened flora (EPA 2007).
- Changes in the composition and structure of floral communities resulting from the spread of Dieback have flow-on impacts throughout the ecosystem, including habitat alteration negatively affecting indigenous fauna populations.
- Dieback can lead to significant soil erosion through the loss of susceptible vegetation.

Disease expression caused by *Phytophthora* species occurs in native vegetation when the following variables and environmental conditions are present:

- **Host** - plant species are present that are susceptible to *Phytophthora* spp. (i.e. *Banksia*, *Hakea*, *Leucopogon* and *Daviesia* spp.).
- **Pathogen** - a *Phytophthora* spp. pathogen must be present, either residing in susceptible or resistant species.
- **Environment** - soil temperatures of 15-30 °C and pH 5-6 (acidic) are required for *P. cinnamomi* survival and activity. Some *Phytophthora* species, including *P. multivora*, can survive in alkaline soils (pH 7+).

Dieback is widespread in areas with greater than 800 mm of annual rainfall, less extensive in areas that receive between 600 and 800 mm, and mainly restricted to water-gaining sites in areas that receive 400–600 mm. The pathogen rarely occurs in areas receiving less than 400 mm annual rainfall. In WA, Dieback is a significant environmental issue for projects between Geraldton in the Midwest and Esperance on the South Coast, and it is widespread in the Southwest region.

Dieback is spread through the movement of water and soil within the landscape. Major vectors of Dieback include, but are not limited to, wet soil adhering to vehicle tyres/tracks and earthmoving equipment. Therefore, quarantine management procedures are an effective tool in reducing the spread of Dieback associated with any earthmoving activity.

1.4 Regulatory Context

Phytophthora Dieback management is required under several regulatory mechanisms including:

- the Federal *Environment Protection and Biodiversity Conservation Act 1999*, which lists Phytophthora Dieback as a Key Threatening Process
- projects being assessed under the Western Australian *Environmental Protection Act 1986*, which requires the Department of Biodiversity, Conservation and Attractions (DBCA) and/or Department of Mines, Industry Regulation and Safety to comment on Dieback management and provides these agencies with the right to impose conditions on new approvals

- the *Environmental Protection Act 1986* Part V S.50A “Serious Environmental Harm” provisions.

2 Existing Environment

2.1 Biogeography

The Interim Biogeographic Regionalisation for Australia (IBRA) has defined 89 bioregions and 419 subregions across Australia, based on climate, geology, landforms, native vegetation and species (DotE 2014). These provide a useful method for reporting biodiversity patterns and categorising assessment areas. The assessment area is located within the Southern Jarrah Forest (JAF02) IBRA subregion.

A biodiversity audit of Western Australia's subregions classified this subregion as follows:

> Southern Jarrah Forest: Duricrusted plateau of the Yilgarn craton characterised by Jarrah-Marri forest on laterite gravels an, in the eastern part, by Wandoo – Marri woodlands on clay soils. Eluvial and alluvial deposits support *Agonis* shrublands. In areas of Mesozoic sediments, Jarrah forests occur in a mosaic with a variety of species rich shrublands. The Climate is Warm Mediterranean. South of Collie the plateau broadens and slopes gently to the south coast. Drainage is still dissected in the west but broadening the levelling of the surface in the east cause's poor drainage and large and small wetlands. The ironstone becomes less evident being buried beneath sands. Rainfall is from 1200 mm in the south-west to 500 mm in the east. Vegetation comprises Jarrah – Marri forests in the west grading to Marri and Wandoo woodlands in the east. There are extensive areas of swamp vegetation in the south-east, dominated by Paperbarks and Swamp Yate. The understory component of the forest and woodlands reflects the more mesic nature of this area. The majority of the diversity in the communities occurs on the lower slopes or near granite soils where there are rapid changes in site conditions.

Dominant land uses in the area includes grazing, dry land agriculture, forestry, and conservation. There are also small areas of plantation forestry, irrigated horticulture, mining, rural residential and infrastructure (Hearn et al, 2002).

2.2 Regional Vegetation

The assessment area lies in the Menzies Botanical Subdistrict within the Southern Jarrah Forest Subregion (Beard 1990). Detailed vegetation complexes were mapped within the Darling Scarp and Plateau by Mattiske and Havel (1998) as part of the Regional Forest Agreement process. Two main vegetation complexes are found within the assessment area using this mapping.

Kingia (KI) is found in the north and west of the assessment area while Donnybrook (DB3) was found in the south and east of the assessment area. Characteristics of these vegetation complexes are listed in

Table 1**.**

Table 1: Vegetation complexes within the assessment area

Vegetation Complex	Kingia (KI)
Geographic Region	Humid Southwest – North west from Nannup
Landform Description	Undulating crests and slopes on divide on Blackwood Plateau
Soils	Gravelly yellow duplex soil with humus enriched topsoil
Soil Hydrology	Water shedding with good infiltration and storage capacity
Overstorey	Open Forest of *Eucalyptus marginata* with *Corymbia calophylla*
Second Storey	Well-developed second stratum of *Allocasuarina fraseriana, Banksia grandis, Persoonia elliptica, Persoonia longifolia* and *Xylomelum occidentale*
Shrubs and Herbs	*Taxandria parviceps, Podocarpus drouynianus, Adenanthos obovatus, Anarthria prolifera, Lindsaea linearis, Dasypogon bromeliifolius* and *Leucopogon australis.*
Interpretability for Dieback Assessment	High
Vegetation Complex	**Donnybrook (DB3)**
Geographic Region	Humid Central – near Donnybrook
Landform Description	Slope on Donnybrook sandstone adjacent to the valley of the Preston River
Soils	Yellow Brown gravelly sand over sandy clay at depth
Soil Hydrology	Moderately water shedding via subsoil, with good infiltration and storage capacity.
Overstorey	Open Forest of *Eucalyptus marginata* with some *Corymbia calophylla*
Second Storey	*Banksia grandis* and *Persoonia longifolia*
Shrubs and Herbs	*Acacia extensa, Hakea ruscifolia, Hibbertia hypericoides, Hibbertia racemose, Gompholobium venustum, Patersonia umbrosa, Adenanthos barbiger, Daviesia incrassata, Hovea chorizemifolia, Bossiaea eriocarpa* and *Grevillea quercifolia*
Interpretability for Dieback Assessment	Moderate to High

2.3 Soils

The soil type of most of south-western Western Australia is Gravelly Soils. Within the assessment area, these are characterised as "gravels, usually in a loamy mix; loamy gravels, common also duplexes, loamy earths" (DAFWA 2012).

Department of Primary Industries and Regional Development (DPIRD 2018) soil mapping for Western Australia shows two main soil subsystems within the assessment area, closely mirroring the vegetation types in **Table 1**. Characteristics of these soil types are listed in **Table 2.**

Table 2: Soil subsystems within DMIRS Argyle Forest Block

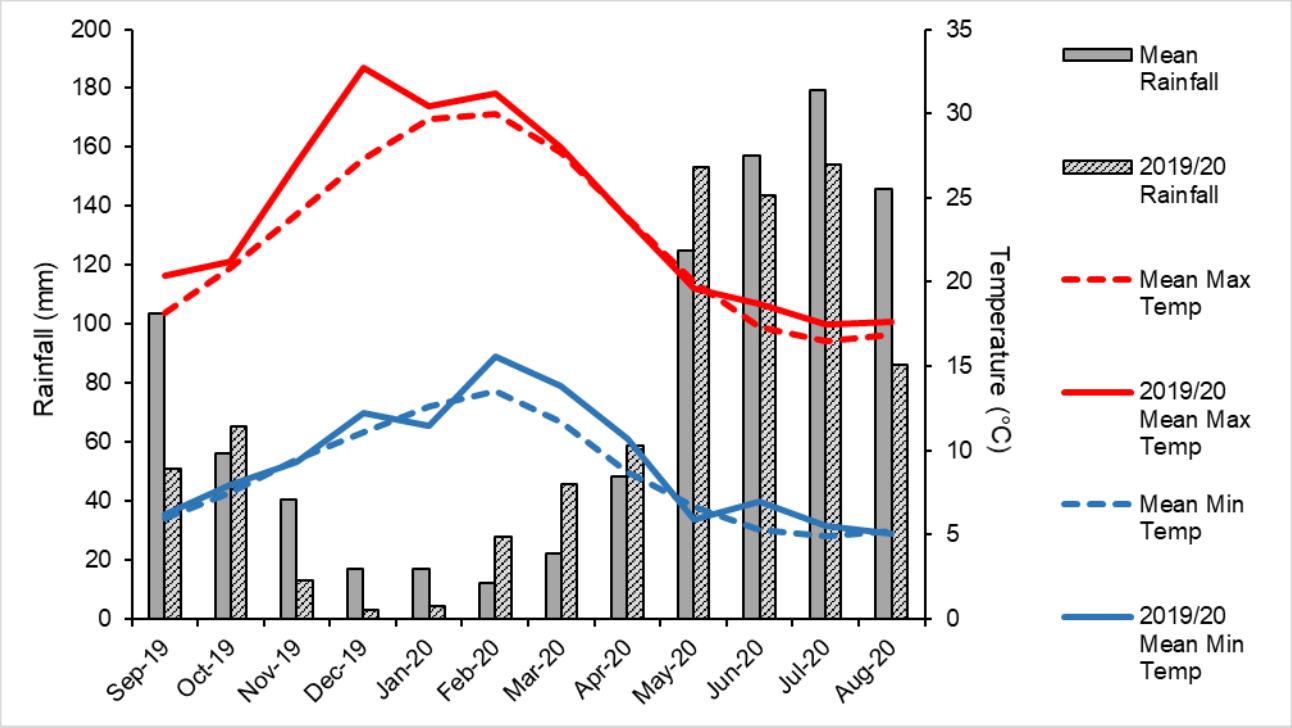
Province	**Swan (21)**
Soil Zone	Donnybrook Sunkland Zone 214
Zone Description (Purdie *et al*. 2004)	Moderately dissected lateritic plateau on Perth Basin sedimentary rocks. Soils are formed in lateritic colluvium, sedimentary rocks weathered in-situ and alluvium (poorly drained sandy alluvial plain in the south)
System Symbol (DPIRD 2018)	214BpKI
System Description (DPIRD 2018)	Broad undulating lateritic crests and divides over sedimentary rocks, relief 5-20 m, slopes 1-10%. Soils are sandy gravels with some deep sands.
Location within assessment area	North and West
Province	**Swan (21)**
Soil Zone	Donnybrook Sunkland Zone 214
Zone Description (Purdie et al. 2004)	Moderately dissected lateritic plateau on Perth Basin sedimentary rocks. Soils are formed in lateritic colluvium, sedimentary rocks weathered in-situ and alluvium (poorly drained sandy alluvial plain in the south)
System Symbol (DPIRD 2018)	214GvDB
System Description (DPIRD 2018)	Relief (20-60 m), slopes (5-20%). Soils are deep sands, sandy gravels and loamy earths.
Location within assessment area	South and East

2.4 Climate

The DMIRS Argyle Forest Block assessment area lies within the Temperate Dry Summer Warm Summer (Csb) category as classified by Peel *et al*. (2007) and within the Temperate 'distinctly dry (and warm) summer' category as classified by the Bureau of Meteorology (BoM; 2020a).

The bioclimate classification shown in Beard (1990) places the assessment area in the 3b Dry Mediterranean (5-6 dry months) categories. This category closely mirrors the Menzies Botanical Subdistricts, which is classified as having 600-1200 mm of annual rainfall respectively.

Temperature and rainfall data from weather station Jarrahdale #9842 are shown in **Graph 1**. The Jarrahdale weather station is not the closest weather station to the assessment area. However, it was chosen due to the completeness of its data records. Mean annual rainfall is 924.3 mm, placing the assessment area within the high-rainfall zone (800-1400 mm annual rainfall) classified by Hopper (1979). The total amount of rainfall recorded for the 12 months prior to and including the Dieback assessment was 807.20 mm. This is a 120 mm below the mean annual rainfall for the area. The three months leading up to the assessment did receive less than the average amount of rainfall. However, the months of February to May did record above average levels of rainfall and as such rainfall was not considered to be a limitation on this survey. Also, despite some temperature variations in the maximum temperatures in the October to January months and the minimal temperatures in the February to April months, temperature was not considered a limitation on this survey.



Graph 1: Rainfall and temperature data for Jarrahdale weather station #9842 (BoM 2020b).

2.5 Historical Land Use and Disturbance

The area has been used for the purposes of small-scale mining since 1897. Peaks in operations occurred in the 1930's and 1980's. The area still possesses a significant number of open mine shafts and costeans.

3 Methods

3.1 Comprehensive Dieback Assessment

The Comprehensive Dieback assessment is conducted in a two-stage process:

- A desktop review of relevant, available information regarding site characteristics plus previous Dieback mapping and sample results.
- A field assessment to observe disease symptoms, record Dieback occurrence category data and collect soil and tissue samples for diagnostic testing.

The Dieback Interpreter's Manual requires a Comprehensive Dieback assessment every three years where ground disturbance activities are planned (FEMD 2015). Recheck assessments can be completed annually for up to three years to update Dieback occurrence maps. While this is only applies to DBCA-managed lands, it is recommended that all land managers follow this guidance where ground disturbance activities are planned in areas of native vegetation.

3.2 Desktop Assessment

A desktop assessment was completed to collect information about the assessment area, surrounding landscape and previous history of Dieback mapping.

The Dieback Information Data Management System (DIDMS; Project Dieback 2014) was used to obtain data from the Vegetation Health Services (VHS) laboratory on Dieback occurrence mapping and sample results from previous assessments in the area.

3.3 Field Assessment

3.3.1 Survey Strategy

Field assessment requires visually assessing native vegetation within the assessment area, recording Dieback occurrence category data, and collecting soil and tissue samples from recently dead disease indicator species for diagnostic testing.

The Comprehensive Dieback field assessment was conducted on 9th-18th September and 9th- 11th November 2020 and was completed by DBCA-registered Dieback Interpreter Joseph Grehan, along with Trainee Interpreters Aaron Caubo and Jemma Marshal.

The assessment was conducted according to the *FEM047 Phytophthora Dieback Interpreter's Manual for lands managed by the* Department produced by the Forest and Ecosystem Management Division (FEMD 2015; hereafter referred to as 'the Dieback Interpreter's Manual').

Transects corridors of maximum 50 m width were walked by foot across the entire assessment area. High risk locations, including watercourses and disturbed areas, outside the assessment area were investigated where necessary to determine the broader landscape potential for Dieback infestation.

Spatial data, including disease evidence points and sample locations and photographs, were recorded using handheld Global Positioning System (GPS) units.

3.3.2 Assessability

The Keighery vegetation disturbance scale in the Dieback Interpreter's Manual (**Table 3**) was used to determine the assessability of vegetated areas within the assessment area.

Areas with a vegetation condition rating of 1-3 (Pristine - Very Good) and enough disease indicator species present to enable a diagnosis of the disease status are considered assessable.

Other areas of vegetation may be categorised as Possibly Assessable based on a condition rating of 4 (Good). In these areas, significant impacts to vegetation, including grazing, forestry harvesting, weed incursion and frequent fire events, have altered vegetation composition and structure so that it is unlikely to recover in the medium- to long-term. Assessability of these areas is at the discretion of the Interpreter.

Areas where native vegetation is significantly degraded or cleared are given a condition rating of 5 (Degraded) or 6 (Completely Degraded) and classified as Excluded from assessment. Non-vegetated areas are also Excluded from assessment, including pasture, pits (including gravel pits), large roads (sealed and unsealed), permanently flooded areas and parkland tree stands.

Table 3: Keighery vegetation disturbance scale and assessability (Keighery 1994, as defined in FEMD 2015)

Assessability	Scale		Condition
Assessable	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 assessable, 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.

Assessability	Scale		Condition
Not assessable 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.

3.3.3 Vegetation Community Descriptions

Vegetation communities encountered within the assessment area are described in accordance with the Scheme for Description of Vegetation Structure in the *Native Vegetation Condition Assessment and Monitoring Manual for Western Australia* (DEC, 2009) (**Table 4**). The scheme uses the dominant species in each stratum, combined with projected foliage cover to describe the vegetation units.

Table 4: Scheme for Description of Vegetation Structure in the *Native Vegetation Condition Assessment and Monitoring Manual for Western Australia* (DEC 2009) as adapted from Muir (1977) and via Alpin (1979) and Keighery (1994)

Canopy Cover				
Growth Form/ Height Class	**100% to 70%**	**70% to 30%**	**30% to 10%**	**10% to 2%**
Trees over 30 m	Tall Closed Forest	Tall Open Forest	Tall Woodland	Tall Open Woodland
Trees 10-30 m	Closed Forest	Open Forest	Woodland	Open Woodland
Trees under 10 m	Low Closed Forest	Low Open Forest	Low Woodland	Low Open Woodland
Mallee over 8 m (Tree Mallee)	Closed Tree Mallee	Tree Mallee	Open Tree Mallee	Very Open Tree Mallee
Mallee under 8 m (Shrub Mallee)	Closed Shrub Mallee	Shrub Mallee	Open Shrub Mallee	Very Open Shrub
Shrubs over 2 m	Closed Tall Scrub	Tall Open Scrub	Tall Shrubland	Tall Open Shrubland
Shrubs 1-2 m	Closed Heath	Open Heath	Shrubland	Open Shrubland
Shrubs under 1 m	Closed Low Heath	Open Low Heath	Low Shrubland	Very Open Shrubland
Grasses	Closed Grassland	Grassland	Open Grassland	Very Open Grassland
Herbs	Closed Herbland	Herbland	Open Herbland	Very Open Herbland
Sedges	Closed Sedgeland	Sedgeland	Open Sedgeland	Very Open Sedgeland

3.3.4 Dieback Occurrence Categories

The assessability of vegetated and non-vegetated areas and associated Phytophthora Dieback occurrence categories can be determined using **Table 5**.

Uninfested vegetation exhibits the following characteristics:

- No positive sample results received for *P. cinnamomi.*
- An acceptable diversity of healthy disease indicator species is present, including some of the following genera: *Banksia, Persoonia, Xanthorrhoea, Leucopogon, Hakea* and *Adenanthos*.
- Vegetation condition is in Pristine-Very Good (1-3) condition according to the Keighery scale with a good density of vegetation cover and no obvious reduction in biomass or masking by resistant species.
- No evidence found of disease pattern or chronology.

Infested vegetation is identified and characterised by the following features:

- Positive sample results for *P. cinnamomi* are found either in the immediate area, upslope or upstream of the Infested area.
- Multiple disease indicator species deaths (ISDs) are occurring.
- Disease pattern and chronology are visible.
- Vegetation structure and composition are obviously altered.

Uninterpretable vegetation exhibits the following characteristics:

- Insufficient amounts of disease indicator species are present, including the following genera: *Banksia, Persoonia, Xanthorrhoea, Leucopogon, Hakea* and *Adenanthos*.
- Vegetation condition is in Pristine-Very Good (1-3) condition according to the Keighery scale with a good density of vegetation cover, possible masking by resistant species and no obvious reduction in biomass.
- Environmental conditions occur that discourage the pathogen, such as highly fertile soils, fewer host species or a dominating resistant host.

Uninterpretable areas may contain Dieback (e.g. in very low levels as an endemic or incipient disease) without showing signs of its presence and determining the presence of the pathogen is not possible using interpretation methods (FEMD 2015). Uninterpretable areas that meet the protocols for identifying Protectable Areas are managed as being both Infested and Uninfested so that the pathogen is neither imported into, nor exported from, these areas.

The Temporarily Uninterpretable category is allocated to areas of native vegetation that have been disturbed but will recover over time and become interpretable and mappable in the future (i.e. within five years). Examples of Temporarily Uninterpretable areas include vegetation that has been impacted by fire, timber harvesting, grazing, flooding or mining with subsequent rehabilitation (FEMD 2015).

Excluded areas (see **Section 3.3.2**) are distinguished from Temporarily Uninterpretable areas in that they cannot normally regenerate naturally and become mappable for Dieback occurrence in the future. Excluded areas were mapped from both field data and, where applicable, aerial imagery.

Table 5: Assessability of vegetated and non-vegetated areas (adapted from FEMD 2015)

	Phytophthora occurrence category	Typically present	May be present
Naturally vegetated areas Keighery disturbance rating of 3 or less. Phytophthora occurrence categorisation is possible. Small unvegetated areas can exist and may be included in the assessment area considering total environmental context.	**INFESTED**	Dead and dying reliable indicator species	Healthy reliable indicator species Indicator Species Deaths (ISDs) that have been killed by other agents
	UNINFESTED	Healthy reliable indicator species	ISDs that have been killed by other agents
	UNINTERPRETABLE	Very few reliable indicator species	Occasional reliable indicators, but too few for Phytophthora Dieback interpretation
	NOT YET RESOLVED	Usually reliable indicator species in an environment not favourable to disease development	Negative sample results for all *Phytophthora* species
Vegetation structure temporarily altered Phytophthora occurrence assessment will be possible when vegetation structure recovers. Recovery times will be variable depending on severity and type of disturbance.	**TEMPORARILY UNINTERPRETABLE**	Indicator species masked by disturbance typically from fire, harvesting, temporary flooding, poisoning	Occasional reliable indicator species, but disturbance prevents accurate placement of Phytophthora occurrence
Road disturbance area	**DISEASE RISK ROAD (DRR)**	Unformed track with shoulders of interpretable vegetation	Shoulders and batters with regenerated vegetation Incipient infestation
Vegetation structure severely altered Keighery disturbance rating 5 or greater. Phytophthora occurrence assessment is not possible. Can be determined by desktop assessment (aerial photo). Small, vegetated areas can exist and may be excluded from the assessment area considering total environmental context.	**EXCLUDED**	Pasture, pits, easements, infrastructure, large roads (sealed and unsealed) permanent flooding, plantations, parkland tree stands	Sporadic reliable indicator species

3.3.5 Hypothesis

The Comprehensive Dieback assessment of the assessment area is testing the hypothesis that "disease indicator species deaths and changes in vegetation community composition and structure are the result of *Phytophthora cinnamomi* infestation".

3.3.6 Sampling Strategy and Methods

Sampling strategies for the assessment of Dieback aim to resolve the following scenarios:

- Sampling to support an Infested diagnosis - recently dead and dying indicator species are sampled to support an Interpreter's diagnosis of an area as Infested.
- Sampling to support an Uninfested diagnosis - recently dead and dying indicator species are sampled to support an Interpreter's diagnosis of an area as Uninfested.

To test the hypothesis in **Section 3.3.4**, potential sample locations were selected throughout the assessment area. Potential sample locations were allocated a rating from 1-5 as defined in **Table 6**. Final sample locations were selected by geographic location, ensuring samples were spread throughout the assessment area and in areas that would adequately test the hypothesis. This includes sampling ISDs that would support either an Uninfested or Infested diagnosis, in both upland and low-lying areas, along roadsides, and within or adjacent to areas previously mapped as Infested or Uninfested.

Table 6: Sample requirement rating and description (adapted from FEMD 2015)

Rating	Requirement for Sampling	Description
1	Very Low	The result is not expected to alter the assessment outcome, e.g. area that is obviously Infested with multiple observable factors.
2	Low	The result is not expected to alter the assessment outcome, but the site may have value for training purposes.
3	Moderate	The results may add extra evidence to a particular strategy. Soil and tissue samples may be taken from these sites where Interpreters are required to provide extra evidence for sensitive or difficult areas or where further proof is needed to support field diagnosis. Sites rated '3' may be left not sampled.
4	High	The results of these samples will be critical to the assessment outcome; however, occasional sample sites with this rating may not be sampled at the completion of the assessment.

Rating	Requirement for Sampling	Description
5	Very High	The results of these samples will be critical to the assessment outcome. All sites rated '5' will be sampled.

The following sampling strategy for the assessment area was used:

- Take some initial samples on the boundary of areas previously mapped as Infested to test the hypothesis.
- Take samples of indicator species deaths (ISDs) in mid-slope and upland areas to test the hypothesis.
- Retest samples (through rebaiting or DNA test) where a positive result was expected but not returned.
- Reformulate the hypothesis if the second test returned the same unexpected result to test for other factors causing ISDs and changes to community composition and structure (e.g. drought, *Armillaria luteobubalina*, fire).

Samples must be collected of soil and tissue from recently dead or dying disease indicator species to confirm the presence, or indicate the possible absence, of Dieback and to inform interpretation of the assessment area. Caution must be applied to interpreting the results of sampling and claiming that an area is Uninfested. Prolonged unfavourable conditions for *Phytophthora cinnamomi* can lead to false negative results due to low levels of inoculum present in a sample. Sample results should be considered within the context of other field evidence, including disease vectors, pattern, chronology, biomass reduction and changes in vegetation structure.

All sampling strictly adhered to the following procedures:

- All tools used in sampling were thoroughly sterilised with a 70:30 mixture of methylated spirits and water before samples were taken. Tools were dry prior to sampling so that the results were not compromised.
- The plant sampled was excavated to a depth that ensured adequate plant tissue material could be obtained from the roots and cambium layer around the collar of the plant being sampled (not more than 150 mm depth).
- Material from all around the plant was taken in addition to any obvious lesions to avoid missing any infected material. Plant tissue material plus soil from around the roots and other places in the soil profile were placed in a polythene bag.

- All relevant information pertaining to the plant sampled and sample location was recorded on the Sample Information Sheet.
- Two aluminium tags that provided the date, project name, sample number, species sampled, and the name of the Interpreter were prepared. One tag was placed in the sample bag and the other was tied near the sample site, which was also demarcated with fluorescent pink flagging tape.
- The sample hole was backfilled to prevent fauna from becoming trapped.
- All tools were brushed off to remove excess soil and sterilised to prevent contamination of the next sample site and sample.

All soil and tissue samples were lodged with the VHS laboratory, where diagnostic baiting was conducted. All sample point locations were recorded using a hand-held GPS unit.

Dieback assessment is conducted in a manner to ensure it does not spread Dieback within the assessment area. The following procedures are followed:

- Start all field assessments with a clean vehicle and footwear free of soil and vegetative material.
- Only work in dry conditions (i.e. when soil is not adhering) to reduce spreading of soil from footwear and vehicle movement.
- In wet conditions on more exposed soils, carry a small cleaning brush and spray bottle with a 70:30 solution methylated spirits/water to remove soil and mud from footwear when moving from Infested to Uninfested areas.
- In wet conditions:
  - Aim to work from Uninfested into Infested or Uninterpretable or Excluded areas.
  - Drive vehicle only on well-formed tracks avoiding muddy and wet areas.
  - If Uninfested areas need to be entered, complete an in-field vehicle inspection and clean down if required.

If a water-crossing or muddy area must be driven through, drive through slowly to reduce mud-spraying and complete an in-field vehicle inspection and clean down if required.

In-field vehicle cleaning can be difficult to achieve. An in-field vehicle inspection and clean down involves the following process:

- Before entering an Uninfested area or after completing a water/mud-crossing, stop at an appropriate site as soon as possible. This should be a dry and sandy or hard-pan location in the Infested area, draining onto or into the Infested area.
- Remove soil and mud from tyres, bumper, wheel arches, steps and under vehicle.
- Spray down the undercarriage and wheels of vehicle with 70:30 solution methylated spirits/water.

- Spray all equipment used to clean the vehicle and footwear with 70:30 solution methylated spirits/water.

3.3.7 Demarcation

Infested and Uninterpretable areas were demarcated as per the guidelines in the Dieback Interpreter's Manual.

Infested areas were demarcated using 25 mm fluorescent pink flagging tape. All Infested areas are expected to become 'high impact' over the next fifty years; therefore, no Infested areas have been separately demarcated as 'high impact'.

Uninterpretable areas were demarcated using 25 mm pink-and-black tiger-stripe flagging tape using the same buffers as the Infested area taping.

The following buffers were applied during the assessment in accordance with the Dieback Interpreter's Manual:

Minimum upslope buffer of 15 m depending on complexity of disease expression.
Minimum downslope buffer of 25 m depending on degree of slope, drainage patterns, soil type and geology.

3.4 Mapping

Spatial data, including tracks and waypoints recorded on hand-held GPS units, were downloaded into a Geographic Information System (GIS) program. The GIS software used for the project was QGIS 3.4 (QGIS Development Team 2019).

Field evidence and observations plus spatial data were used to prepare a Dieback occurrence map for the assessment area. Phytophthora occurrence categories were mapped using the categories defined in **Table 5**.

For operational purposes, Dieback occurrence mapping is only valid for 12 months after the assessment is completed to counter for autonomous spread of the pathogen (FEMD 2015).

3.5 Protocols for Identifying Protectable Areas

The Dieback Interpreter's Manual outlines the following primary criteria for defining Protectable Areas as those areas that:

- have been determined to be free of the *Phytophthora* spp. pathogen by a registered Dieback Interpreter (all susceptible indicator plant species are healthy and no plant disease symptoms normally attributed to Phytophthora Dieback are evident)

- are in locations receiving >600 mm rainfall per year or are water-gaining sites (e.g. granite outcrops, impeded drainage or engineering works that aggregate rainfall) in the 400-600 mm per year rainfall range
- consist of areas where human vectors are controllable (e.g. not an open road, private property)
- are positioned in the landscape and are of sufficient size (e.g. >4 ha with axis >100 m) such that a qualified Interpreter judges that the pathogen will not autonomously engulf them in the short term (a period of a few decades)
- include areas of high conservation and socio-economic value (e.g. a small Uninfested area with a known population of a susceptible species of threatened flora) (FEMD 2015).

3.6 Limitations

The following limitations were encountered during the Phytophthora Dieback assessment:

- The natural vegetation structure and composition in some areas meant there was a lack of disease indicator species therefore, an Uninterpretable category rating was assigned according to the Dieback Interpreter's Manual.
- The impact of drought on susceptible vegetation made interpretation and disease mapping more difficult.
- False negative sample results complicated interpretation and required re-testing.

4 Results

4.1 Desktop Review

The desktop review identified no positive sample results for *P. cinnamomi* within the assessment area. However, one positive sample for *P. cinnamomi* was obtained just outside the north-western boundary of the assessment area. This sample was obtained in 2003 and due to it topographical position is believed to potentially impact on the protectability of the north-western portion of the assessment area.

This belief was confirmed by the historical Dieback mapping which was conducted in 2004. This mapping indicated that an area of approximately 7.15 ha in the north western corner of the assessment area is Infested with *P. cinnamomi*. Additionally, this mapping indicated that most of the south western corner of the assessment area is also infested with a small corridor of infested vegetation reaching the middle of the south eastern boundary. The rest of the assessment area was categorised as Uninfested in the 2003 mapping.

4.2 Disease Indicator Species

Disease indicator species observed within the assessment area include, but are not limited to, representatives of the Casuarinaceae, Dasypogonaceae, Ericaceae, Iridaceae, Proteaceae, Xanthorrhoeaceae and Zamiaceae Disease indicator species observed during the field survey are listed in **Table 7.**

Table 7: Disease indicator species within the DMIRS Argyle Forest Block

Family	Species	Primary Indicator	Secondary Indicator
Dasypogonaceae	*Dasypogon bromeliifolius*		•
Ericaceae	*Leucopogon capitellatus*	•	
	Leucopogon propinquus		•
	Leucopogon verticilatus		•
Iridaceae	*Patersonia occidentalis*	•	
	Patersonia umbrosa	•	
Proteaceae	*Adenanthos meisneri*		•
	Banksia attenuata	•	
	Banksia grandis	•	
	Persoonia longifolia	•	
	Xylomelum occidentale	•	
Xanthorrhoeaceae	*Xanthorrhoea gracilis*	•	
	Xanthorrhoea preissii	•	
Zamiaceae	*Macrozamia riedlei*		•

4.3 Vegetation Communities

Vegetation community descriptions within the assessment area are described in accordance with **Table 4** from the *Native Vegetation Condition Assessment and Monitoring Manual for Western Australia* (DEC 2009). Four vegetation types were identified within the assessment area **(Table 8).** The C1 community dominated the north eastern portion of the assessment area and it is situated on the lower slopes in very sandy soil. Up slope of this community in the north east but before a lot of lateritic rock outcropping was common the C2 community is dominant. Both of these communities contained very minimal number of Dieback susceptible species. The C3 community occurs in areas where lateritic outcropping is widespread. These areas are mainly concentrated around the centre and western portions of the assessment area. The C4 community dominates the mid-sloped areas in the south of the assessment area.

Table 8: Vegetation communities observed within the assessment area described in accordance with the Scheme for Description of Vegetation Structure in the *Native Vegetation Condition Assessment and Monitoring Manual for Western Australia* (DEC 2009).

C1 (Uninterpretable Lower Slope)
Open Forest of *Allocasuarina fraseriana,* over Closed Tall Scrub of *Kunzea glabrescens over Closed Low Heath of Adenanthos meisneri*, *Stirlingia latifolia Patersonia sp.* and *Dasypogon bromeliifolius* **(**  Photo 1**)**
C2 (Uninterpretable Mid-Slopes)

Open forest of *Corymbia calophylla, Allocasuarina fraseriana* over Tall Open Shrubland of *Bossiaea linophylla, Kunzea glabrescens* and *Acacia extensa* over Closed Low Heath of *Dasypogon bromeliifolius, Adenanthos meisneri* and *Lepidosperma ? tenue* **(Photo 2)**
C3 (Lateritic Upper Slopes)
Low Closed Forest of *Eucalyptus marginata, Corymbia calophylla, Allocasuarina fraseriana* and *Banksia grandis* over Tall Open Scrub of *Persoonia longifolia, Bossiaea linophylla* and *Acacia extensa* over Low Shrubland of *Macrozamia riedlei, Acacia pulchella* and *Patersonia sp.* **(Photo 3)**
C4 (Interpretable Mid-Slope)
Open forest of *Eucalyptus marginata* and *Corymbia calophylla* over Low Woodland of *Banksia grandis* and *Persoonia longifolia* over Shrubland of *Xanthorrhoea preissii* and *Macrozamia riedlei* over Closed Low Heath of *Hibbertia hypericoides, Patersonia sp.* and *Acacia pulchella* **(Photo 4)**

4.4 Sample Results

Eight soil and tissue samples were taken during the Dieback assessment, five of which returned positive results for *P. cinnamomi* through diagnostic baiting. Two samples were retested after receiving an unexpected negative result and again both returned negative results. The false negatives may be caused by the low inoculum levels in the sandy mid-slope soils. All sample results are presented in **Table 9.** The VHS laboratory Phytophthora testing results are provided in **Appendix A**. The individual sample sheets are provided in **Appendix B**.

Table 9: Sample results from DMIRS Argyle Forest Block

Sample	Species	Easting	Northing	Result	Retest
AS01	*Dasypogon bromeliifolius*	0389975	6281861	Negative	N/A
AS02	*Banksia grandis*	0389834	6281502	*P. cinnamomi*	N/A
AS03	*Banksia grandis*	0390085	6281127	Negative	Negative
AS04	*Banksia grandis*	0390249	6281457	Negative	Negative
AS05	*Banksia grandis*	0390356	6281029	*P. cinnamomi*	N/A
AS06	*Xanthorrhoea gracilis*	0390296	6281753	*P. cinnamomi*	N/A
AS07	*Xanthorrhoea gracilis*	0390091	6281753	*P. cinnamomi*	N/A
AS08	*Xanthorrhoea gracilis*	0390148	6281797	*P. cinnamomi*	N/A

4.5 Dieback Occurrence

Figure 2 presents a Dieback occurrence map for the assessment area. In total, 50.6 ha of forest were assessed for Dieback occurrence. **Table 10** provides a breakdown of the Dieback occurrence area calculations. Mapping categorised 23.0 ha (45.4%) of the assessed area as Infested. A further 22.4 ha (32.2 %) of the assessed area was mapped as Uninfested of which 0.3ha (0.6%) was mapped as Unprotectable. The remaining 5.2 ha (10.3%) of the assessment area was mapped as Uninterpretable. No areas were Excluded from the assessment.

Table 10: Dieback occurrence area statement for DMIRS Argyle Forest Block

Occurrence Category	Area (ha)	Unprotectable (ha)	% of Assessment Area
Infested	23.0	-	45.4
Uninfested	22.4	0.3	44.3 (0.6)
Uninterpretable	5.2	-	10.3
Total	**50.6**	**0.3**	**100 %**

5 Discussion

5.1 Dieback Occurrence at DMIRS Argyle Forest Block

Approximately 23.0 ha (45.4%) of the assessment area was determined to be Infested with *P. cinnamomi*. The infestations occurred in two areas, one in the north-west, and the other which covers the southern and eastern sides of the assessment area. Large areas of disturbed soil and vegetation caused by the historical construction of mineshafts and costeans were also present.

The north-eastern infested area was previously mapped as infested in 2003 and this area was confirmed to be infested by sample AS02 returning positive for *P. cinnamomi*. This infestation is believed to be a very old due to the area having a significantly reduced biomass with no alive or dead indicator species being present, apart from along the boundary with the Uninfested vegetation **(Photo 5)**.

Portions of the other area of infested vegetation were also mapped as Infested in the 2003 assessment. However, the pathogen has spread further upslope and along the eastern boundary of the assessment area. This area is dominated by Vegetation Community Four **(Photo 4)** which contained a number of species susceptible to *P. cinnamomi* which had rapidly died recently indicating an infestation. Large areas of disturbed soil and vegetation caused by the historical construction of mineshafts and costeans **(Photo 6 & Photo 7)** were also present.

Eight soil and tissue samples were taken during the Dieback assessment, five of which returned positive results for *Phytophthora cinnamomi* through diagnostic baiting. Two samples (AS03 & AS04) were retested after

receiving unexpected negative results, but again returned negative results on re-testing. The AS03 sample is believed to be false negatives as the areas show clear evidence of infestation **(Table 8)**. The cause of the false negatives may be due to low inoculum levels in the sandy mid-slope soils. The Dieback Interpreter's Manual states the following in relation to false negative results:

> Interpreters will consider these factors (and factors from 11.2) when analysing negative sample results. At sites where false negatives are suspected, Interpreters can choose to resample – improving the chances of a positive recovery by using a better sample technique. Interpreters may also choose to abandon sampling at a site where a negative result has been achieved if *Phytophthora* symptoms and observable factors are obvious (FEMD Page 154)

The central and eastern portion of the assessment area was mapped as Uninfested, this is approximately 22.4 ha (44.3%). A small spur of Uninfested vegetation also penetrates into the south eastern section of Infested vegetation. The Uninfested vegetation occurred predominately on a ridge which ran through the centre of the assessment area. This ridge contained significant lateritic outcropping which can hinder the spread and impact which the pathogen can have on the vegetation. This area was dominated by Vegetation Community Three **(Photo 3)** which contained a number of primary indicator species including *Banksia grandis, Persoonia longifolia* and *Patersonia sp.* All were in healthy conditions with some individual plants displaying symptoms of drought. This area was also determined to be Uninfested in the previous assessment which was conducted in 2003.

There is a small section (0.3ha (0.6%)) of Uninfested vegetation on the eastern boundary of the assessment area which has been mapped as Unprotectable. This is due to the area occurring downslope of an area of Infested vegetation as well as this portion being too small in size and diameter (less then 3ha and 100m respectively) to be protectable from the autonomous spread of the pathogen.

The north-western corner of the assessment area, approximately 5.2 ha (10.3%), was mapped as Uninterpretable. This area was dominated by Vegetation Communities One **(Photo 1)** and Two **(Photo 2).** Both communities lacked a sufficient number of primary and secondary indicator species to allow this vegetation to be interpretable.

5.2 Other Potential Impacts to Vegetation

5.2.1 Drought

Impacts to vegetation through prolonged drought are distinguished from impacts caused by *P. cinnamomi* by the following characteristics:

- No disease pattern or chronology is seen in the surrounding vegetation.

- *Phytophthora*-resistant species are exhibiting evidence of stress and mortality.
- The plant 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 is visible on dying plants.

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.

Evidence of drought impacts was observable in rocky upper slope areas where species including *Banksia grandis* and *Persoonia longifolia* had senesced during the summer month but had epicormic regrowth as a result of heavy winter rainfall.

6 Conclusion and Recommendations

DMIRS commissioned Terratree to undertake a Comprehensive Phytophthora Dieback assessment within the Argyle Forest Block in Boyanup State Forest near Donnybrook. The objective of the Dieback assessment was to map the extent of disease occurrence caused by the plant pathogen *Phytophthora cinnamomi*. This will inform hygiene management plans for rehabilitation operations within the forest block.

The Comprehensive Dieback field assessment was conducted on 9th-18th September and 9th- 11th November 2020 and was completed by DBCA registered Dieback Interpreter Joseph Grehan, along with Trainee Interpreters Aaron Caubo and Jemma Marshal. The assessment was conducted according to the *FEM047 Phytophthora Dieback Interpreter's Manual for lands managed by the* Department produced by the Forest and Ecosystem Management Division (FEMD 2015).

Eight soil and tissue samples were taken during the Dieback assessment, five of which returned positive results for *P. cinnamomi* through diagnostic baiting. Two samples (AS03 & AS04) were retested after receiving unexpected negative results, but again returned negative results on re-testing. The AS03 sample is believed to be false negatives as the areas show clear evidence of infestation. The cause of the false negatives may be due to low inoculum levels in the sandy mid-slope soils.

Mapping categorised 23.0 ha (45.4 %) of the assessed area as Infested. A further 22.4 ha (44.3 %) of the assessed area was mapped as Uninfested with 0.3 ha of this also being mapped as Unprotectable. The remaining 5.2 ha (10.3%) of the assessment area was mapped as Uninterpretable. No areas were Excluded from the assessment.

Approximately 23.0 ha (45.4%) of the assessment area was determined to be Infested with *P. cinnamomi*. The Infested area occurred in two areas, one in the north-west of the assessment area and the other covers all of the south and portions of the eastern side of the assessment area. Large areas of disturbed soil and vegetation caused by the historical construction of mineshafts and costeans were also present.

The central and eastern portion of the assessment area was mapped as Uninfested, this is approximately 22.4 ha (44.3%). A small spur of Uninfested vegetation also penetrates into the south eastern section of Infested vegetation. The Uninfested vegetation occurred predominately on a ridge which ran through the centre of the assessment area.

There is a small section (0.3ha (0.6%)) of Uninfested vegetation on the eastern boundary of the assessment area which has been mapped as Unprotectable. This is due to the area occurring downslope of Infested vegetation as well as this portion being too small in size and diameter (less then 3ha and 100m respectively) to be protectable from the autonomous spread of the pathogen.

The north-western corner of the assessment area, approximately 5.2 ha (10.3%), was mapped as Uninterpretable. This area was dominated by Vegetation Communities One and Two**.** Both communities lacked a sufficient number of primary and secondary indicator species to allow this vegetation to be interpretable.

Terratree makes the following recommendations to manage the Argyle Forest Block Assessment area:

- Movement of vehicles and machinery into and out of areas mapped as Infested should be avoided in wet conditions to reduce the chance of spreading the pathogen.
- All vehicles and machinery should be Clean on Exit when leaving the areas mapped as Infested.
- All vehicles and machinery should be Clean on Entry before entering areas mapped as Uninfested.
- All vehicles and machinery should be Clean on Entry and Exit when operating in areas that have been mapped as Uninterpretable.

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Glossary of Terms (adapted from FEMD 2015)

Assessment - 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.

Diagnosis - a determining or analysis of the cause or nature of a problem or situation.

Dieback (Phytophthora) - in the south-west of Western Australia, a disease of plants caused by infection by the soil-borne organisms of the genus *Phytophthora*, of which *P. cinnamomi* is the most widespread.

Dieback (Phytophthora) Interpreter - a registered person who conducts Phytophthora Dieback interpretation.

Dieback (Phytophthora) Interpretation - the method of determining Phytophthora Dieback infestation using procedures in the Dieback Interpreter's Manual (Forest and Ecosystem Management Division (2015). FEM047 Phytophthora Dieback Interpreter's manual for lands managed by the department. Version 1.0. Department of Parks and Wildlife, Perth, Western Australia).

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 that act on an individual organism during its lifetime.

Excluded Area - an area that has been disturbed to an extent that it is not assessable and therefore excluded from Dieback interpretation.

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

Indicator species – a plant species that is more susceptible to Phytophthora disease and reliably shows symptoms earlier than other species.

Infested Area - an area that an accredited Dieback Interpreter has determined has plant disease symptoms consistent with the presence of the pathogen *Phytophthora cinnamomi.*

Inoculum - cells, tissue, or viruses that are used to inoculate a new culture.

Not Yet Resolved - an area that is interpretable for Dieback but where a determination regarding the disease status cannot be made due to a lack of evidence in the form of positive sample results.

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.

Protectable Area - an area of land managed by the landowner where hygiene management rules for the plant pathogen *Phytophthora*, including clean on entry, will apply. These areas are generally free of disease.

Susceptible - influenced or able to be harmed by Phytophthora Dieback.

Symptom - a phenomenon that arises from and accompanies a particular disease or disorder and serves as an indication of it.

Uninfested Area - an area that an accredited Dieback Interpreter has determined to be free of plant disease symptoms that indicate the presence of Phytophthora Dieback.

Uninterpretable Area - an area situated in locations receiving >600 mm rainfall per year or are water-gaining sites (e.g. granite outcrops, impeded drainage or engineering works that aggregate rainfall) in the 400-600 mm per year rainfall zone where indicator plants are absent or too few to determine the presence or absence of disease caused by Phytophthora Dieback.

Vector - any agent that acts as a carrier or transporter.

Photos

Photo 1: Uninterpretable Vegetation Community 1.

Photo 2: Uninterpretable Vegetation Community 2.

Photo 3: Uninfested Vegetation Community 3.

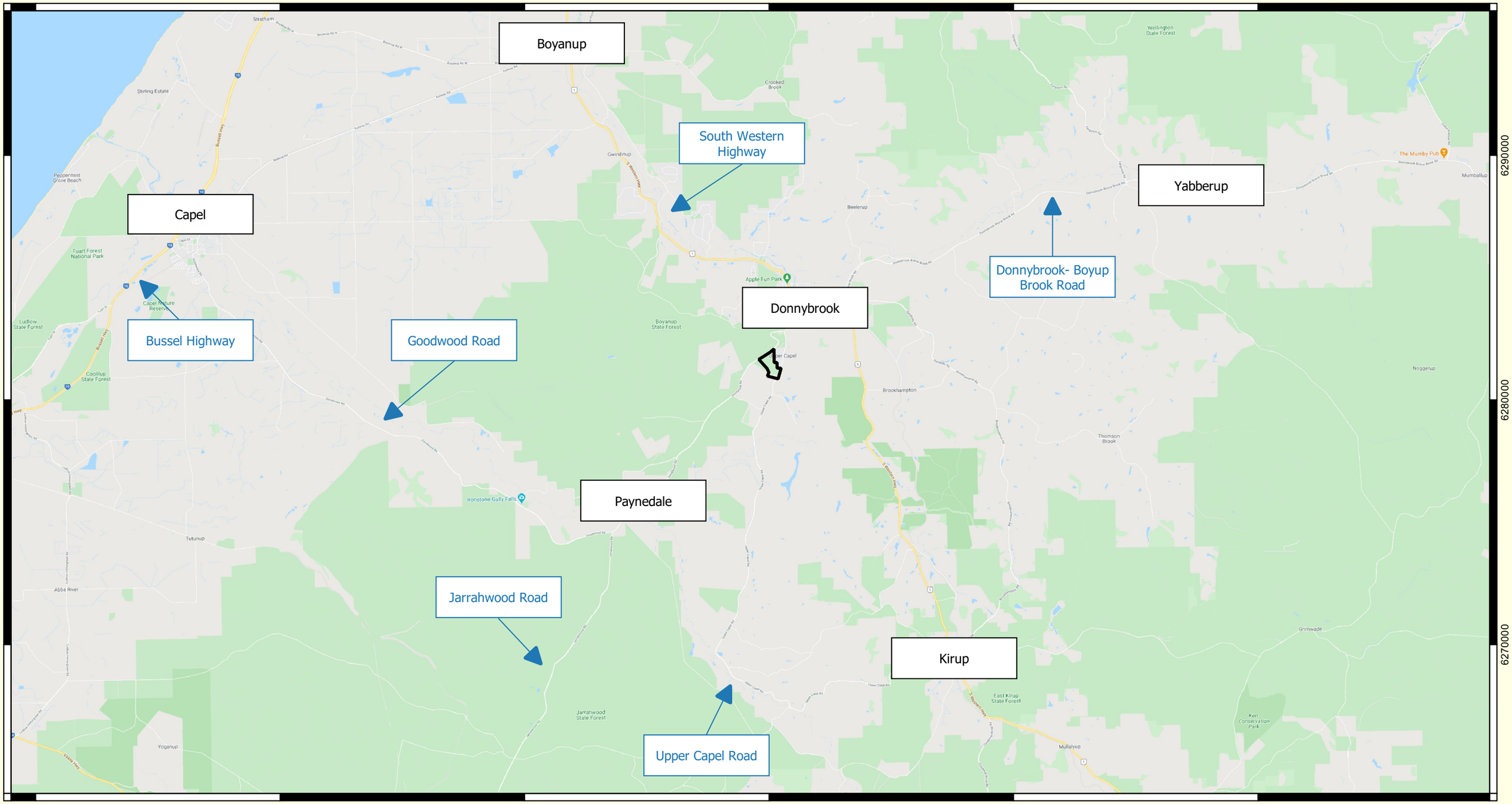
Photo 4: Infested Vegetation Community 4.

Photo 5: North Western Infested vegetation.

Photo 6: Example of abandoned mines present in Argyle forest block

Photo 7: Example of costean present in Argyle forest block.

Photo 8: Uninfested (Left) and Infested (Right) boundary. Significant biomass and indicator species deaths in Infested vegetation.



Legend

Assessment Area

Project Location

Project Location Map

2020 DMIRS Donnybrrok Dieback Assessment

0 5 10 km

N

Datum: GDA 1994
Projection: MGA Zone 50

Scale: 1:15000 at A3

Date: 23/09/2020	Prepared: A. Caubo	Project #: T20032
Expiry:	Checked: A. Caubo	
Figure 2	Review: J. Grehan	Terratree
	Revision:	

NOTE: Terratree Pty Ltd does not guarentee that this figure is without any mistakes and disclaims all liability for any error, loss or other consequence that may arise from any of the spatial information illustrated.
Spacial information in this figure is based on observable diseas symptoms made during the field survey component of the assessment and does not take into account recent or inipient disease symptoms.

MAP LIMITATIONS
The information represened on this map is digitised relative to mapped features and may not be accurate, consequently the field demaraction should be followed.

Goodwood Rd

Upper Capel Rd

AS01
AS02
AS03
AS04
AS05
AS06
AS07
AS08

Occurrence Category	Area (ha)	Unprotectable (ha)	% of Assessment Area
Infested	23.0	-	45.4
Uninfested	22.4	0.3	44.3(0.6)
Uninterpretable	5.2	-	10.3
Total	**50.6**	**0.3**	**100 %**

Legend

- Assessment Area
- 2 Meter Contours
- Tracks
- Roads

Points of Interest
- Mine Shafts & Costeans

Sample Locations
- Negative
- P.cinnamomi

Dieback Occurence
- Infested
- Uninfested
- Uninfested Unprotectable
- Uninterpretable

Project Location

Dieback Protectable Areas Map

2020 DMIRS Donnybrook Dieback Assessment

0 50 100 150 200 m

N

Datum: GDA 1994
Projection: MGA Zone 50

Scale: 1: 4000 at A3

Date: 18/11/2020	Prepared: A. Caubo	Project No: T20032
Expiry: 18/11/2021	Checked: J. Grehan	
Figure 2	Revision:	Terratree
	Review:	

Appendices

1. VEGETATION HEALTH SERVICE - PHYTOPHTHORA SAMPLE INFORMATION SHEET

SEND TO: VHS Lab, Forest and Ecosystem Management Div - DPaW, 17 Dick Perry Ave KENSINGTON 6151 **Phone**:(08) 9334 0317 **Fax:** (08) 9334 0114

CONTACT DETAILS of sender
Name: Joe Grehan and Aaron Caubo
Fax No. _____ Phone No.: 0892501163
DPaW Office or Company Name: Terratree Pty Ltd

GDA (1)	Job Type (Please indicate)		VHS USE ONLY	NOTIFY DFWA?
GDA 94 ✓	DPaW (C)	Alcoa (A)	Date received 21.9.20	
	Recoup (R)	FPC	Date faxed 4.10.20 19.10.20	
	Private (P)	Other____		

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)
VHS 41577	18 SEP 20	AS03	*Banksia grandis*	Med	50	E 0390085 N 6281127	SF		NEG
VHS 41578	18 SEP 20	AS04	*Banksia grandis*	Med	50	E 0390249 N 6281457	SF		NEG
						E N			
						E N			
						E N			
						E N			
						E N			
						E N			

DB

NEG

NEG

PM

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*, = *P. megasperma*, PN = *P. nicotianae*, CON = *P. constricta*, ALT = *P. alticola*, 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: A= Argyle Forest

Requested DB

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GDA (1)	Job Type (Please indicate)		VHS USE ONLY	NOTIFY DFWA?
GDA 94 ✓	DPaW (C)	Alcoa (A)	Date received 24.9.20	
	Recoup (R)	FPC	Date faxed 1.10.20, 7.10.20	
	Private (P)	Other_____		

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)
VHS 41582	18 SEP 20	AS01	*Dasypogon bromilifolus*	Nil	50	E 0389975 N 6281861	SF		NEG
VHS 41583	18 SEP 20	AS02	*Banksia grandis*	Med	50	E 0389834 N 6281502	SF	CIN	CIN
VHS 41584	18 SEP 20	AS05	*Banksia grandis*	Med	50	E 0390356 N 6281029			CIN
						E _ _ _ _ _ _ N _ _ _ _ _ _ _			
						E _ _ _ _ _ _ N _ _ _ _ _ _ _			
						E _ _ _ _ _ _ N _ _ _ _ _ _ _			
						E _ _ _ _ _ _ N _ _ _ _ _ _ _			
						E _ _ _ _ _ _ N _ _ _ _ _ _ _			

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PM

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COMMENTS: A= Argyle Forest

VEGETATION HEALTH SERVICE - PHYTOPHTHORA SAMPLE INFORMATION SHEET

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CONTACT DETAILS of sender
Name: Joe Grehan
Phone No. 9250 116 ; M: 0400 003 688; E: joeg @terratree.com.au
DPaW Office or Company Name: Terratree Pty Ltd

GDA (1)
GDA 94 X

Job Type (Please indicate)
DPaW (C) Alcoa (A)
Recoup (R) FPC
Private (P) OtherDMIRS

VHS USE ONLY
Date received 13.11.20
Date faxed 17.11.20

NOTIFY DFWA?

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)
VHS 41933	8/11/2020	AS06	~~*Banksia grandis*~~ *X. grac.*	L	50	390296 6281440	SF		CIN
VHS 41934	9/11/2020	AS07	*Xanthorrhoea gracilis*	M	50	390091 6281753	SF		CIN
VHS 41935	9/11/2020	AS08	*Xanthorrhoea gracilis*	L	50	390148 6281797	SF		CIN

NOTES:
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PM

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: A = Argyle, DMIRS/DBCA

Appendix B: Sample Information

Sample ID	*AS01*
Plant Sampled	*Dasypogon bromeliifolius*
Coordinates (GDA 94)	E: 0389975
	N: 6281861
Vegetation Type	C2
Aspect (N, S, E, W)	N
Slope (^{O})	<5
Soil Type	Sandy
Site Disturbance	Mining and Logging
ISD Class	Scattered
Vector	Yes
Topographical Position	Mid-Slope
Disease Expression	None
Chronological Pattern	None
Spatial Pattern	None
Drought Effect	Medium
***Armillaria* evidence**	No
Fire Effects	No
Current Dieback Impact	None
Biomass Reduction	Low
Drainage	Good
Other ISDs	*Nil*
Comments	Sample taken to support an Uninfested diagnosis
Photo	

Sample ID	*AS02*
Plant Sampled	*Banksia grandis*
Coordinates (GDA 94)	E: 0389834
	N: 6281502
Vegetation Type	C3
Aspect (N, S, E, W)	S
Slope (^{o})	<5
Soil Type	Gravelly Sand
Site Disturbance	Logging and Mining
ISD Class	Isolated
Vector	Yes
Topographical Position	Mid-Slope
Disease Expression	None
Chronological Pattern	None
Spatial Pattern	None
Drought Effect	Medium
***Armillaria* evidence**	No
Fire Effects	No
Current Dieback Impact	None
Biomass Reduction	Low
Drainage	Impeded
Other ISDs	*Xylomelum occidentale*
Comments	Sample taken to support and Uninfested diagnosis
Photo	

Sample ID	*AS03*
Plant Sampled	*Banksia grandis*
Coordinates (GDA 94)	E: 0390085
	N: 6281127
Vegetation Type	C4
Aspect (N, S, E, W)	S
Slope (^{o})	6-10
Soil Type	Sandy gravel
Site Disturbance	Mining and Logging
ISD Class	Multiple
Vector	Yes
Topographical Position	Mid-slope
Disease Expression	Average
Chronological Pattern	Moderate
Spatial Pattern	Moderate
Drought Effect	Medium
***Armillaria* evidence**	No
Fire Effects	No
Current Dieback Impact	Medium
Biomass Reduction	Low
Drainage	Average
Other ISDs	*Persoonia longifolia* and *Patersonia sp.*
Comments	Sample taken to support an Infested diagnosis.
Photo	

Sample ID	*AS04*
Plant Sampled	*Banksia grandis*
Coordinates (GDA 94)	E: 0390249
	N: 6281457
Vegetation Type	C4
Aspect (N, S, E, W)	E
Slope (^{o})	6-10
Soil Type	Sandy gravel
Site Disturbance	Roading, Logging and Mining
ISD Class	Multiple
Vector	Yes
Topographical Position	Mid-slope
Disease Expression	Subtle
Chronological Pattern	Low
Spatial Pattern	Low
Drought Effect	Medium
***Armillaria* evidence**	No
Fire Effects	No
Current Dieback Impact	Medium
Biomass Reduction	Low
Drainage	Poor
Other ISDs	*Patersonia sp.* and *Xanthorrhoea preissii*
Comments	Sample taken to support an Infested diagnosis
Photo	

Sample ID	*AS05*
Plant Sampled	*Banksia grandis*
Coordinates (GDA 94)	E: 0390356
	N: 6281029
Vegetation Type	C4
Aspect (N, S, E, W)	E
Slope (^{o})	<5
Soil Type	Sandy
Site Disturbance	Mining and Logging
ISD Class	Multiple
Vector	Yes
Topographical Position	Lower Slope
Disease Expression	Obvious
Chronological Pattern	Strong
Spatial Pattern	Average
Drought Effect	Low
***Armillaria* evidence**	No
Fire Effects	No
Current Dieback Impact	Medium
Biomass Reduction	Low
Drainage	Average
Other ISDs	*Xanthorrhoea preissii* and *Macrozamia riedlei*
Comments	Sample taken to support, and Infested diagnosis of area previously mapped as Uninfected (2004)
Photo	

Sample ID	*AS06*
Plant Sampled	*Xanthorrhoea gracilis*
Coordinates (GDA 94)	E: 0390296
	N: 6281440
Vegetation Type	Community 4
Aspect (N, S, E, W)	E
Slope (^{O})	<5
Soil Type	Sandy Gravel
Site Disturbance	Mining and Roading
ISD Class	Clustered
Vector	Yes
Topographical Position	Mid-Slope
Disease Expression	Average
Chronological Pattern	Medium
Spatial Pattern	Low
Drought Effect	Low
***Armillaria* evidence**	No
Fire Effects	No
Current Dieback Impact	Low
Biomass Reduction	Low
Drainage	Good
Other ISDs	*Banksia grandis*
Comments	Sample taken to support an Infested diagnosis
Photo	Nil

Sample ID	*AS07*
Plant Sampled	*Xanthorrhoea gracilis*
Coordinates (GDA 94)	E: 0390091
	N: 6281753
Vegetation Type	Community 4
Aspect (N, S, E, W)	E
Slope (^{o})	<5
Soil Type	Sand
Site Disturbance	Logging and Mining Exploration
ISD Class	Clustered
Vector	Yes
Topographical Position	Mid-Slope
Disease Expression	Average
Chronological Pattern	Low
Spatial Pattern	Low
Drought Effect	Medium
***Armillaria* evidence**	No
Fire Effects	No
Current Dieback Impact	Low
Biomass Reduction	Low
Drainage	Good
Other ISDs	*Banksia grandis, Xanthorrhoea preissii, Persoonia longifolia*
Comments	Sample is growing on top of a rock but still potential to be P.C
Photo	Nil

Sample ID	*AS08*
Plant Sampled	*Xanthorrhoea gracilis*
Coordinates (GDA 94)	E: 0390148
	N: 6281797
Vegetation Type	Community 4
Aspect (N, S, E, W)	E
Slope (^{O})	<5
Soil Type	Sand
Site Disturbance	Logging and Mining Exploration
ISD Class	Clustered
Vector	Yes
Topographical Position	Lower
Disease Expression	Subtle
Chronological Pattern	Low
Spatial Pattern	Low
Drought Effect	Medium
***Armillaria* evidence**	No
Fire Effects	No
Current Dieback Impact	Low
Biomass Reduction	Low
Drainage	Good
Other ISDs	*Banksia grandis*
Comments	Sample taken to support an Infested diagnosis
Photo	Nil