KD.1 Pty Ltd

Lot 3 Buller Road, Waroona

Phytophthora Dieback occurrence assessment – Version 2.0

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CONSULTING

Disclaimer

This report has been prepared in accordance with the scope of work agreed between the Client and Glevan Consulting and contains results and recommendations specific to the agreement. Results and recommendations in this report should not be referenced for other projects without the written consent of Glevan Consulting.

Procedures and guidelines stipulated in various Department of Environment and Conservation and Dieback Working Group manuals are applied as the base methodology used by Glevan Consulting in the delivery of the services and products required by this scope of work. These guidelines, along with overarching peer review and quality standards ensure that all results are presented to the highest standard.

Glevan Consulting has assessed areas based on existing evidence presented at the time of assessment. The Phytophthora pathogen may exist in the soil as incipient disease. Methods have been devised and utilised that compensate for this phenomenon; however, very new centres of infestation, that do not present any visible evidence, may remain undetected during the assessment.

Author Glevan Consulting

Note on version numbering:

0.1 – 0.∞	*Internal documents*
1.0 – 1.∞	*First draft and iterations to Client.*
2.0	*Final document.*

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1 Summary

Glevan Consulting conducted an assessment of Lot 3 Buller Road, Waroona for the presence of Phytophthora Dieback. The Project Area covered 36.797 hectares, of which 22.133 hectares was assessed, with the remaining 14.664 ha being excluded due to a lack of vegetation (cleared areas associated with old pits).

The assessment was conducted from 05-05-2015 to the 29-05-2015 by Simon Robinson, and no records or evidence of previous Phytophthora Dieback assessments were identified for the area.

The study area has previously been used for sand mining (clean fill), and no records or evidence of hygiene practices for this operation were identified during the assessment and there is a high probability that the sand pit area is infested. This is supported by the presence of infested areas in the surrounding vegetation, where the evidence suggests that the pathogen has spread from the operational area into the vegetation.

The study area is a mosaic of infested, uninterpretable, temporarily uninterpretable and uninfested areas. A single, potentially protectable area was identified during the assessment, covering an area of 1.764 ha. The area is contiguous with other uninfested vegetation to north, and comprises a total of approximately 3.5 ha. If found to contain significant environmental values during other aspects of the environmental survey, it should be considered for retention/management. The area is still relatively small however, and if no significant values are identified, the proponent may downgrade the protectable area to unprotectable and no hygiene management will be required.

Should the proponent wish to use the sand from the protectable area as a Dieback free source of clean fill, then a 15m buffer (minimum) of vegetation is required to be retained between the pit and the uninfested area during mining of the Dieback free sand.

The Phytophthora Dieback category mapping presented in the this report is valid for 12 months, and will expire on the 29-05-2016

2 Introduction

2.1 Background

Glevan Consulting was commissioned by KD.1 to conduct an assessment of Lot 3 Buller Rd, Waroona for the presence of Phytophthora Dieback. The study area contains a sand pit which was previously mined for clean fill by Carbone bros. Pty Ltd. Sand mining operations within the study area ceased approximately 8 years ago. Access to the land has since been acquired by AMG (WA Pty Ltd), who are seeking to re-establish the sand mining operations. The proponent is proposing to extend the boundaries of the existing sand pit into the surrounding native vegetation, and this assessment is part of a broader environmental survey being conducted to determine the environmental attributes of the study area and the presence of any environmental significant values.

2.2 Location of Project Area

The study area is located on Buller Road, in the Shire of Waroona approximately 8km east of the town of Waroona, and comprises an area of 36.797 ha. The vegetation is largely Jarrah/Banksia Woodland, with occasional thickets of *Kunzea ericifolia*.

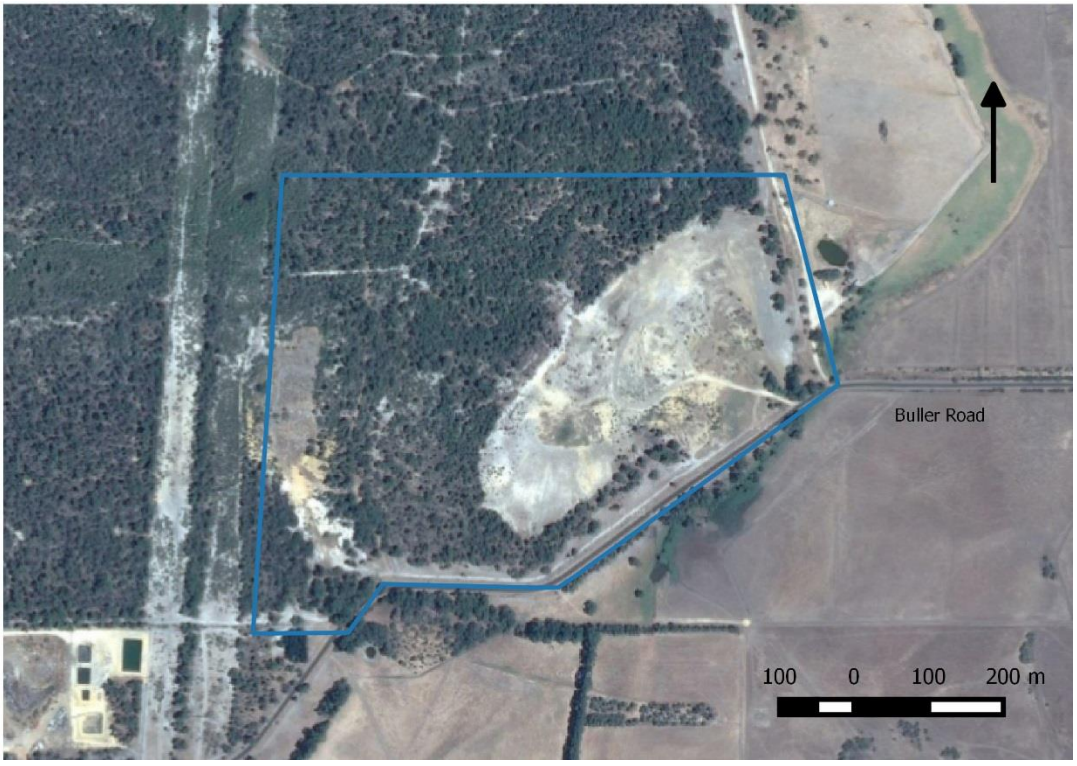

Figure 1 - Project Area

2.3 Historical land use and previous disturbances.

The study area contains a sand pit that was previously used to provide clean fill for building projects and the area associated with the sand pit was cleared and is still almost entirely void of native vegetation. There is evidence of attempts to revegetate the cleared area post mining, but these attempts appear to have been largely unsuccessful. The study area is also bordered by farming land to the east and the south, and by a powerline corridor to the west, all of which exhibit significant levels of disturbance.

2.4 Study team

The assessment was conducted by Simon Robinson of Glevan Consulting in May of 2015. Mr Robinson is accredited by the Department of Parks and Wildlife (DPaW) in the detection, diagnosis and mapping of the Dieback disease. This accreditation recognises the skills and experience of Mr Robinson.

3 Phytophthora Dieback

The pathogen *Phytophthora cinnamomi* is an agent of environmental disease found in vulnerable areas of Western Australia. Phytophthora Dieback is the common name for the observable disease result of interaction between the pathogen (*P. cinnamomi*) and the vegetation hosts (susceptible plant species within vulnerable areas).

The environment conditions of the site significantly affect the pathogens ability to survive or flourish and spread over time. All land with an annual average rainfall of more than 400 millimetres and suitable soil composition is considered vulnerable to Phytophthora Dieback. This large area stretches approximately from Perth, Bunbury and Augusta in the west to Narrogin, Ravensthorpe and Esperance in the east, and as far north as Kalbarri.

This vulnerable area has many different bioregions, having specific characteristics formed by climate and geology. These two factors are highly significant in determining the pathogen's effectiveness and resulting disease impact levels.

3.1 The Pathogen

Phytophthora cinnamomi is a microscopic water mould. It belongs to the class Oomycetes and belongs in the Kingdom Stramenopila. It is more closely related to brown algae than to true fungi. Oomycetes organisms occupy both saprophytic and pathogenic lifestyles however *P. cinnamomi* is considered parasitic. It behaves largely as a necrotrophic pathogen causing damage to the host plant's root tissues because of infection and invasion.

The life cycle of *Phytophthora cinnamomi* is a continuous circle of infection, sporulation and further infection and is readily vectored by animals and human activity allowing for rapid invasion into new areas.

3.2 Host

A population of hosts is made up of susceptible, infected and immune or resistant individuals. The infection of host plants is an unseen activity happening constantly beneath the soil at an infested site. The environmental conditions favouring or disfavouring the pathogen may change at a critical point during disease development, temporarily changing the rates of infection and invasion. This can be observed symptomatically after soil temperature change through winter months.

The plant host is a highly variable component of the disease development. Sites may range from having no susceptible host, to being vegetated almost entirely with species that are highly susceptible. Within vulnerable areas, three main family groups are regarded as highly susceptible to Phytophthora Dieback disease, being:

- Proteaceae
- Ericaceae
- Xanthorrhoeaceae.

3.3 Environment

Two fundamental environmental characteristics influencing Phytophthora Dieback disease are rainfall and soil. Areas vulnerable to Phytophthora Dieback are defined as native vegetation which occur west of the 400 millimetre rainfall isohyet. The correlation of increased Phytophthora Dieback impact with increased annual rainfall is generally applicable.

Certain soil properties influence Phytophthora Dieback disease development within the vulnerable areas:

1. Moisture is critical for *Phytophthora cinnamomi* to survive in the soil and for sporangia production.
2. Soil pH affects the growth and reproduction of the pathogen. The calcareous sands closest to the coast are alkaline and hostile to *Phytophthora cinnamomi,* but are favourable to *P. multivora.*
3. Fertile soils are less favourable to Phytophthora Dieback because the richness of nutrients aids strong host resistance, good soil structure allows water movement and drainage, and high organic matter provides antagonistic microflora.
4. Coarse-textured soils have larger pore spaces which favour dispersal of spores.
5. The optimum temperature for *Phytophthora cinnamomi* sporulation is 21 to 30°C, peaking at 25°C., but some sporangia can still be produced at temperatures as low as 12°C. The optimum growth range is 15 to 30°C and temperatures lower than 5°C or greater than 35°C are unfavourable for the persistence of survival of spores and the vegetative mycelia of *P. cinnamomi.*

4 Methods

4.1 Pre survey desktop study

Known databases of *Phytophthora* locations retained by Glevan Consulting and Vegetation Health Services (DPaW) were searched to determine previous recoveries of *Phytophthora* within the project area.

4.2 Interpretation

Based on the considerations of Section 3 'Phytophthora Dieback', the personnel involved in the field work determined the presence of Phytophthora Dieback based on symptoms and disease signatures displayed in susceptible vegetation. These symptoms are supported through the strategic sampling and subsequent recovery of Phytophthora from soil and tissue samples taken during the assessment.

The detection of the plant pathogen Phytophthora Dieback involves the observation and interpretation of plant deaths (or reduction of biomass or perceived temporal change in vegetation structure) using a logical assessment of factors that imply pathogen presence above other possible causes of plant deaths or vegetation change. A combination of the following factors may indicate the presence of disease caused by *Phytophthora* Dieback or other *Phytophthora* species.

Deaths of disease indicating species:

An indicator species is a plant species, which is reliably susceptible to Phytophthora Dieback (i.e. will die). Common indicators include several species of *Banksia, Patersonia*, *Persoonia*, and *Xanthorrhoea*. The distribution and composition of indicator species will vary from place to place according to vegetation types.

Chronology of deaths:

As the pathogen spreads through an area, some or all susceptible plants become infected and die. Consequently there will be an age range from more recent deaths with yellowing or brown leaves through to older leafless stags to remnant stumps in the ground.

Pattern of deaths:

The topography, soil type, vegetation type and drainage characteristics of an area together with the influence of climatic patterns and disturbances will influence the shape or pattern of an infested area over time. A typical recent infestation may show a small cluster of dead indicator species which, in time, will spread to become a small circular shape 'the ulcer effect' and then begin lengthening towards natural drainage channels. A fringe of recent deaths is often seen around the edge of the infested area. Patterns may be further highlighted by a paucity of ground cover within the infested area.

Other causes of indicator species death:

Phytophthora cinnamomi is not the only agent to cause death of native vegetation. Other agents include, but are not limited to:

- other *Phytophthora* spp, *Armillaria luteobubalina*, various cankers, insects;
- drought, wind scorch, frost, salinity, water logging, fire and lightning;
- senescence, competition, physical damage;
- herbicides, chemical spills (for example fuel).

Based on the field assessment, the Project Area can be distributed to the following occurrence categories.

Table 1 - Phytophthora Dieback occurrence categories

Vegetated area	Infested	Areas that have plant disease symptoms consistent with the presence of Phytophthora Dieback
	Uninfested	Areas free of plant disease symptoms that indicate the presence of Phytophthora Dieback.
	Uninterpretable	Areas where indicator plants are absent or too few to determine the presence or absence of Phytophthora Dieback.
	Unmappable	Areas that are sufficiently disturbed so that Phytophthora Dieback occurrence mapping is not possible at the time of inspection.
	Not yet resolved	Areas where the interpretation process has not confidently determined the status of the vegetation.
Non-vegetated area	Excluded	Areas devoid of vegetation are excluded from the assessment area.

4.3 Demarcation of hygiene boundaries

The potentially protectable area was demarcated with day-glow orange flagging tape. A single band of tape was tied to a suitable tree with the knot facing towards the infested areas. The taped boundaries were positioned approximately 20m outside the infested areas, to provide the required buffer zone, and placed approximately 10 -15m apart.

The uninterpretable, temporarily uninterpretable, and unprotectable uninfested areas were not demarcated, as they are all unprotectable and hygiene measures are not required.

4.4 Soil and tissue sampling

Suspicious sites can have a representative soil and tissue sample taken to assist with the interpretation process. The laboratory result can confirm the presence of the *P. cinnamomi* pathogen. A negative result does not necessarily prove that the pathogen isn't present at the site, and should be supported by the field interpretation.

Sampling was conducted using the following procedure:

- All digging implements used were thoroughly sterilised prior to use with methylated spirits. The implements were then allowed to dry so that the integrity of the sample was not compromised.
- The area around the base of the plant/s to be sampled was cleared of vegetative matter to aid the digging process.
- The plant was dug to a satisfactory depth so that the tissue with the highest moisture content was obtained.
- Sections of the roots and stem base from all sides of the plant were taken and placed in a plastic bag. If any lesion was noticed on the tissue, it was also placed in the bag. A few handfuls of sand from various depths were also deposited in the plastic bag.
- The sample bags were irrigated with distilled water to try and simulate the optimum conditions for the *Phytophthora* to survive.

- Details, such as the date, sample number and interpreters were written on an aluminium tag, which was left at the site. The tag was demarcated with a strip of day-glow orange flagging tape.
- All digging implements used were again sterilised after each sample was taken to ensure that infected soil was not transported to the next sample site.

4.5 Mapping

Subsequent to hygiene boundary demarcation, the boundaries were again walked and recorded utilising a handheld GPS. The recorded data was then transferred to a desktop computer and used to produce the relevant maps.

4.6 Limitations of disease mapping

The assessment for the disease caused by Phytophthora Dieback is based on interpreting the vegetation for symptoms which can be ascribed to the disease presence. These observable factors must be present during the assessment period. Management recommendations may be included if it is considered that the disease may be cryptic, or the project area displays evidence of activities that are considered a high risk of introducing the disease.

The validity of the hygiene boundaries mapped for this project is twelve months from the completion of this project. All boundaries should be reassessed by the 29-05-2016 if activities are still occurring beyond this time.

5 Project area environmental data

5.1 Rainfall

Climate data available from the Bureau of Meteorology for the Waroona area indicates that the study area has an annual average rainfall of approximately 990 mm per year, which, combined with several months of average soil temperatures above 21 degrees Celsius, combines to provide ideal conditions for sporulation and disease activity.

5.2 Soil types

The sands within the study area are described as very light grey at the surface, yellow at depth, fine to medium sub-rounded quartz, and moderately sorted. The interdunal depressions are subject to seasonal waterlogging, and have poor drainage, providing high moisture conditions for extended periods, which are very favourable to the pathogen.

5.3 Vegetation structure

The vegetation within the study area is typical of that normally observed on the Bassendean Dune system. It is primarily Banksia woodland, dominated by *Banksia attenuata* and *Banksia menziesii* with a species rich understorey of Myrtaceous, and Proteaceous shrubs and grass trees, with dense pockets of Spearwood (*Kunzea ericifolia*) in lower areas. Such vegetation has relatively high susceptibility to Phytophthora Dieback and generally provides good levels of disease expression, assisting in the detection and mapping of infested areas.

6 Results

6.1 Phytophthora Dieback occurrence distribution

A total of 13.595 ha of the study area was found to be infested. In addition, 2.262 ha of the study area was observed to be temporarily uninterpretable, and a further 1.952 ha was observed to be uninterpretable, both of which are also unprotectable. A single, uninfested, potentially protectable area was identified, which comprised an area of 1.764 ha, while a further 2.560 ha of uninfested vegetation was observed to be unprotectable (Table 2).

Table 2 - Area Summary

Category	Area (ha)	% of total area
Infested (with *P. cinnamomi*)	13.595 ha	37%
Uninfested	1.764 ha	5%
Uninterpretable	1.952 ha	5%
Temporarily uninterpretable	2.262 ha	6%
Excluded	14.664 ha	40%
Uninfested (Unprotectable)	2.560 ha	7%
TOTAL AREA	36.797 ha	

6.2 Disease expression

Disease expression was highly variable throughout the study area, and while the presence of the disease was obvious in some areas, the current expression levels were observed to be quite subtle. Disease expression was generally characterised by the presence of multiple old *Banksia* deaths and a significant reduction in biomass.

6.3 Soil and tissue samples

A total of six soil and tissue samples were taken during the assessment, four of which tested positive for the presence of *P. cinnamomi*.

Table 3 – Project Area Sample Summary

Sample	Plant sampled	Easting	Northing	Result
1	***Xanthorrhoea preissii***	**391152**	**6363658**	***Positive***
2	***Xanthorrhoea preissii***	**390995**	**6363470**	***Positive***
3	***Banksia menziesii***	**390977**	**6363752**	***Positive***
4	***Banksia attenuata***	**391090**	**6363262**	***Negative***
5	***Banksia attenuata***	**390975**	**6363278**	***Negative***
6	***Banksia attenuata***	**391135**	**6363735**	***Positive***

7 Discussion

7.1 Phytophthora Dieback occurrence distribution

The existing sand pit located within the study area was excluded from the assessment due to having a Keighery Vegetation Disturbance and Assessability scale rating of 6 (DPaW, 2015), meaning it was almost entirely void of native vegetation. The evidence in the surrounding vegetation however, suggests that the pit is almost certainly infested, as the pattern of infestation (chronology, biomass variations) exhibited by the obvious infestation that occurs on the pit boundary (see map 1.1), indicates that it has spread from the pit into the surrounding vegetation. This infestation extends into the remnant vegetation to a distance of approximately 50 – 60m, and along the pit boundary for approximately 120m.

The infestation almost converges with the infestation to the north associated with sample 6 (Map1.2), and also with the large infestation spreading from the wetland area to the north and west. The infestation associated with sample 3 appears to be related to an old access track, and this infestation will soon converge with the wetland infestation. The narrow strip of vegetation adjacent to Buller Rd also exhibited strong evidence of infestation.

The other pit located on the western boundary was also excluded from the assessment, however, the health of the small number of B. grandis specimens observed within the pit, and the state of the surrounding vegetation suggests that this pit is actually uninfested. There is insufficient native vegetation however, to make an accurate or confident assessment of the Dieback status of this pit, especially as it is surrounded by uninterpretable areas.

The uninfested protectable area delineated within the study area comprises only a relatively small area of 1.764 ha, however the area is contiguous with other uninfested vegetation that occurs beyond the study area boundary (to the north). The uninfested section outside the study area was also assessed to gain an idea of the approximate size of the uninfested area, and the total uninfested area (including that mapped within the study area) is believed to be approximately 3.5 ha.

The uninfested section is positioned in the landscape such that much of it could remain uninfested for a considerable length of time. However, it is relatively small, and exhibited obvious signs of disturbance (Keighery rating 3), and unless the section is found to have significant environmental values during other aspects of the environmental assessment, the proponent may choose to downgrade this area to unprotectable if it cannot be easily managed during operations.

Should the proponent wish to use the sand from the protectable area as a Dieback free source of clean fill, then a 15m buffer (minimum) of vegetation is required to be retained between the pit and the uninfested area.

The study area contains several other uninfested areas, the largest of which are shown on the map (Map 1.1). However, these areas are relatively small and surrounded by infested areas, or other categories in which the Dieback status is unknown, and as a result have been mapped as unprotectable.

Temporarily unmappable areas were identified around the old pit on the western boundary and also on eastern boundary north of the main sand pit. The area surrounding the western pit exhibited high levels of disturbance associated the previous mining activity, and more time is required for the vegetation to recover to a sufficient level so that the Dieback status can be confidently and accurately determined. The area in the north eastern corner of the study area is almost completely void of understorey vegetation in places and as such, the presence or distribution of any Dieback infestations that may be present cannot be determined.

An uninterpretable area was also observed to the north of the western pit, associated with a vegetation change (Map 1.1). The area borders a Kunzea thicket that is associated with an infested wetland area to the north. No definitive evidence of infestation was observed within the uninterpretable area, but the vegetation does not contain sufficient indicator species, and the Dieback status cannot be accurately determined.

7.2 Disease expression

The most notable disease expression was observed in the infestation that appears to have spread from the sand pit area. The pathogen has been highly destructive in this section, resulting in older parts of the infestation containing only old Banksia stags, and being almost entirely void of understorey vegetation, creating a strong 'graveyard' effect. Interestingly however, where this obvious infestation meets the healthy, susceptible vegetation, the levels of fresh disease expression are relatively subtle, featuring only scattered Banksia deaths and very occasional deceased *Xanthorrhoea* specimens.

Expression associated with the infested wetland area in the north west corner, was quite variable and characterised by scattered and occasionally clustered *X. gracilis* and *Banksia* deaths. The disease front was not entirely clear in most cases and the exact extent of the infested areas was difficult to determine.

Several areas exhibiting significant decline were observed during the assessment, however the symptoms were not entirely consistent with Phytophthora Dieback presence, and may be drought related. Unfortunately, many of these areas did not contain fresh indicator species deaths (ISD's) to sample, and without sample results it was not possible to confirm the presence / absence of Phytophthora Dieback. Such areas were considered to be unprotectable, and have been included in the infested category.

7.3 Soil and tissue sampling strategies

Samples 1 -4 (Map .2) were taken to assist in confirming the presence of Phytophthora Dieback in areas believed to be infested. Samples 1 -3 did confirm the presence of the pathogen, however, the negative result produced by sample 4 suggests that the decline observed in this area may be related to factors other than Phytophthora Dieback.

Samples 5 and 6 were taken to assist in supporting the view that the decline observed in these areas was not related to Phytophthora Dieback. Sample 5 tested negative, and did assist in supporting the belief that Phytophthora Dieback was not the cause of the plant deaths observed. Sample 6 was taken in an area were the symptoms were thought to be more consistent with drought and a negative result was expected, however the sample

returned a positive result indicating that it is in fact Phytophthora Dieback causing the decline observed.

8 Recommendations

- Consider retention of protectable area if found to contain significant environmental values during other aspects of the environmental survey. If no significant values are identified, proponent may downgrade the protectable area to unprotectable and no hygiene management will be required.

- Soil and plant material of infested or unknown dieback status should not be introduced to protectable sections (if retained as protectable by proponent) of the study area.

- Soil and plant material should not be transported from the infested, temp uninterpretable or uninterpretable sections of the study area for use at any other protectable area.

- Should the proponent wish to use the sand from the protectable area as a Dieback free source of clean fill, then a 15m buffer (minimum) of vegetation is required to be retained between the pit and the uninfested area during mining of the Dieback free sand.

- Vehicles/machinery involved in mining of the Dieback free sand must be clean on entry into the area.

9 Bibliography

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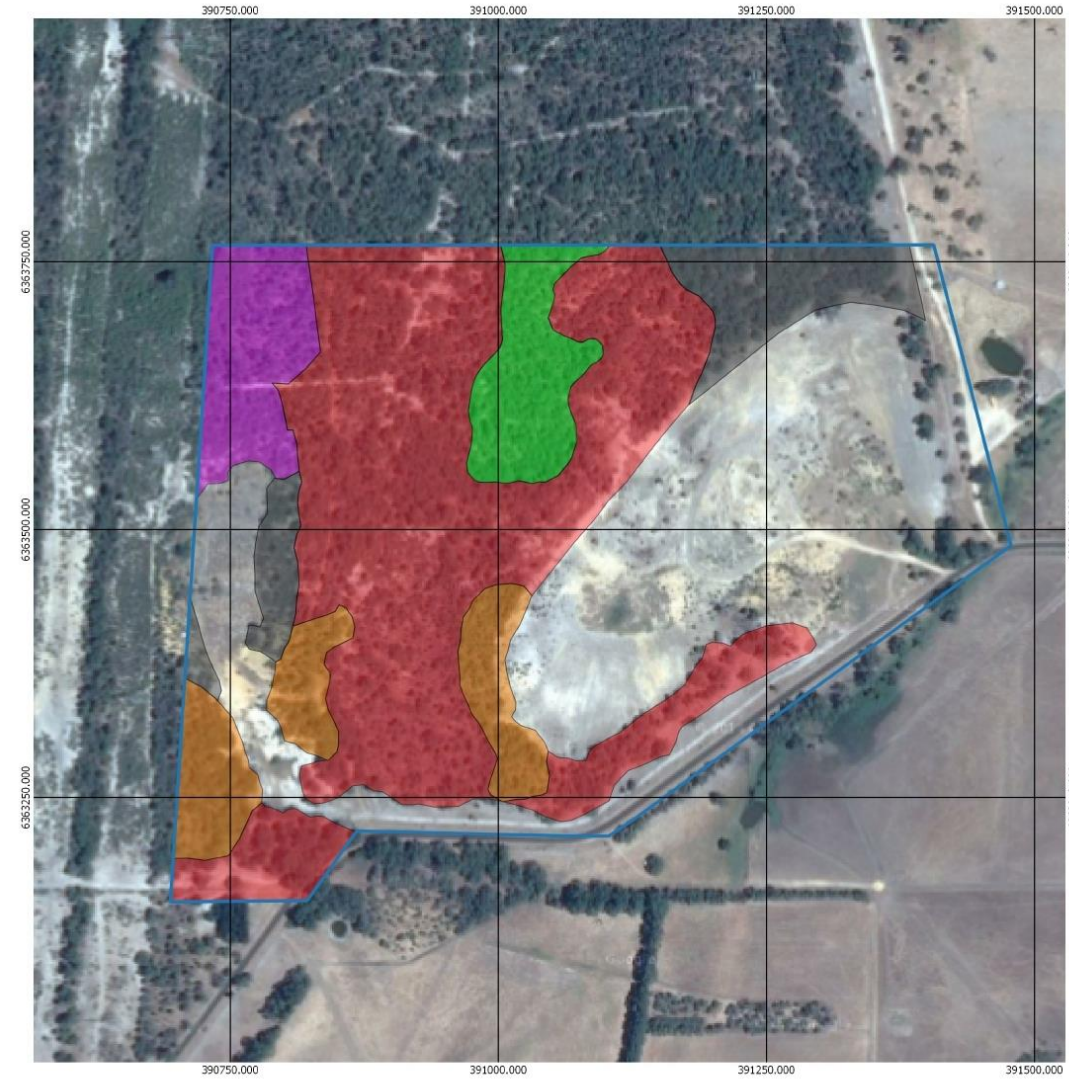
10 Appendix – Phytophthora occurrence map



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Legend
- Boundary
- Uninfested
- Uninfested unprotectable
- Infested
- Temp UI unprotectable
- UI unprotectable

Area Statement (ha)
Uninfested: 1.764
Uninfested unprotectable: 2.560
Temp UI unprotectable: 2.262
UI unprotectable: 1.952
Infested: 13.595
Excluded: 14.664
Total 36.797

N

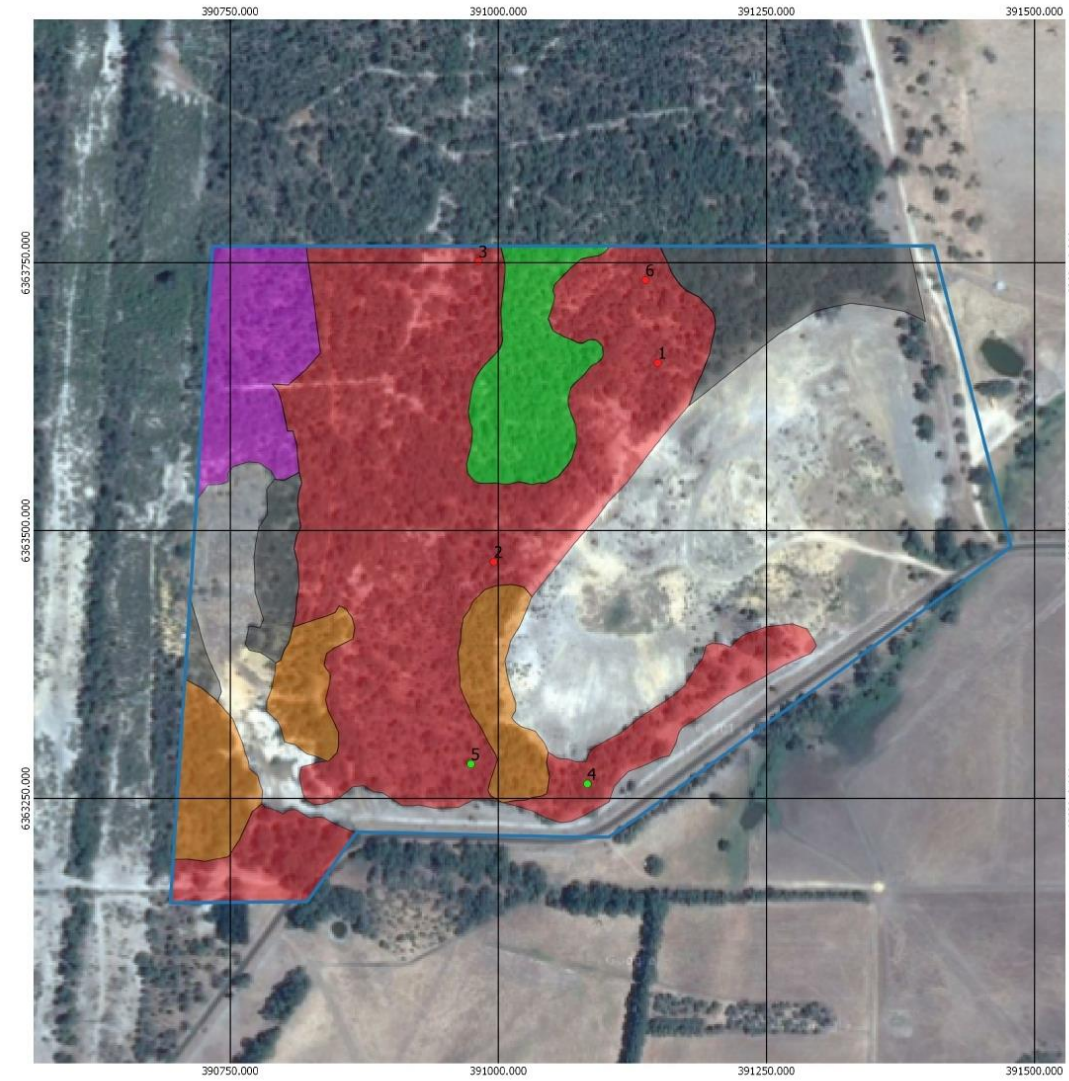
MAP 1.1
Lot 3 Buller Rd - KD1
Protectable Areas

Map Details
Client: KD1
Project: BRM Pit Extension
Site: Lot 3 Buller Rd
Interpretation: SR, 29-05-15
Digitising: SR 02-06-15

50 0 50 100 150 200 m

Projection: Universal Transverse Mercator
MGA Zone 50. Datum: GDA94

11 Appendix – Sample locations map



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Legend

Boundary

Samples

Negative

Positive

Uninfested

Uninfested unprotectable

Infested

Temp UI unprotectable

UI unprotectable

Projection: Universal Transverse Mercator
MGA Zone 50. Datum: GDA94

N

MAP 1.2
Lot 3 Buller Rd - KD1
Sample Sites

Map Details

Client:	KD1
Project:	BRM Pit Extension
Site:	Lot 3 Buller Rd
Interpretation:	SR, 29-05-15
Digitising:	SR 02-06-15

50 0 50 100 150 200 m