

H008 South Coast Highway Kojaneerup Section SLK 46-66
***Phytophthora* Dieback Assessment**
2019

Prepared for
Main Roads Western Australia



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Abbreviations

Abbreviation	Definition
Astron	Astron Environmental Services
DBCA	Department of Biodiversity, Conservation and Attractions
EPA	Environmental Protection Authority
EPBC Act	<i>Environment Protection and Biodiversity Conservation Act 1999</i>
GDA	Geocentric Data of Australia
GPS	Global Positioning System
ha	Hectare
IBRA	Interim Biogeographic Regionalisation for Australia
km	Kilometre
mm	Millimetre
MGA	Map Grid of Australia
MRWA	Main Roads Western Australia
P	Priority species
SLK	Straight line kilometre
TEC	Threatened Ecological Community

Executive Summary

Astron Environmental Services was engaged by Main Roads Western Australia to conduct a *Phytophthora* dieback occurrence survey and to identify protectable areas along the South Coast Highway between straight line kilometre 46.4 to 65.7 in the area between Cheyne Road (south) and Kojaneerup West Road (north), located approximately 40 km north-east of the City of Albany (herein termed the 'Project'). The Survey Area is a narrow corridor that includes the South Coast Highway road reserve (approximately 40 metres wide) and a section of Hassel National Park (27), which encompasses the entire length of the Project. The Survey Area is approximately 277.5 hectares.

The narrow, linear shape of Hassel National Park intersected by South Coast Highway has facilitated the widespread dispersal of soil pathogens and subsequently the majority of the Survey Area is currently Infested (60%) or unprotectable from *Phytophthora cinnamomi*. Many areas mapped as 'Infested' continue to support significant vegetation, flora and fauna. However, in the context of soil hygiene management the primary objective is to prevent infested soil establishing the pathogen in 'Uninfested' areas.

Ten 'Preliminary Protectable Areas' comprising a total of 36 hectares have been delineated and may require hygiene management controls if road construction or maintenance occurs within their vicinity. The majority of the Uninfested and Protectable Areas occur in hydrologically isolated uplands. Significant values that are susceptible to *Phytophthora* occur in the majority of these areas, including a Commonwealth listed Threatened Ecological Community and four Department of Biodiversity, Conservation and Attractions-listed Priority flora species.

A minority of the Survey Area was determined to be either 'Uninterpretable' (and Unprotectable) (10.9 hectares) or was 'Temporarily Excluded' (10 hectares) due to the impact of recent fire.

This report summarises the occurrence information, the Preliminary Protectable Areas and the potential for *Phytophthora* to impact susceptible significant vegetation and flora.

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1 Introduction

1.1 Project Background

Main Roads Western Australia (MRWA) is planning for road upgrade works on South Coast Highway between straight line kilometre (SLK) 46.4 and 65.7 in the area between Cheyne Road (south) and Kojaneerup West Road (north), located approximately 40 km north-east of the City of Albany (herein termed the 'Project').

Astron Environmental Services (Astron) was engaged by MRWA to conduct a *Phytophthora* dieback occurrence survey and to identify protectable areas within the Survey Area. MRWA also requested that Astron remap the vegetation condition. The Survey Area is a narrow corridor that includes the South Coast Highway road reserve (approximately 40 m wide) and a section of Hassel National Park (27), which extends the entire length of the Project. The Survey Area is approximately 277.5 ha.

Phytophthora dieback disease, caused by the soil-born pathogen *Phytophthora cinnamomi*, is a major threat to biodiversity in south-western Australia and is recognised as a key threatening process under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) (Department of the Environment 2014). In Western Australia the pathogen affects 40% of native plant species and there is no known cure for the disease. *Phytophthora cinnamomi* can be spread in water, soil or plant material that contains the pathogen or its spores and dispersal is often favoured under warm and moist conditions (Shearer and Tippet 1989). It can be carried in surface or sub-surface water flow and by the movement of infested soil or organic material by either anthropogenic or natural vectors. Consequently, knowledge of the pathogen's occurrence within the landscape is essential to inform suitable hygiene management practices to mitigate its spread during soil disturbance activities.

The outcome of the survey and information supplied in this report will be used to inform the environmental assessment and approvals process, and in the preparation of a Significant Vegetation and Flora Management Plan and Dieback Management Plan.

1.2 Scope of Work

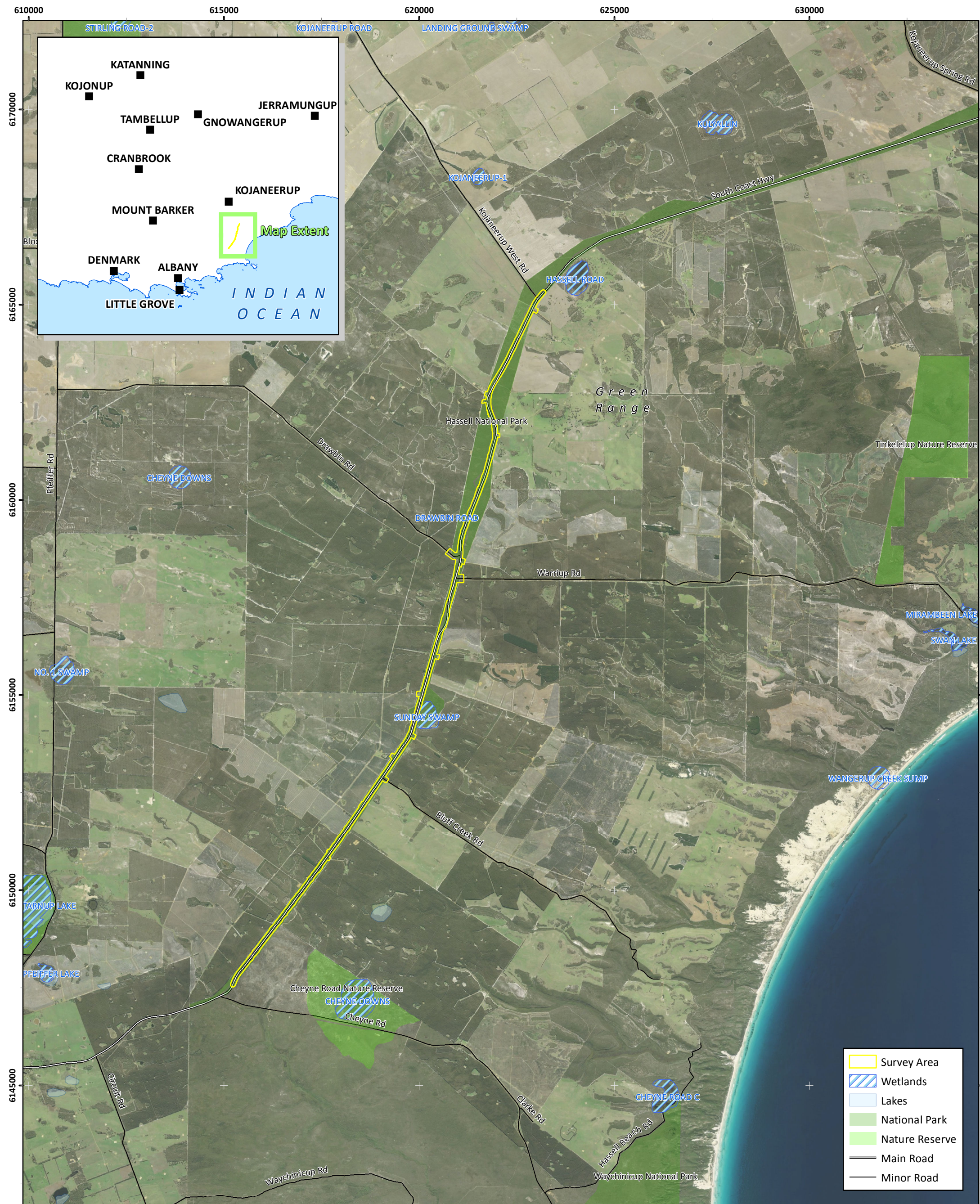
The scope of works was to undertake a *Phytophthora* occurrence assessment of the Survey Area in accordance with the Department of Parks and Wildlife guideline, *Phytophthora Dieback Interpreters Manual for lands managed by the Department* (Department of Parks and Wildlife 2015).

Specifically, MRWA requested:

- survey for *Phytophthora* occurrence and identification of protectable areas
- remapping of vegetation condition.

The assessment involved:

- a desktop review of topography, soils, land use, access and known infestations within the vicinity of the Survey Area
- linear field assessment of the Survey Area, including all peripheral tracks and access points
- report outlining the occurrence of the pathogen and management recommendations to reduce the spread of *Phytophthora* dieback.

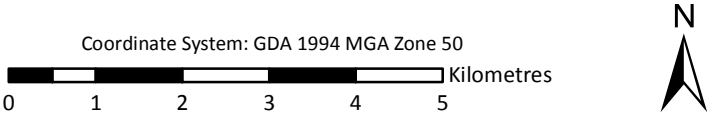


Main Roads Western Australia
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Figure 1: Survey Area Location



Author: J. Johnston	Date: 01-07-2019
Drawn: L. Robinson	Figure Ref: 8602-18-BISR-2Rev0_190701_Fig01_Locn



2 Environmental Context

2.1 Physical Environment

2.1.1 Geology

The surface geology of the Survey Area is comprised of five units and dominated by gravelly and sandy soils (Stewart et al. 2008) (Table 1). Sandy soils or sandy gravels are more transmittable to water and therefore assist *Phytophthora* movement (Dieback Working Group 2000).

Table 1: Geological units of the Survey Area (Stewart et al. 2008).

Label	Description	Area within Survey Area (ha)
Czcp	Siltstone, sandstone	24.3
Czl	Pisolitic, nodular or vuggy ferruginous laterite; some lateritic soils; ferricrete; magnesite; ferruginous and siliceous duricrusts and reworked products, calcrete, kaolinised rock, gossan; residual ferruginous saprolite	110.0
Czs	Sand or gravel plains; quartz sand sheets commonly with ferruginous pisoliths or pebbles, minor clay; local calcrete, laterite, silcrete, silt, clay, alluvium, colluvium, aeolian sand	39.7
Mn	Garnet-biotite-quartz-feldspar augen gneiss, migmatite, quartz-feldspar granofels, metadolerite; granitic gneiss; ultramafic, mafic, and felsic granulites; banded granulite; felsic gneiss, granite, banded gneiss	19.5
Qd	Dunes, sandplain with dunes and swales; may include numerous interdune claypans; residual and aeolian sand with minor silt and clay; aeolian red quartz sand, clay and silt, in places gypsiferous; yellow hummocky sand	84.0

2.1.2 Surface Water and Hydrology

The Survey Area occurs within a number of catchments, specifically within the Wilyun Creek, Cordinup River, Mullocullop Creek, Wongerup Creek, Coastal and Waychinicup River catchment areas (Department of Water 2014).

The Survey Area does not contain, and is not in close proximity to, any wetlands listed as Ramsar sites (Department of Environment and Energy 2019). One Department of Biodiversity, Conservation and Attractions (DBCA) listed Conservation Category wetland, named Sunday Swamp (UFI BA21603875) intersects the Survey Area (Department of Biodiversity, Conservation, and Attractions 2017). Local surface water mapping is provided in Appendix A.

2.2 Biological Environment

2.2.1 Interim Biogeographic Regionalisation of Australia

The Interim Biogeographic Regionalisation for Australia (IBRA version 7) divides the Australian continent into 89 bioregions and 419 subregions (Department of the Environment and Energy 2019). The Survey Area occurs in the Esperance Plains and Jarrah Forest bioregions, and at a finer scale falls within the Fitzgerald and Southern Jarrah Forest subregions (Department of the Environment and Energy 2019, 2018). Approximately 80% (220 ha) of the Survey Area occurs within the Esperance Plains bioregion, and approximately 20% (57.5 ha) of the Survey Area occurs within the Jarrah Forest bioregion.

The Fitzgerald subregion is characterised by myrtaceous and proteaceous scrub and mallee heaths on sandplain overlying Eocene sediments, and is rich in endemic species, often cryptic and localised in nature. Eucalypts dominate most systems. The Southern Jarrah Forest subregion is characterised by jarrah-marri forest on laterite gravels and, in the eastern part, by wandoo-marri woodlands on clayey 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 (Hearn et al. 2002). Mapping of IBRA subregions is provided in Appendix A.

2.2.2 Conservation Reserves

The majority of the Survey Area (189.7 ha, 69%) coincides with Hassell National Park, a Class A reserve vested under the Conservation Commission of Western Australia. The Hassell National Park, proclaimed in 1963 and covering an area of approximately 1,200 ha, is a long linear Park between approximately 200 m to 600 m wide that follows the alignment of the South Coast Highway.

The Cheyne Road Nature Reserve is the nearest other conservation area, being located approximately 1.1 km south-east of the southern end of the Survey Area. Local conservation reserves are presented in Appendix A.

2.2.3 Pre-European Vegetation

Two broad scale pre-European vegetation associations (Shepherd, Beeston, and Hopkins 2002) are present within the Survey Area:

- East Kalgan 994: Low forest; jarrah & casuarina (probably *Allocasuarina fraseriana*), comprising 60.4 ha (21.8 %) of the Survey Area between SLK 46.3 to 50.5 within the Jarrah Forest IBRA region.
- Riche 980: Shrublands; jarrah mallee-heath, comprising 217.1 ha (78.2 %) of the Survey Area between SLK 50.5 to 65.7 within the Fitzgerald IBRA region.

3 Methods

3.1 Personnel

The *Phytophthora* dieback field survey was conducted by accredited interpreter Damien Rathbone (Southern Ecology) (PDI-032). Damien has over 14 years of experience within Western Australia. He has previously been employed as the South Coast Region Dieback Conservation Officer for the DBCA and has completed several regional flora surveys and scientific publications. Therefore, he is highly familiar with the flora and plant diseases of the region.

3.2 Desktop Assessment

Database searches and a review of available literature were conducted to determine the context of significant values and the potential extent of *Phytophthora* dieback (Table 2).

Three biological assessments previously conducted for MRWA within the Survey Area were available for review as part of the desktop assessment:

- South Coast Hwy Kojaneerup – Targeted Significant Flora Survey (Astron Environmental Services 2019)
- Biological Survey: Kojaneerup Project South Coast Highway, 46.4 to 65.7 SLK (Southern Ecology 2018)
- South Coast Highway – Kojaneerup Biological Survey (GHD 2016).

Table 2: Database searches undertaken.

Database	Date search results received	Search focus	Search area
<i>Dieback Information Delivery and Management Systems [DIDMS]</i> (Department of Biodiversity, Conservation, and Attractions 2018)	31/10/2018	Disease confidence mapping and Disease points public/private land.	15 km radius from the centre point of the Survey Area, defined by the coordinates: 34°43'50 S, 118°18'53 E

3.3 Field Survey

The field survey was conducted over 10 days. The survey dates were 22, 26, 27, 29 and 30 November 2018, 5 and 7 December 2018, 25 and 26 March and 1 April 2019. The timing of the field assessments is considered adequate for disease expression and pathogen recovery in the bioregion. The survey effort is presented in Figures B.1 to B.4 (Appendix B).

The survey was undertaken in accordance with the requirements outlined in the MRWA Biological Survey Consultant Brief, dated 2 July 2018.

3.3.1 Vegetation Condition Mapping

The vegetation condition categories were mapped according to Environmental Protection Authority (EPA) (2016) (Table 3) using a combination of previous vegetation condition mapping (GHD 2016), opportunistic observations and extrapolation of orthophotos in an ARCGIS environment.

Table 3: Vegetation condition rating scale (Environmental Protection Authority 2016).

Condition	Description
Pristine	Pristine or nearly so, no obvious signs of disturbance or damage caused by human activities since European settlement.
Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species. Damage to trees caused by fire, the presence of non-aggressive weeds and occasional vehicle tracks.
Very Good	Vegetation structure altered, obvious signs of disturbance. Disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing.
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it. Disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.
Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. Disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds at high density, partial clearing, dieback and grazing.
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 and shrubs.

3.3.2 *Phytophthora* Interpretation

Field interpretation was undertaken following the standard operating procedures for linear assessments as described in the "*Phytophthora Dieback Interpreters Manual for lands managed by the department*" (Department of Parks and Wildlife 2015). Most of the Survey Area was interpreted by traversing along tracks and fire breaks. Detailed examination was undertaken at sites where pathogen vectors were present, such as drains, dams, access points and disturbed areas.

The potential occurrence of *Phytophthora* species was determined through observation of the symptomatic evidence of disease and supported by sampling of soil and roots of recently dead susceptible host plants. Areas were allocated into six potential disease status categories relevant to *Phytophthora cinnamomi*:

- Infested - disease symptoms present
- Uninfested - disease symptoms absent
- Uninterpretable - undisturbed areas where susceptible host plants are absent, or sparse
- Temporarily Uninterpretable - indeterminate due to disturbance with anticipated short to medium term recovery, e.g. fire or rehabilitation
- Not Yet Resolved - indeterminate due to inconsistent or incomplete evidence in low interpretability climatic zones (400 to 600 mm rainfall range)

- Disease Risk Roads - potential incipient disease on road with apparent recent use under unknown hygiene conditions.

The protectability of Uninfested or Uninterpretable areas was also defined with consideration of the conservation values present and with reference to regulatory guidance (Department of Parks and Wildlife 2015). Protectable Areas are defined as areas that will not be invaded by *Phytophthora* via autonomous spread in the short term (10 to 20 years) and anthropogenic spread can be mitigated by soil hygiene management.

3.3.3 Soil and Root Sampling

Soil and root samples associated with dead or dying susceptible host plants were collected in accordance with guidelines (Department of Parks and Wildlife 2015) by an accredited interpreter to confirm the presence of *Phytophthora* species. Samples were taken at 13 locations of susceptible plant species from the Iridaceae, Xanthorrhoeaceae and Proteaceae families. Diagnostic baiting of the samples was conducted by the Vegetation Health Service (Kensington, Perth), which determined the potential presence and species identity of the *Phytophthora*.

3.3.4 Mapping

All Protectable Areas were demarcated with management stop/start points to guide construction activities and temporarily marked with 25 mm fluorescent pink tape at the road edge with the knot facing into the infested area. Buffers applied to Infested areas were located 15 m upslope or 25 m (or greater) downslope from the active disease edge. The management points, disease status boundaries (including buffers), soil and root samples and field observations were recorded with a non-differential, hand-held global positioning system (GPS) (Garmin Oregon 7000, ± 5 m accuracy) (MGA zone 50, GDA94).

3.3.5 Weather

Daily weather observations recorded from Albany weather station (Bureau of Meteorology station number 9500) were used to describe local rainfall and temperatures in the 12 months preceding the current survey (Figure 2). A total of 714.1 mm of rainfall was received in the 12 months prior to the last survey; 213 mm below the long term mean of 927.1 mm (1961 to 2019) (Bureau of Meteorology 2019). The season prior to the survey was characterised by slightly lower than average daily maxima and three above average rainfall events (July and August 2018 and March 2019). Remaining months exhibited lower than average rainfall.

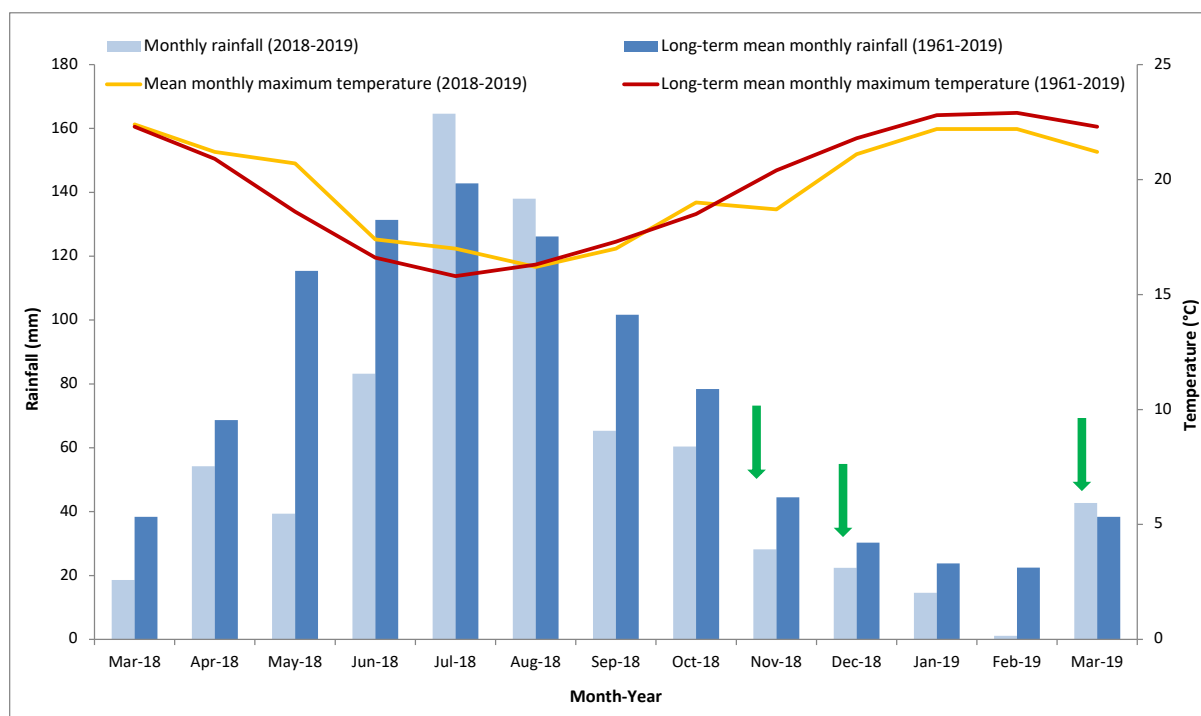


Figure 2: Long-term (1961 to 2018) mean monthly rainfall (mm) and maximum temperatures (°C) and total recorded monthly rainfall (mm) and monthly maximum temperatures (°C) (March 2018 to March 2019) at Albany weather station number 9500 (Bureau of Meteorology 2019). Green arrows indicate current survey timing.

3.4 Limitations

Following completion of the desktop assessment and field surveys, a review of any limitations that may have affected a complete assessment of the data collected was conducted. The limitations listed in Table 4 are based on those suggested as considerations the EPA's *Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment* (Environmental Protection Authority 2016). No avoidable limitations were identified that may have affected the reliability of the results of the field survey. Some small areas of the Survey Area were burnt during the course of the field assessment and therefore could not be surveyed and were mapped as Temporarily Excluded for dieback assessment purposes. The existing vegetation condition mapping (GHD 2016) was used and not re-assessed in this burnt area.

Table 4: Statement of limitations.

Potential for limitation	Assessment
Availability of contextual information	Existing biological survey reports and some limited desktop data was available to allow for an appropriate level of contextual information prior to the field survey.
Personnel experience	Damien Rathbone has an excess of 14 years' experience in the south coast region (Esperance Sandplains and Southern Jarrah Forest IBRA bioregions).
Extent of survey and site access	<p>The area of survey is large and very dense in places. Ten field days were undertaken to adequately cover the area.</p> <p>Thirteen soil and root sample were collected. This sampling regime was considered adequate due to the generally obvious disease expression and the capacity to extrapolate disease status mapping within catchments.</p>
Survey timing	The survey timing and season is considered appropriate for dieback assessments in this bioregion. The Survey Area occurs in a moderate rainfall zone; therefore, <i>Phytophthora</i> assessments can be undertaken at any time during the year.
Disturbances	<p>Two areas within the Survey Area were burnt during the course of the survey and were therefore not interpretable and were mapped as Temporarily Excluded for dieback assessment purposes.</p> <p>Potentially confounding influences on field interpretation of <i>Phytophthora</i> were drought, road side herbicide spraying, <i>Armillaria</i>, recent slashing and road works/offshoot drain maintenance. The experience of field personnel and empirical evidence from soil and root sampling was considered adequate to account for these disturbances.</p>
Validity of <i>Phytophthora</i> occurrence mapping.	Mapping of <i>Phytophthora</i> occurrence is considered accurate at the time of the report. However <i>Phytophthora</i> can spread autonomously or by animals, bushwalkers and unauthorised vehicles, therefore the mapped boundaries may change in the future.

4 Results and Discussion

4.1 Desktop Assessment

No previous comprehensive *Phytophthora* dieback mapping is known to have occurred within the Survey Area. Broad-scale (low confidence) interpretation indicates the Survey Area is infested (GAIA 2017). *Phytophthora cinnamomi* has not previously been recorded from soil and roots samples within the Survey Area, however, records occur within 10 to 15 km of the Survey Area on private property and nature reserves (GAIA 2017).

Biological assessments in the Survey Area determined that populations of 17 flora 'Priority' listed by DBCA are known to be present. Extensive sections of the Survey Area are known to be analogous with the "*Proteaceae Dominated Kwongan Shrublands of the southeast coastal floristic province of Western Australia threatened ecological community*" (Kwongan TEC), which is listed as Endangered under the EPBC Act and *Phytophthora* dieback is listed as one of its major threatening processes (Department of Environment 2014).

4.2 Vegetation Condition

The vegetation condition of the Survey Area was re-assessed and is presented in Figures C.1 to C.12 (Appendix C) and summarised in Table 5. The majority of the Survey Area was determined to be in Excellent condition. Several areas where gravel has previously been removed were classified as a lower condition category than previously mapped and several boundaries were adjusted.

Table 5: Extent of vegetation condition categories within the Survey Area.

Vegetation condition (EPA 2016)	Area (ha)
Excellent	180.9
Very Good to Excellent	13.9
Very Good	16.7
Good to Very Good	8.1
Good	3.6
Degraded to Good	0.3
Degraded	0.3
Completely Degraded	0.7
Cleared	53
Total:	277.5

4.3 *Phytophthora* Field Survey

4.3.1 Field Evidence

The majority of the Survey Area comprised vegetation in Excellent condition with a sufficient density of susceptible host plant species for confident field interpretation of *Phytophthora* occurrence. A list of susceptible host species that were relatively common across the Survey Area is provided in Table 6. The incidence and pattern of disease symptoms in these taxa was considered an indication of the potential presence of *P. cinnamomi*. The weather conditions preceding the survey were considered adequate for interpretation of disease and recovery of *Phytophthora* species from soil and root sampling.

Table 6: Susceptible species from the Survey Area considered to be useful indicators (likely to show disease symptoms) for the presence of *Phytophthora cinnamomi*.

Family	Taxon
Ericaceae	<i>Andersonia caerulea</i>
	<i>Andersonia simplex</i>
	<i>Leucopogon obovatus</i>
	<i>Leucopogon rubricaulis</i>
	<i>Sphenotoma capitata</i>
Fabaceae	<i>Daviesia flexuosa</i>
	<i>Daviesia incrassata</i>
	<i>Gompholobium scabrum</i>
	<i>Jacksonia spinosa</i>
	<i>Latrobea recurva</i>
	<i>Pultenaea verruculosa</i>
	<i>Sphaerolobium grandiflorum</i>
Iridaceae	<i>Patersonia lanata</i>
	<i>Patersonia limbata</i>
	<i>Patersonia occidentalis</i>
	<i>Patersonia umbrosa</i>
Myrtaceae	<i>Melaleuca thymoides</i>
Proteaceae	<i>Banksia arctotidis</i>
	<i>Banksia armata</i>
	<i>Banksia attenuata</i>
	<i>Banksia baxteri</i>
	<i>Banksia biterax</i>
	<i>Banksia coccinea</i>
	<i>Banksia dryandroides</i>
	<i>Banksia grandis</i>
	<i>Banksia mucronulata</i>
	<i>Banksia nutans</i>
	<i>Banksia obovata</i>
	<i>Banksia sphaerocarpa</i>
	<i>Isopogon cuneatus</i>
	<i>Isopogon longifolius</i>
	<i>Lambertia inermis</i>
	<i>Lambertia uniflora</i>
	<i>Petrophile divaricata</i>
	<i>Petrophile diversifolia</i>
	<i>Petrophile rigida</i>
	<i>Petrophile squamata</i>
	<i>Synaphea polymorpha</i>
Xanthorrhoeaceae	<i>Xanthorrhoea platyphylla</i>

Disease symptoms (indicator species deaths) in the Survey Area were mainly less than six months old and may have largely occurred after a significant rainfall event in February 2017, which would have been conducive for pathogen spread and establishment. Plant deaths associated with water logging may have partially confounded disease interpretation in low lying areas and some roadside drains.

However, most low-lying areas were likely to be Infested or Unprotectable due to obvious upslope infestations.

Overall expression was generally obvious in large infestations and on sandy substrates, where impacts to multiple species in several vegetation layers were evident. Several isolated “spot” infestations were subtle and difficult to detect, indicated only by isolated or small patch deaths of *Xanthorrhoea platyphylla*. A large portion of the Survey Area was composed of a dense shrubland dominated by *Hakea* species, from the Proteaceae family. Species from this family are typically susceptible to *Phytophthora* (e.g. *Banksia*, *Grevillea* and *Isopogon*). The dominant *Hakea* species within the Survey Area were *H. cucullata*, *H. trifurcata*, *H. lasiantha* and *H. ferruginea* which generally displayed low susceptibility.

Most infestations were associated with low lying areas and road drains; less often they occurred on access tracks and kangaroo trails. Several old gravel quarries showed very old symptoms of prolonged disease impacts in the surrounding vegetation. The eastern road verge was generally more thoroughly infested due to the natural watershed (which facilitates pathogen spread) towards the coast. Potentially confounding influences on field interpretation were drought, road side herbicide spraying, *Armillaria*, recent slashing and road works/offshoot drain maintenance.

Soil and root samples were collected to provide empirical evidence to support the disease interpretation of the Survey Area; the locations are presented in Table 7 and mapped in Figures B.1 to B.7, Appendix B. Analysis by the Vegetation Health Service determined nine samples were positive for *P. cinnamomi*. No other *Phytophthora* species were recovered. The results from three samples (DAR134, 138 and 141) where strong symptomatic evidence was present are considered likely to be ‘false negatives’, resulting from a failure to recover soil pathogens during the sampling or laboratory process. One sample returned negative (DAR145), indicating pathogens other than a *Phytophthora* may have been responsible for the host death.

Table 7: Soil and root samples locations and results of analysis by Vegetation Heath Service, Department of Biodiversity, Conservation and Attractions. Coordinates are in GDA 94 MGA Zone 50.

Accession No.	Easting	Northing	Sample No.	Date	Result
38886	615874	6148552	DAR134	5/12/2018	Negative
38887	616872	6149770	DAR135	5/12/2018	Positive <i>P. cinnamomi</i>
38888	617042	6150163	DAR136	5/12/2018	Positive <i>P. cinnamomi</i>
38889	617432	6150660	DAR137	5/12/2018	Positive <i>P. cinnamomi</i>
38890	617631	6150881	DAR138	5/12/2018	Negative
38891	619419	6153498	DAR139	5/12/2018	Positive <i>P. cinnamomi</i>
38892	619676	6153882	DAR140	5/12/2018	Positive <i>P. cinnamomi</i>
38893	620163	6155419	DAR141	5/12/2018	Negative
38894	620681	6156928	DAR142	5/12/2018	Positive <i>P. cinnamomi</i>
38895	621707	6162558	DAR143	5/12/2018	Positive <i>P. cinnamomi</i>
38896	622018	6162961	DAR144	5/12/2018	Positive <i>P. cinnamomi</i>
38897	622059	6163247	DAR145	5/12/2018	Negative
38898	622950	6164965	DAR146	5/12/2018	Positive <i>P. cinnamomi</i>

4.3.2 Disease Status and Protectability

A total of 227.5 ha of the Survey Area is considered remnant vegetation and was mapped into four disease status categories (Table 8 and Figure D.1 to D.12, Appendix D). The narrow, linear shape of Hassel National Park intersected by South Coast Highway has facilitated the widespread dispersal of soil pathogens, and subsequently the majority of the Survey Area is currently Infested (167.0 ha, 60%) or Unprotectable (74.6 ha, 27%) from *P. cinnamomi*. Ten 'Preliminary Protectable Areas', comprising a total of 35.8 ha (13% of the Survey Area) have been delineated (Figures D.1 to D.12, Appendix D) that may require hygiene management controls if road construction or maintenance occur within their vicinity. A minority of the Survey Area was determined to be Uninterpretable (10.9 ha, 4%) or was Temporarily Excluded (10 ha, 4%) due to the impact of recent fire. Due to the highly transmissible nature of the *Phytophthora* pathogen, particularly within the sandy and gravelly soils of the Survey Area, this assessment is considered accurate at the time of the survey, but is dynamic and likely to change in the future, with the most likely response being an increase in Infested areas. Re-sampling may be required after one year to assess any further spread of *P. cinnamomi*.

Table 8: Extent of disease status categories and protectability of the remnant vegetation within the Survey Area.

Disease Status	Unprotectable (ha)	*Protectable (ha)	Total (ha)
Uninfested	3.8	36.2	40.0
Infested	163.6	0	163.6
Uninterpretable	10.9	0	10.9
Temporarily Excluded (Burnt)	10.0	0	10.0
Cleared	53.0	0	53.0
Total	241.3	36.2	277.5

*Protectable status is preliminary only, may vary depending on the extent and type of disturbance proposed.

4.3.2.1 Uninfested Areas

A total of 39.8 ha of the Survey Area were mapped as Uninfested. These are moderate to large areas that are either free of *P. cinnamomi* or have a very low incidence of detectable disease. Other less virulent species of *Phytophthora* may exist in these areas undetected if symptoms are incipient. Small areas of Uninfested vegetation occur sporadically throughout the area mapped as Infested, which have been rationalised as Infested due to their small size (usually <1 ha) and absence of protectable values.

The majority of the Uninfested areas mapped in the Survey Area occur in natural, hydrologically isolated uplands. They are typically upslope of the road formation and offshoot drains are absent. The vegetation is typically a shrubland (1 to 3 m, 30% to 70% foliage cover) of *Banksia mucronulata*, *Banksia baxteri*, *Banksia biterax*, *Hakea cucullata*, *Hakea ferruginea* and *Hakea lasiantha* over low Shrubland (0.5 to 1 m, 10% to 30%) of *Petrophile squamata*, *Taxandria spathulata* and *Melaleuca striata* over a ground cover (0.5 m, 10% to 30%) of *Lepidosperma drummondii*, *Patersonia lanata*, *Patersonia limbata* and *Anarthria prolifera* (Plate 1 and Plate 2). Susceptible indicators are generally present in all vegetation layers.



Plate 1: Uninfested vegetation dominated by Proteaceous species.



Plate 2: Uninfested vegetation dominated by Proteaceous species.

4.3.2.2 Protectable Areas

Ten 'Preliminary Protectable Areas', comprising a total of 35.8 ha were mapped in the Survey Area (Table 8 and Figures D.1 to D.12, Appendix D). These areas are currently Uninfested and are unlikely to be invaded by *Phytophthora* via autonomous spread in the short term (10 to 20 years) and anthropogenic spread can be mitigated by soil hygiene management. Size thresholds for Protectable Areas can be varied depending on the application (Department of Parks and Wildlife 2015). Given the presence of significant values that are susceptible to *Phytophthora*, the minimum size threshold used in this assessment was 1 ha. Congregations of multiple Uninfested areas (< 500 m apart) were treated as one management zone and subsequently were mapped and numbered as one Protectable Area. The Protectable Areas defined here are 'Preliminary' as their protectability and area of extent following the proposed disturbance may fall below the threshold.

Significant values that are susceptible to *Phytophthora* occur in the majority of the Preliminary Protectable Areas (Table 9). Kwongkan TEC occurs in nine of the Preliminary Protectable Areas mapped within the Survey Area. The Kwongkan TEC is composed of several highly susceptible species; therefore, the invasion of *Phytophthora* can significantly alter the floristics and structure of this community. Flora that is listed as DBCA 'Priority' (P) occurs in five of the Preliminary Protectable Areas mapped in the Survey Area. Based on field observations and the generic level of susceptibility, *Leucopogon* sp. Manypeaks (A.S. George 6488) (P1) and *Petrophile carduacea* (P2) are considered moderately to highly susceptibility (likely to be eliminated from infested areas over a few generations), and *Synaphea incurva* (P3) and *Synaphea preissii* (P3) are low to moderately susceptible (likely to persist at reduced population density in infested areas).

Table 9: Extent and significant values of the Preliminary Protectable Areas mapped in the Survey Area.

Protectable Area no.	SLK location	Kwongkan TEC present	Susceptible Priority (P) flora species present	Area (ha)
1	48.5 - 48.6	No	No	1.3
2	49.2 - 49.5	Yes	<i>Synaphea incurva</i> (P3)	1.4
3	50.3 - 51.2	Yes	No	5.2
4	52.0 - 52.5	Yes	No	2.3
5	53.6 – 54.1	Yes	<i>Petrophile carduacea</i> (P2)	5.2
6	55.0 – 56.5	Yes	No	2.8
7	57.3 – 57.4	Yes	No	0.4*
8	60.6 – 61.5	Yes	<i>Synaphea preissii</i> (P3)	2.2
9	62.0 – 63.9	Yes	<i>Leucopogon</i> sp. Manypeaks (A.S. George 6488) (P1)	7.8
10	64.8 – 66.0	Yes	<i>Synaphea preissii</i> (P3)	7.3

Kwongkan TEC refers to “*Proteaceae Dominated Kwongkan Shrublands of the southeast coastal floristic province of Western Australia ecological community*” (Endangered under the EPBC Act).

*Protectable Area 7 extends upslope of the Survey Area, therefore meets the 1 ha threshold in its entirety.

4.3.2.3 Other Disease Status Categories

The majority of the Survey Area (167 ha, 60%) was mapped as Infested, as *P. cinnamomi* is currently present (Plate 3 and Plate 4) or its autonomous invasion is likely in the short term. Many areas mapped as Infested continue to support significant vegetation, flora and fauna. However, in the context of soil hygiene management the primary objective is to prevent infested soil establishing the pathogen in Uninfested areas.



Plate 3: Symptomatic evidence of *Phytophthora cinnamomi* in the Survey Area.



Plate 4: Symptomatic evidence of *Phytophthora cinnamomi* in the Survey Area.

A minority of the Survey Area was determined to be Uninterpretable (10.9 ha, 4%) or was Temporarily Excluded (10 ha, 4%) due to the impact of recent fire. Uninterpretable areas consisted of vegetation with a naturally low density of flora susceptible to *Phytophthora*. These areas were dominated by either *Melaleuca preissii*, *Eucalyptus* species or were very long unburnt *Hakea cucullata* shrublands (Plate 5), where susceptible species may have naturally senesced. Some old gravel pits (Plate 6) with a sparse regeneration of native flora were also deemed Uninterpretable as

the presence of *Phytophthora* was difficult to determine. The Uninterpretable areas were generally not considered to contain protectable values and had a high likelihood of incipient disease.



Plate 5: Uninterpretable long unburnt *Hakea cucullata* shrubland.



Plate 6: Old gravel extraction area.

5 Conclusion

The majority of Survey Area is currently Infested (60%) or unprotectable from *P. cinnamomi*. Many areas mapped as 'Infested' continue to support significant vegetation, flora and fauna. However, in the context of soil hygiene management the primary objective is to prevent infested soil establishing the pathogen in 'Uninfested' areas.

Ten 'Preliminary Protectable Areas' comprising a total of 36 hectares may require hygiene management controls if road construction or maintenance occurs within their vicinity. Significant values that are susceptible to *Phytophthora* occur in the majority of these areas, including a Commonwealth listed TEC and four DBCA-listed Priority flora species.

6 References

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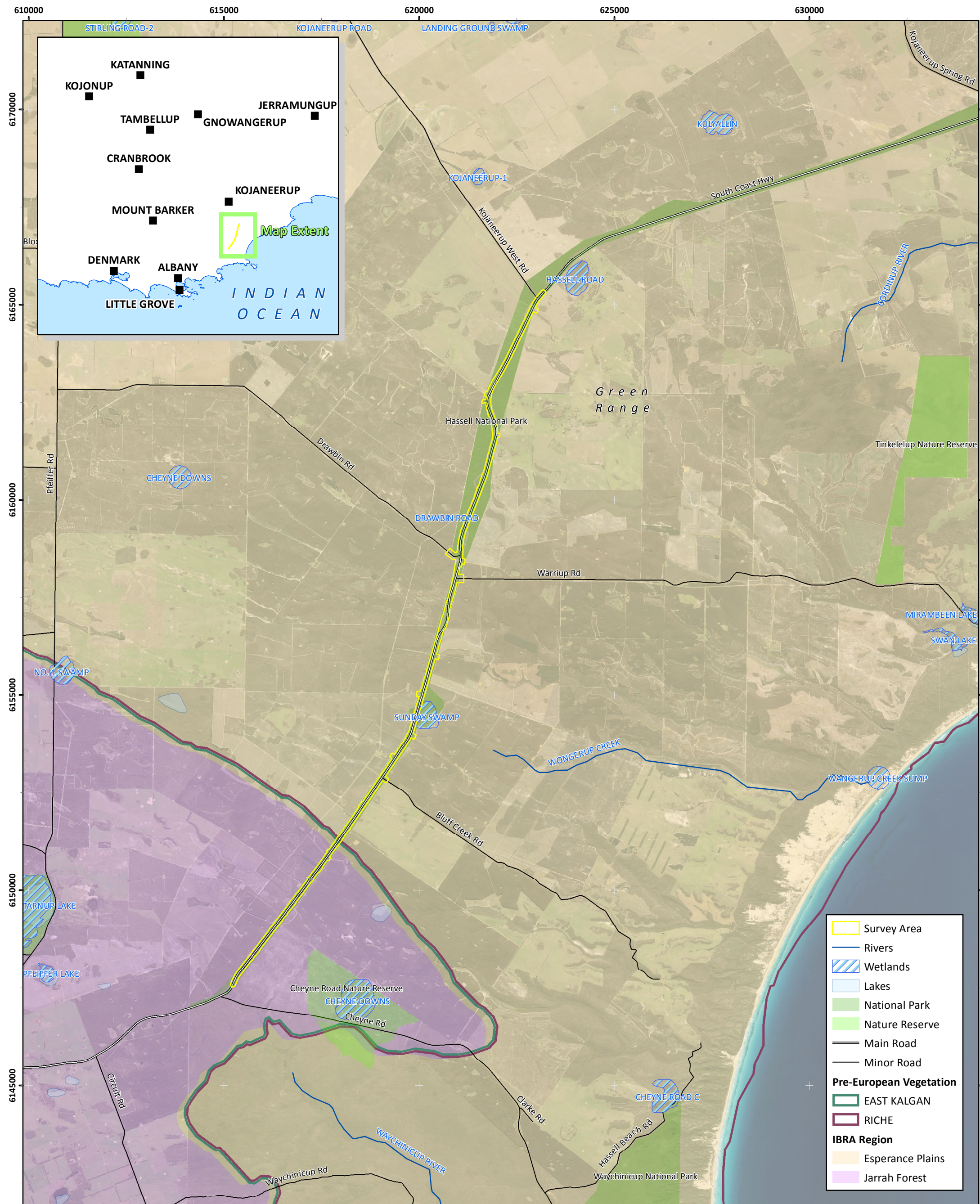
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Appendix A: Environmental Context Map

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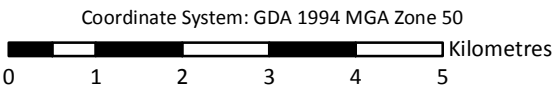


Main Roads Western Australia
H008 - South Coast Highway Kojaneerup Section SLK 46-66 *Phytophthora* Dieback Assessment

Figure A: Environmental Context Map



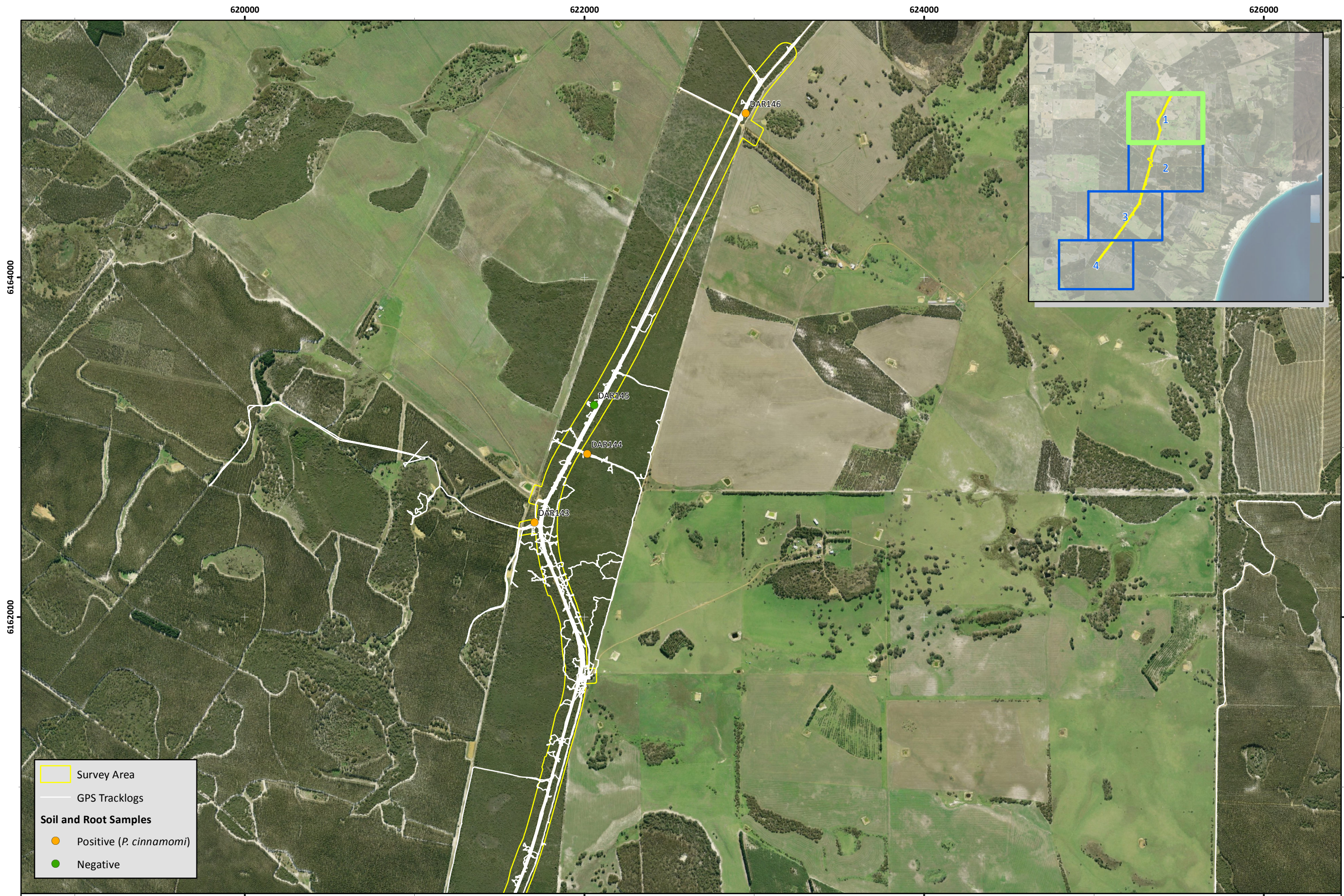
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Drawn: L. Robinson	Figure Ref: 8602-18-BISR-2Rev0_190701_FigA_EnvCons



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Appendix B: Survey Effort

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Main Roads Western Australia
H008 - South Coast Highway Kojaneerup Section SLK 46-66 *Phytophthora* Dieback Assessment

Figure A.1: Survey Effort

Author: J. Johnston

Drawn: L. Robinson

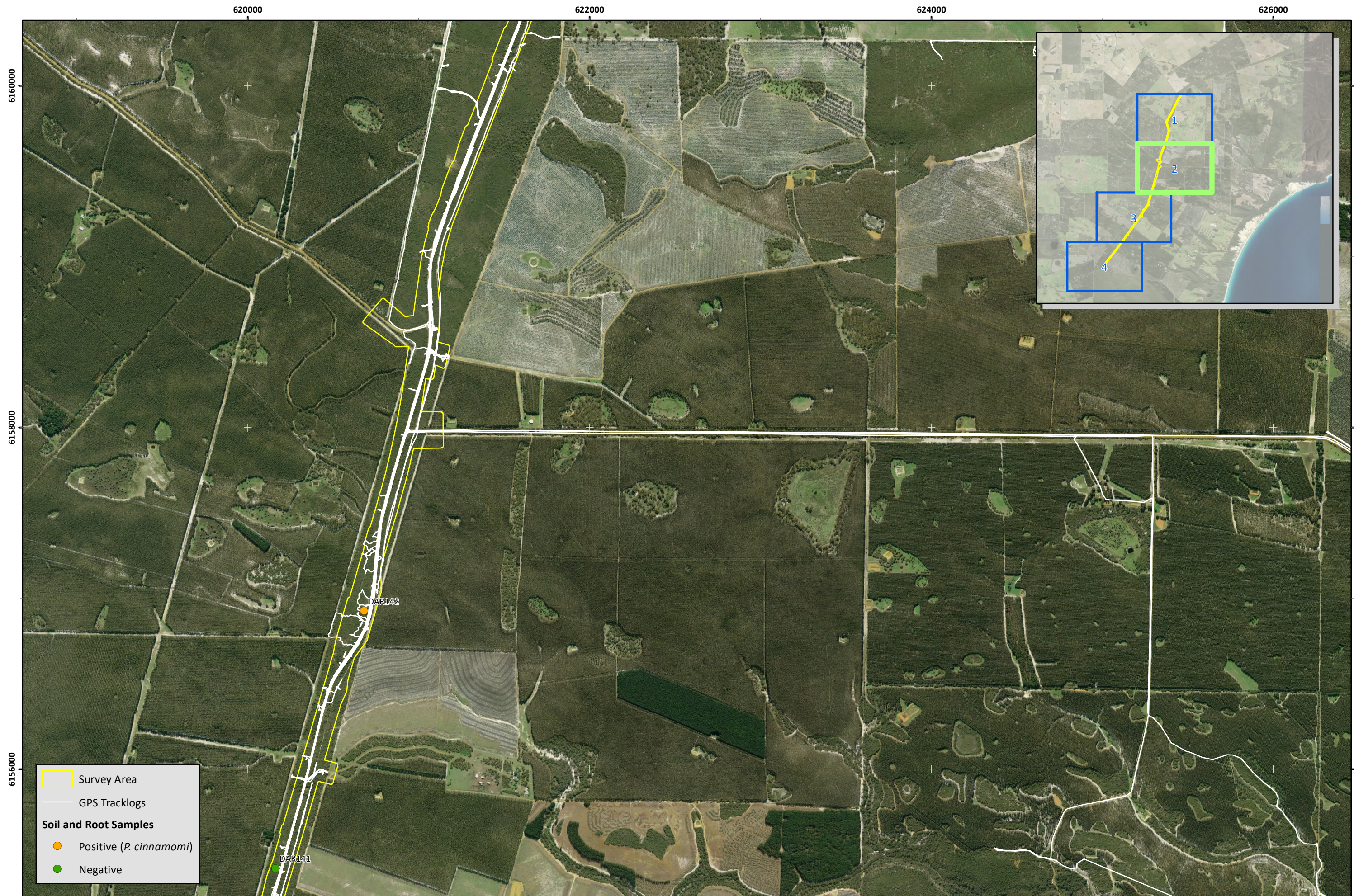
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Scale: 1:20000 at A3

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Figure Ref: 8602-18-BISR-2Rev0_190701_FigB_SurveyEffort



Survey Area

GPS Tracklogs

Soil and Root Samples

Positive (*P. cinnamomi*)

Negative

Main Roads Western Australia
H008 - South Coast Highway Kojaneerup Section SLK 46-66 *Phytophthora* Dieback Assessment

Figure A.2: Survey Effort

Author: J. Johnston

Drawn: L. Robinson

Date: 01-07-2019

Coordinate System: GDA 1994 MGA Zone 50

Scale: 1:20000 at A3

0

200

400

600

800

1,000

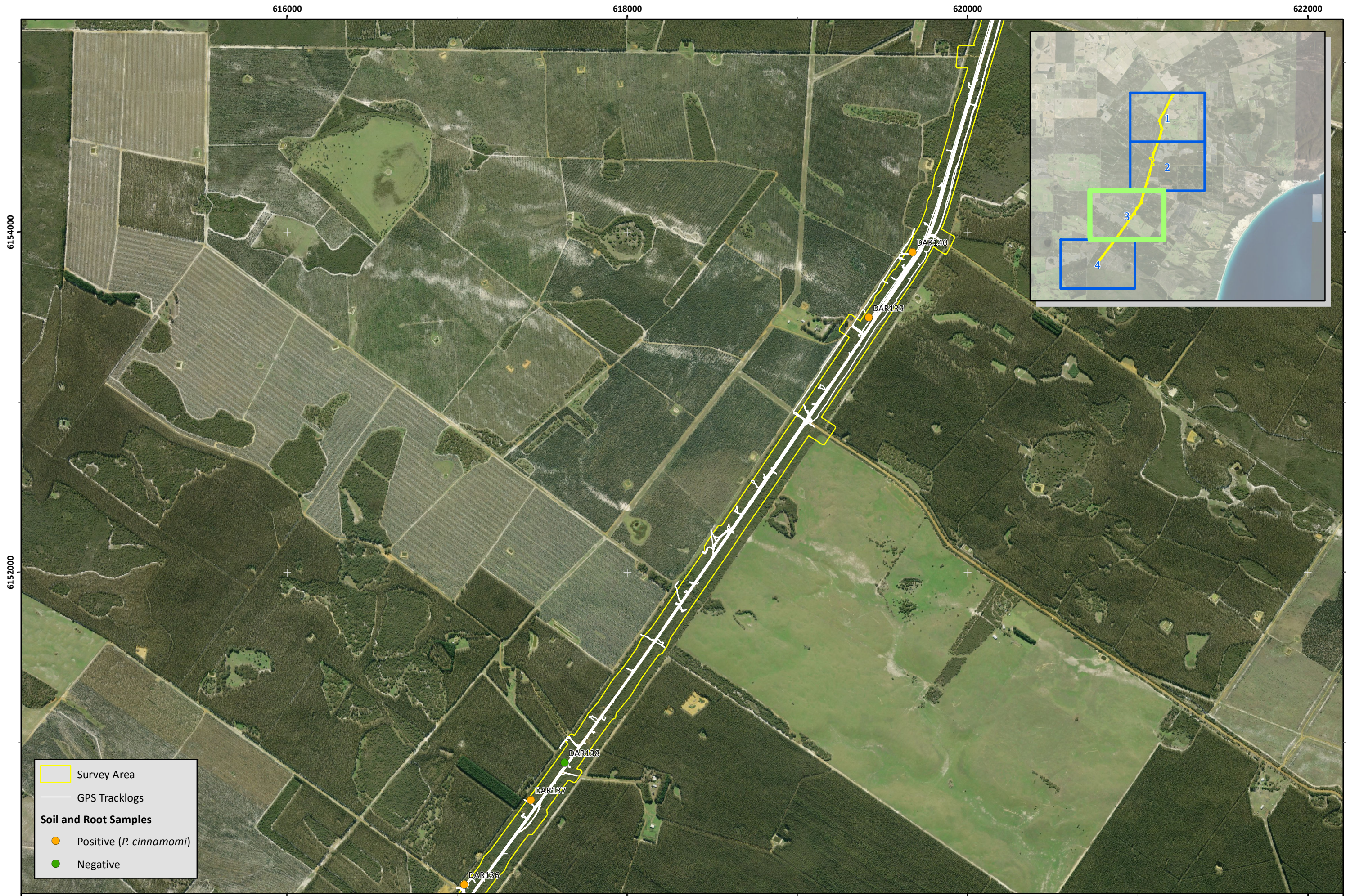
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delivering environmental intelligence™

Figure Ref: 8602-18-BISR-2Rev0_190701_FigB_SurveyEffort



Main Roads Western Australia
H008 - South Coast Highway Kojaneerup Section SLK 46-66 *Phytophthora* Dieback Assessment

Figure A.3: Survey Effort

Author: J. Johnston

Drawn: L. Robinson

Date: 01-07-2019

Coordinate System: GDA 1994 MGA Zone 50
Scale: 1:20000 at A3

0 200 400 600 800 1,000 Metres



Figure Ref: 8602-18-BISR-2Rev0_190701_FigB_SurveyEffort



Main Roads Western Australia
H008 - South Coast Highway Kojaneerup Section SLK 46-66 *Phytophthora* Dieback Assessment

Figure A.4: Survey Effort

Author: J. Johnston

Drawn: L. Robinson

Date: 01-07-2019

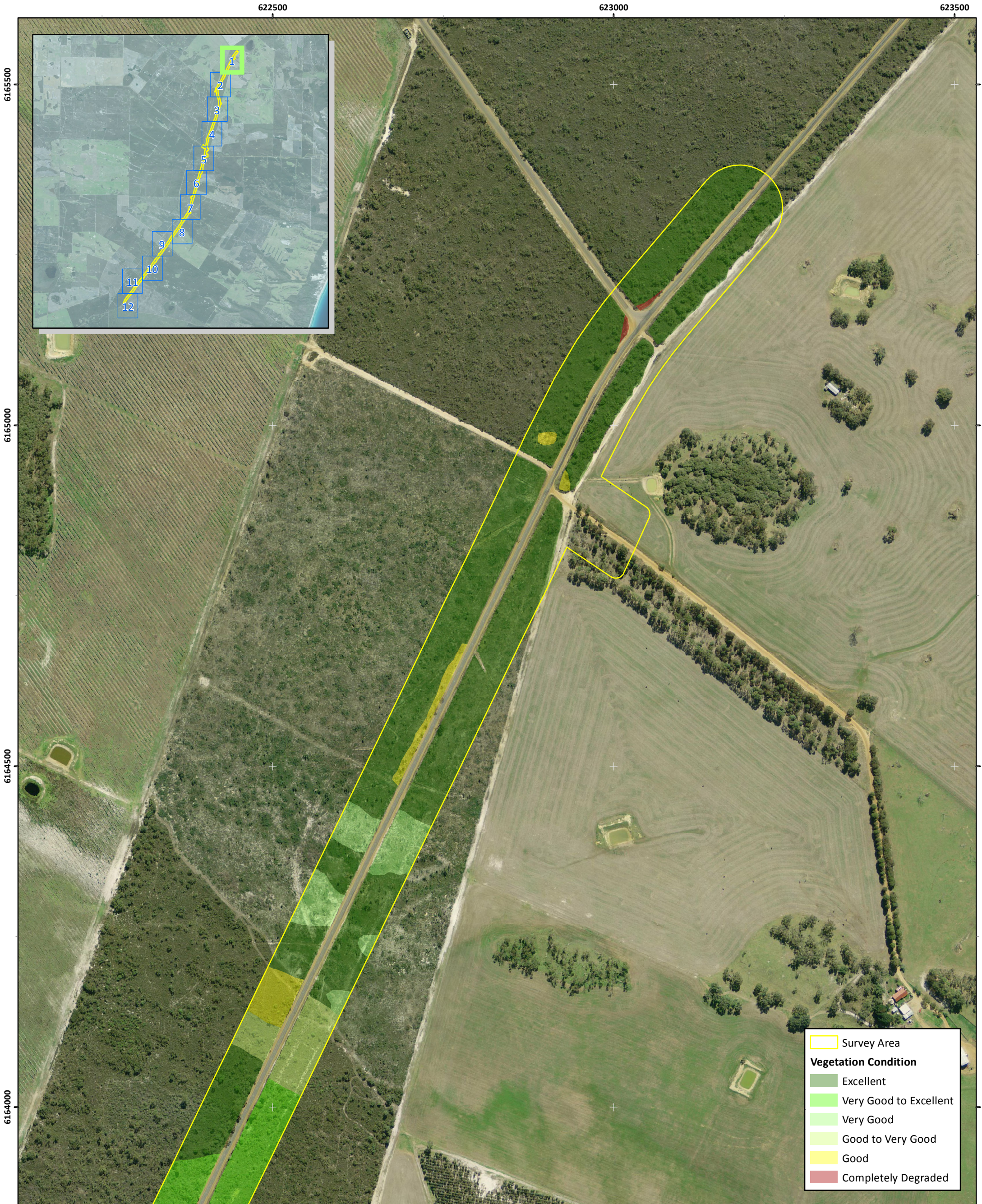
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Figure Ref: 8602-18-BISR-2Rev0_190701_FigB_SurveyEffort

Appendix C: Vegetation Condition Mapping

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Main Roads Western Australia
H008 - South Coast Highway Kojaneerup Section SLK 46-66 *Phytophthora* Dieback Assessment

Figure C.1: Vegetation Condition Mapping



Author: J. Johnston	Date: 01-07-2019
Drawn: L. Robinson	Figure Ref: 8602-18-BISR-2Rev0_190701_FigC_VegCond

Coordinate System: GDA 1994 MGA Zone 50
Scale: 1:5000 at A3

0100200300

Metres

N



Main Roads Western Australia
H008 - South Coast Highway Kojaneerup Section SLK 46-66 *Phytophthora* Dieback Assessment

Figure C.10: Vegetation Condition Mapping



Author: J. Johnston

Date: 01-07-2019

Drawn: L. Robinson

Figure Ref: 8602-18-BISR-2Rev0_190701_FigC_VegCond

Coordinate System: GDA 1994 MGA Zone 50
Scale: 1:5000 at A3
0 100 200 300 Metres





Main Roads Western Australia
H008 - South Coast Highway Kojaneerup Section SLK 46-66 *Phytrophthora* Dieback Assessment

Figure C.11: Vegetation Condition Mapping



Author: J. Johnston

Date: 01-07-2019

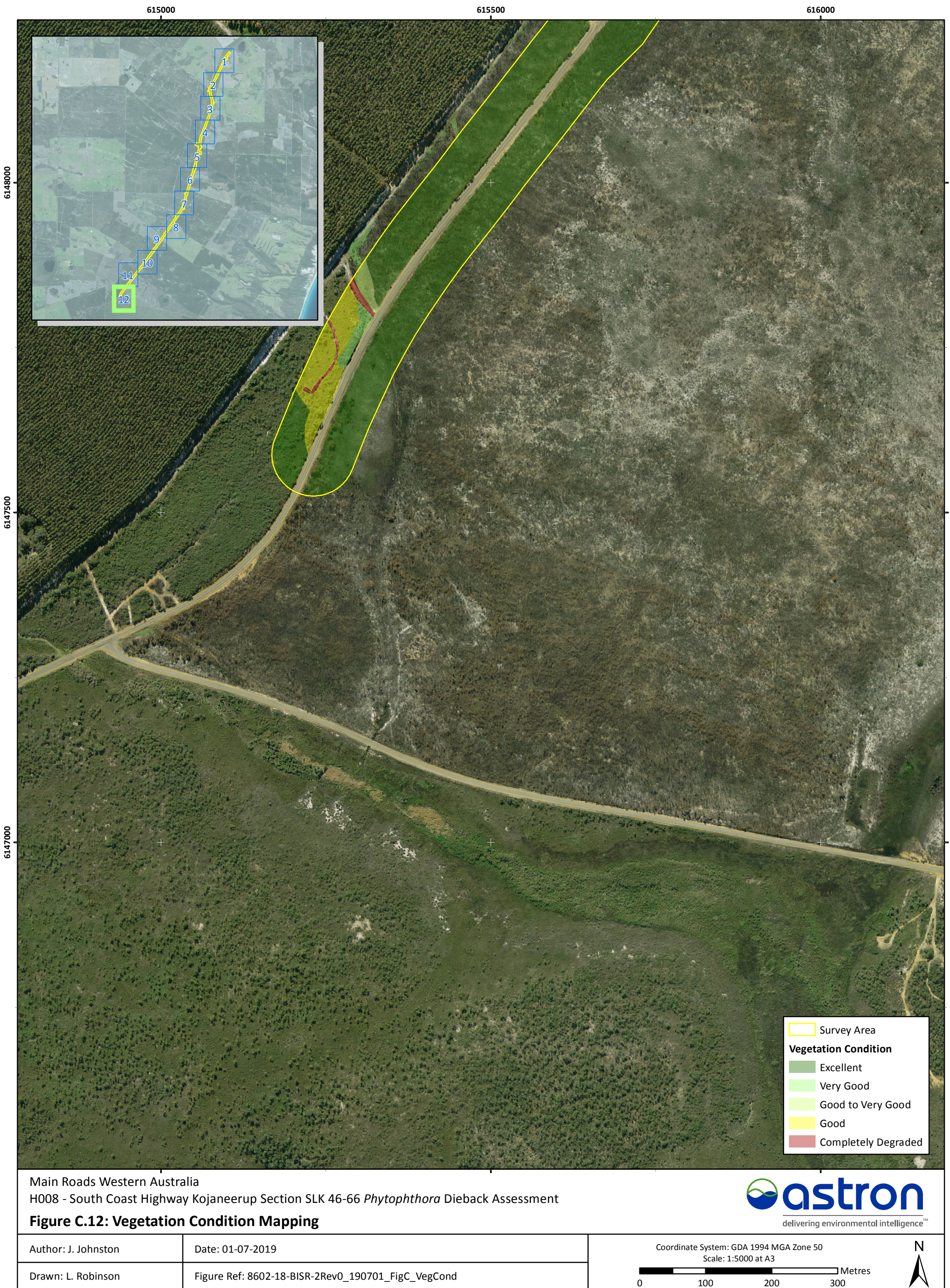
Drawn: L. Robinson

Figure Ref: 8602-18-BISR-2Rev0_190701_FigC_VegCond

Coordinate System: GDA 1994 MGA Zone 50
Scale: 1:5000 at A3

0 100 200 300 Metres







Main Roads Western Australia
H008 - South Coast Highway Kojaneerup Section SLK 46-66 *Phytophthora* Dieback Assessment

Figure C.2: Vegetation Condition Mapping



Author: J. Johnston	Date: 01-07-2019
Drawn: L. Robinson	Figure Ref: 8602-18-BISR-2Rev0_190701_FigC_VegCond

Coordinate System: GDA 1994 MGA Zone 50
Scale: 1:5000 at A3

0100200300

Metres

N



Main Roads Western Australia
H008 - South Coast Highway Kojaneerup Section SLK 46-66 *Phytophthora* Dieback Assessment

Figure C.3: Vegetation Condition Mapping



Author: J. Johnston

Date: 01-07-2019

Drawn: L. Robinson

Figure Ref: 8602-18-BISR-2Rev0_190701_FigC_VegCond

Coordinate System: GDA 1994 MGA Zone 50
Scale: 1:5000 at A3

0 100 200 300 Metres





Main Roads Western Australia
H008 - South Coast Highway Kojaneerup Section SLK 46-66 *Phytophthora* Dieback Assessment

Figure C.4: Vegetation Condition Mapping



Author: J. Johnston	Date: 01-07-2019
Drawn: L. Robinson	Figure Ref: 8602-18-BISR-2Rev0_190701_FigC_VegCond

Coordinate System: GDA 1994 MGA Zone 50
Scale: 1:5000 at A3

0100200300

Metres

N



Main Roads Western Australia
H008 - South Coast Highway Kojaneerup Section SLK 46-66 *Phytophthora* Dieback Assessment

Figure C.5: Vegetation Condition Mapping



Author: J. Johnston

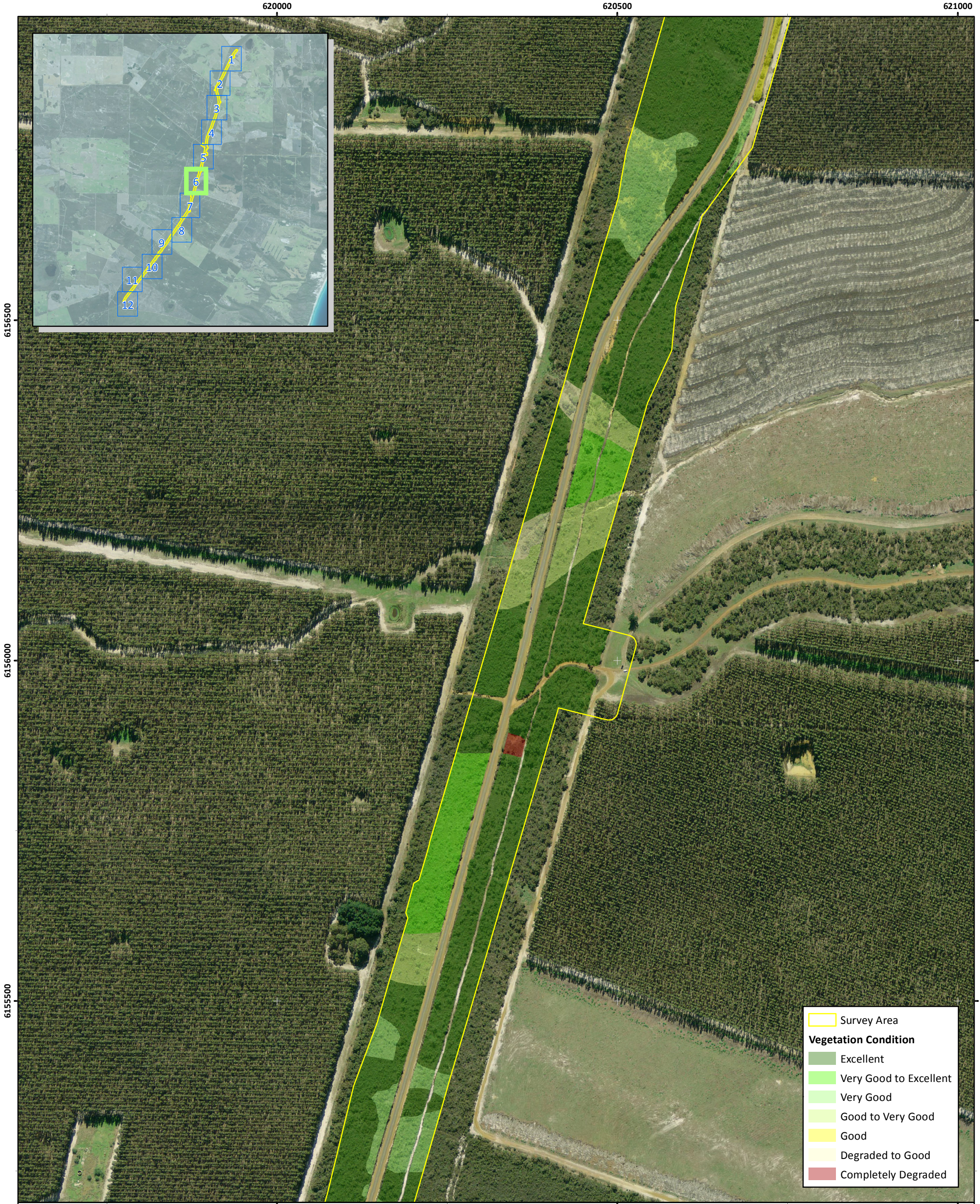
Date: 01-07-2019

Drawn: L. Robinson

Figure Ref: 8602-18-BISR-2Rev0_190701_FigC_VegCond

Coordinate System: GDA 1994 MGA Zone 50
Scale: 1:5000 at A3





Main Roads Western Australia
H008 - South Coast Highway Kojaneerup Section SLK 46-66 *Phytophthora* Dieback Assessment

Figure C.6: Vegetation Condition Mapping



Author: J. Johnston

Date: 01-07-2019

Drawn: L. Robinson

Figure Ref: 8602-18-BISR-2Rev0_190701_FigC_VegCond

Coordinate System: GDA 1994 MGA Zone 50
Scale: 1:5000 at A3



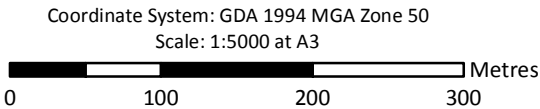


Main Roads Western Australia
H008 - South Coast Highway Kojaneerup Section SLK 46-66 *Phytophthora* Dieback Assessment

Figure C.7: Vegetation Condition Mapping



Author: J. Johnston	Date: 01-07-2019
Drawn: L. Robinson	Figure Ref: 8602-18-BISR-2Rev0_190701_FigC_VegCond





Main Roads Western Australia
H008 - South Coast Highway Kojaneerup Section SLK 46-66 *Phytophthora* Dieback Assessment

Figure C.8: Vegetation Condition Mapping



Author: J. Johnston

Date: 01-07-2019

Drawn: L. Robinson

Figure Ref: 8602-18-BISR-2Rev0_190701_FigC_VegCond

Coordinate System: GDA 1994 MGA Zone 50
Scale: 1:5000 at A3
0 100 200 300 Metres





Main Roads Western Australia
H008 - South Coast Highway Kojaneerup Section SLK 46-66 *Phytophthora* Dieback Assessment

Figure C.9: Vegetation Condition Mapping



Author: J. Johnston

Date: 01-07-2019

Drawn: L. Robinson

Figure Ref: 8602-18-BISR-2Rev0_190701_FigC_VegCond

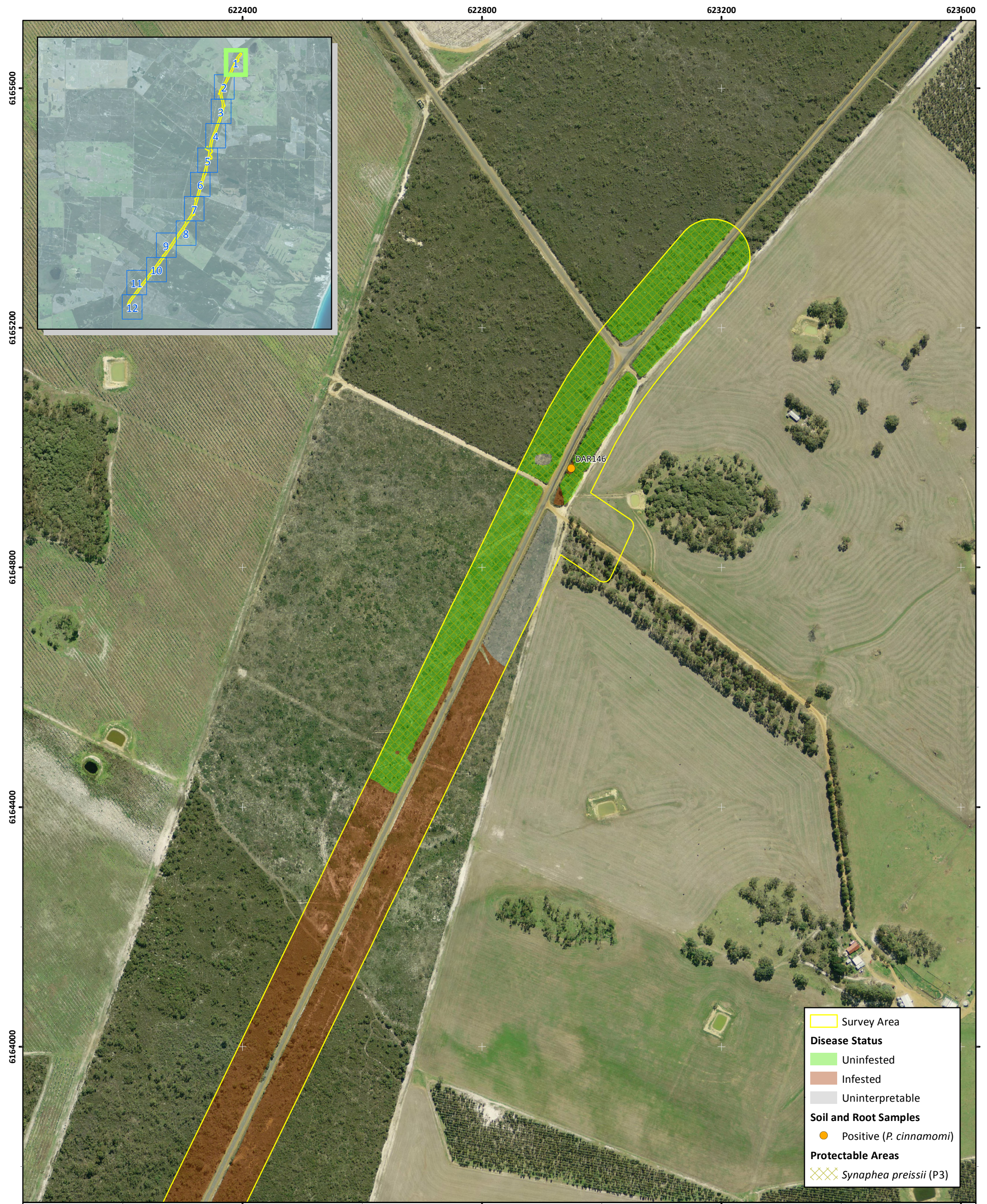
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Appendix D: Dieback Status and Protectable Areas Mapping

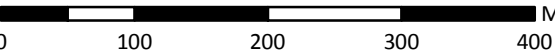

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Main Roads Western Australia
H008 - South Coast Highway Kojaneerup Section SLK 46-66 *Phytophthora* Dieback Assessment

Figure D.1: Dieback Disease Status and Protectability Mapping



Author: J. Johnston	Date: 01-07-2019	Coordinate System: GDA 1994 MGA Zone 50 Scale: 1:5000 at A3  
Drawn: L. Robinson	Figure Ref: 8602-18-BISR-2Rev0_190701_FigD_Dieback	



Main Roads Western Australia
H008 - South Coast Highway Kojaneerup Section SLK 46-66 *Phytophthora* Dieback Assessment

Figure D.10: Dieback Disease Status and Protectability Mapping



Author: J. Johnston	Date: 01-07-2019
Drawn: L. Robinson	Figure Ref: 8602-18-BISR-2Rev0_190701_FigD_Dieback

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Scale: 1:5000 at A3

0100200300400

Metres

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Main Roads Western Australia
H008 - South Coast Highway Kojaneerup Section SLK 46-66 *Phytophthora* Dieback Assessment

Figure D.11: Dieback Disease Status and Protectability Mapping



Author: J. Johnston

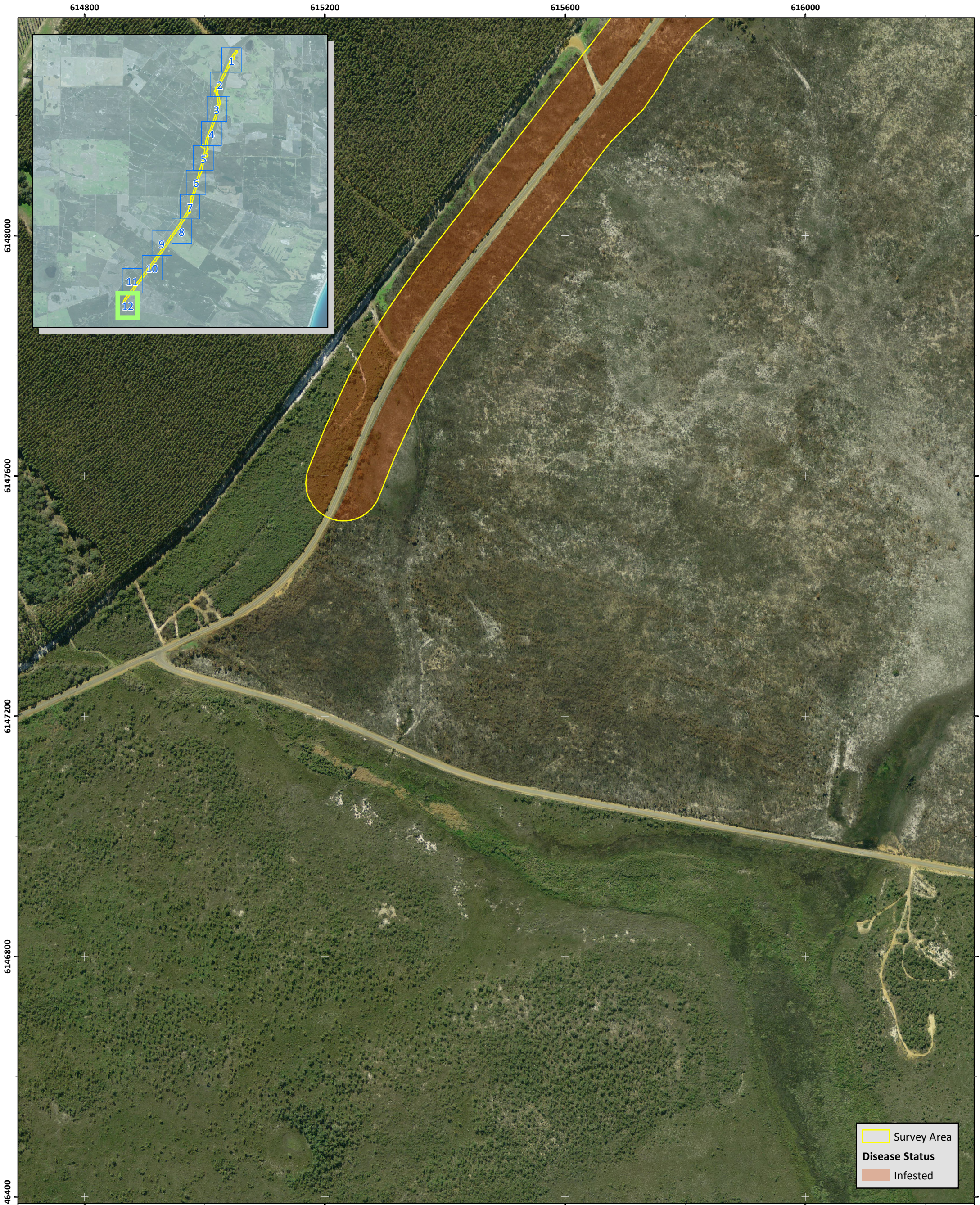
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Figure Ref: 8602-18-BISR-2Rev0_190701_FigD_Dieback

Coordinate System: GDA 1994 MGA Zone 50
Scale: 1:5000 at A3

0 100 200 300 400 Metres



Main Roads Western Australia
H008 - South Coast Highway Kojaneerup Section SLK 46-66 *Phytophthora* Dieback Assessment

Figure D.12: Dieback Disease Status and Protectability Mapping



Author: J. Johnston

Date: 01-07-2019

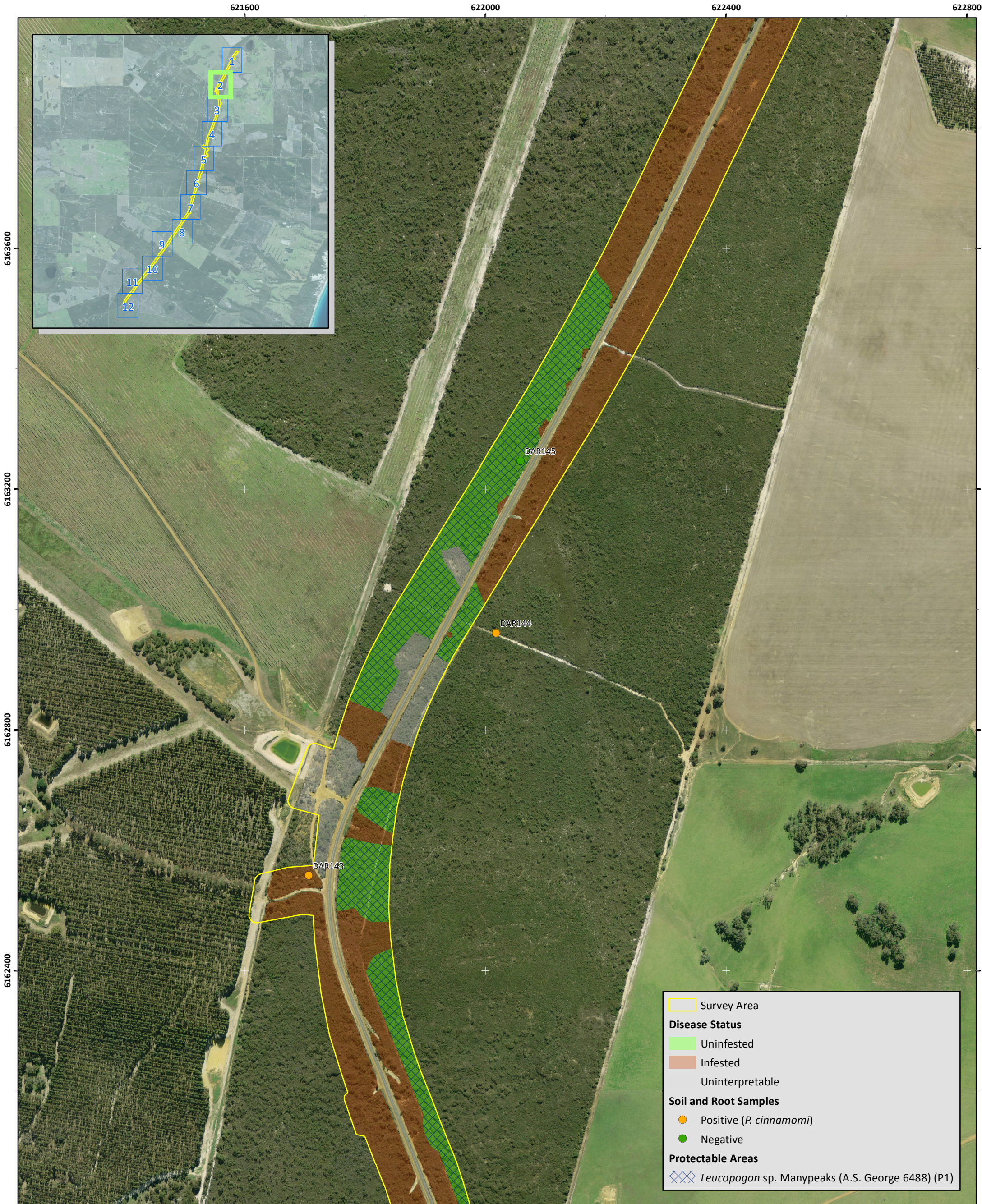
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Figure Ref: 8602-18-BISR-2Rev0_190701_FigD_Dieback

Coordinate System: GDA 1994 MGA Zone 50
Scale: 1:5000 at A3

0 100 200 300 400 Metres

N



Main Roads Western Australia
H008 - South Coast Highway Kojaneerup Section SLK 46-66 *Phytophthora* Dieback Assessment

Figure D.2: Dieback Disease Status and Protectability Mapping

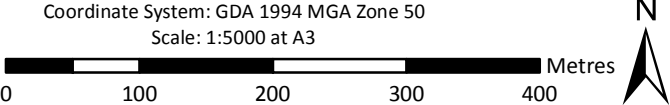


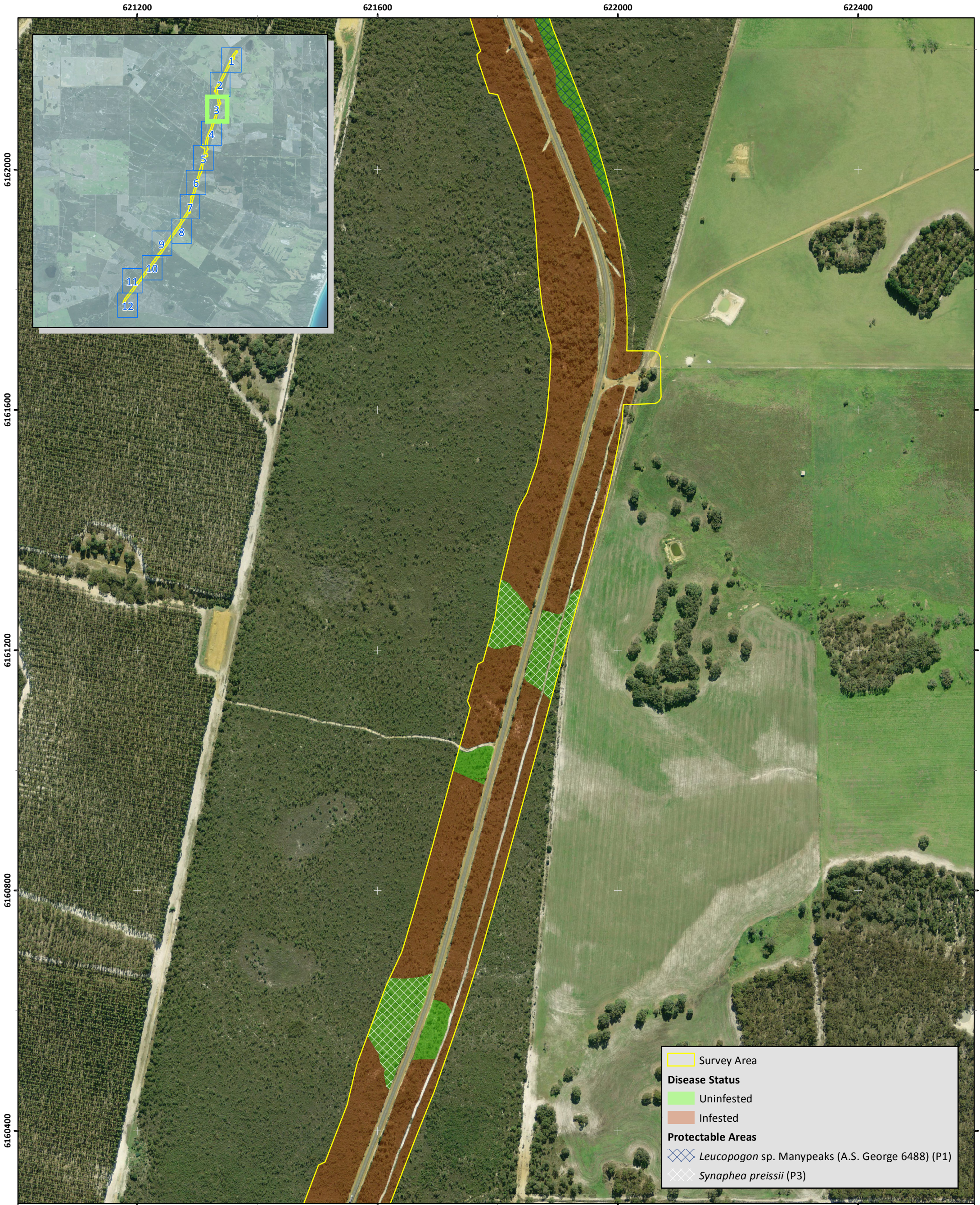
Author: J. Johnston

Date: 01-07-2019

Drawn: L. Robinson

Figure Ref: 8602-18-BISR-2Rev0_190701_FigD_Dieback





Main Roads Western Australia
H008 - South Coast Highway Kojaneerup Section SLK 46-66 *Phytophthora* Dieback Assessment

Figure D.3: Dieback Disease Status and Protectability Mapping

Author: J. Johnston

Date: 01-07-2019

Drawn: L. Robinson

Figure Ref: 8602-18-BISR-2Rev0_190701_FigD_Dieback

Survey Area

Disease Status

Uninfested

Infested

Protectable Areas

Leucopogon sp. Manypeaks (A.S. George 6488) (P1)

Synaphea preissii (P3)



Main Roads Western Australia
H008 - South Coast Highway Kojaneerup Section SLK 46-66 *Phytophthora* Dieback Assessment

Figure D.4: Dieback Disease Status and Protectability Mapping



Author: J. Johnston

Date: 01-07-2019

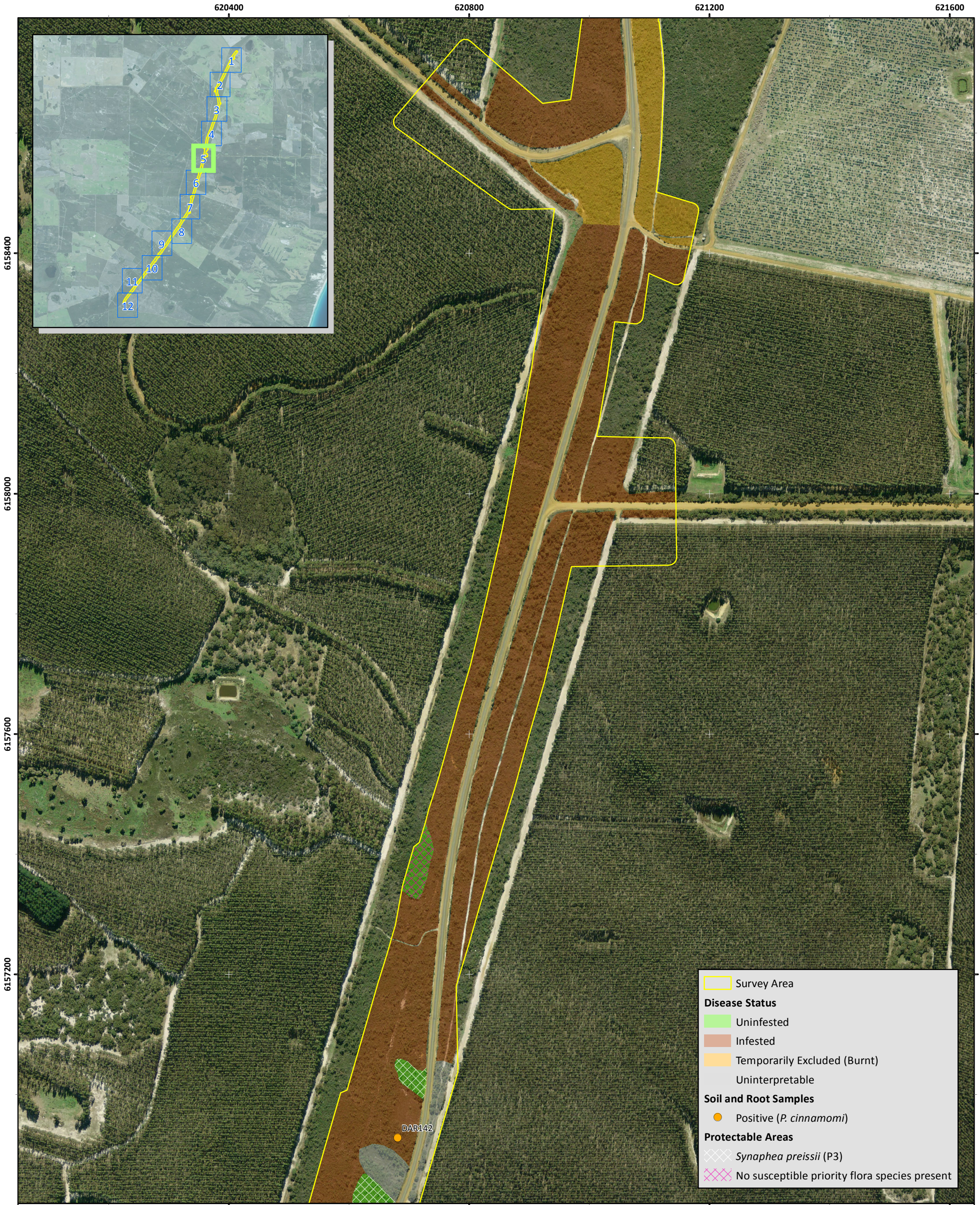
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Figure Ref: 8602-18-BISR-2Rev0_190701_FigD_Dieback

Coordinate System: GDA 1994 MGA Zone 50
Scale: 1:5000 at A3

0 100 200 300 400 Metres

N

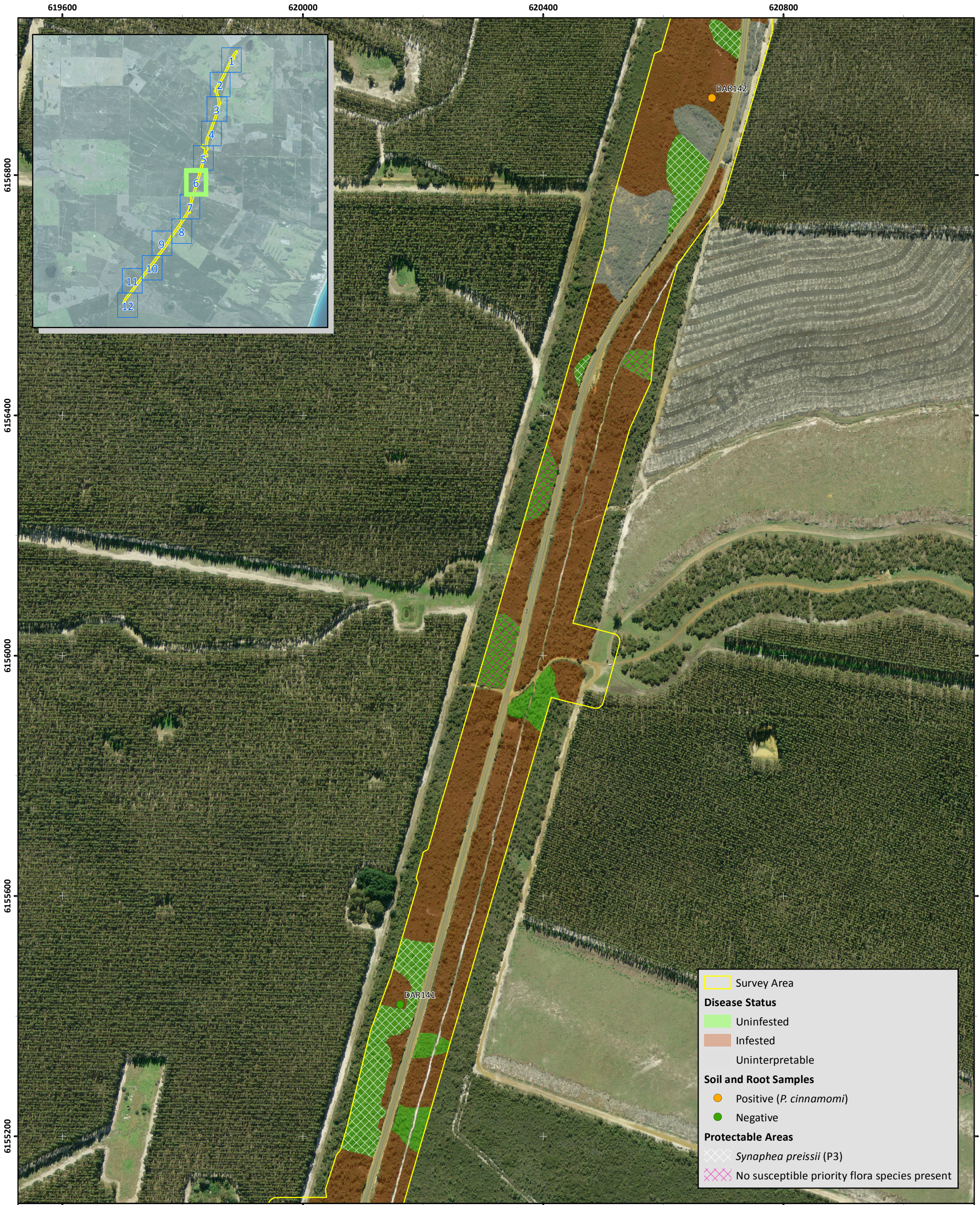


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Figure D.5: Dieback Disease Status and Protectability Mapping



Author: J. Johnston	Date: 01-07-2019	Coordinate System: GDA 1994 MGA Zone 50 Scale: 1:5000 at A3 N
Drawn: L. Robinson	Figure Ref: 8602-18-BISR-2Rev0_190701_FigD_Dieback	



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Figure D.6: Dieback Disease Status and Protectability Mapping



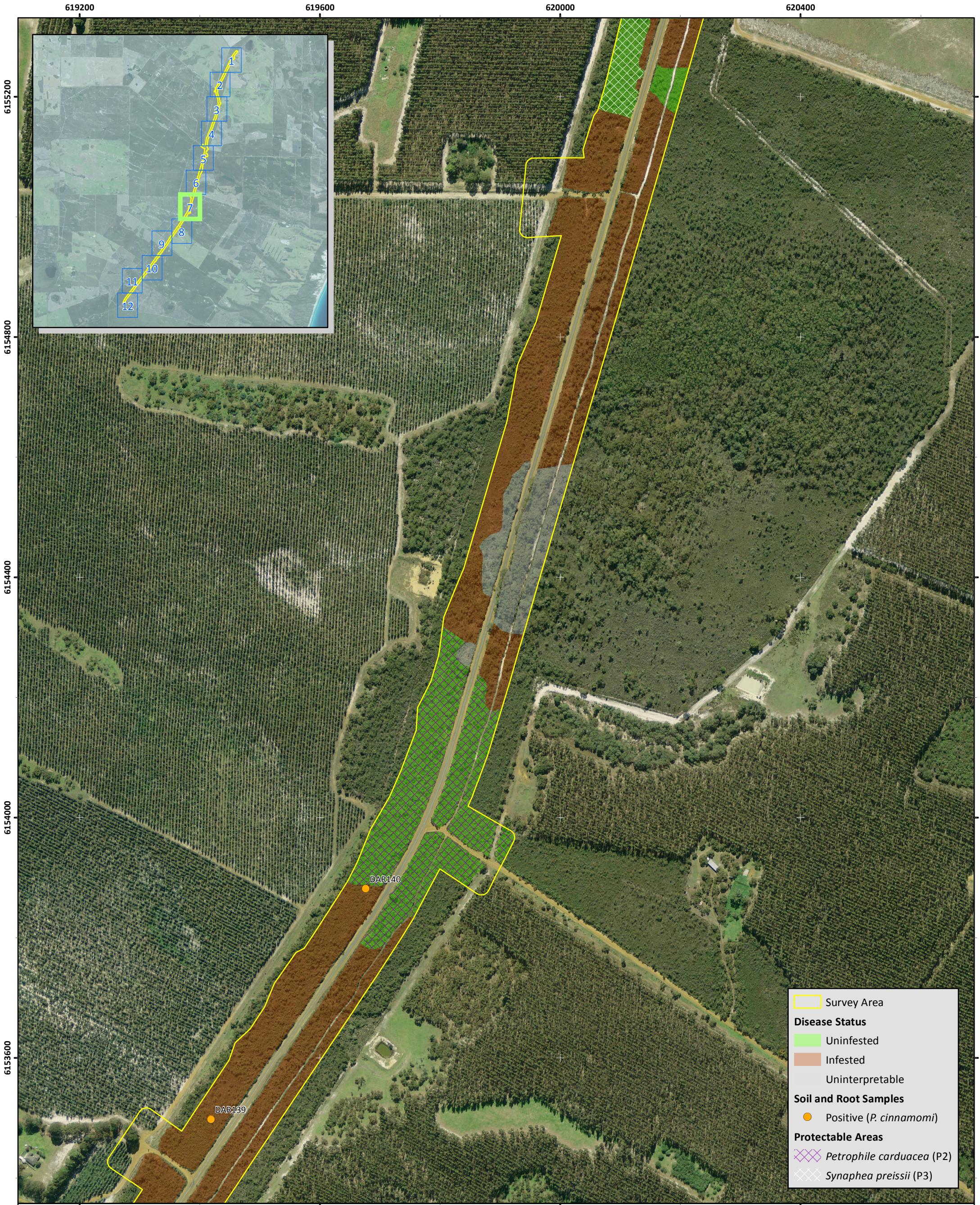
Author: J. Johnston	Date: 01-07-2019
Drawn: L. Robinson	Figure Ref: 8602-18-BISR-2Rev0_190701_FigD_Dieback

Coordinate System: GDA 1994 MGA Zone 50
Scale: 1:5000 at A3

0100200300400

Metres

N



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Figure D.7: Dieback Disease Status and Protectability Mapping



Author: J. Johnston

Date: 01-07-2019

Drawn: L. Robinson

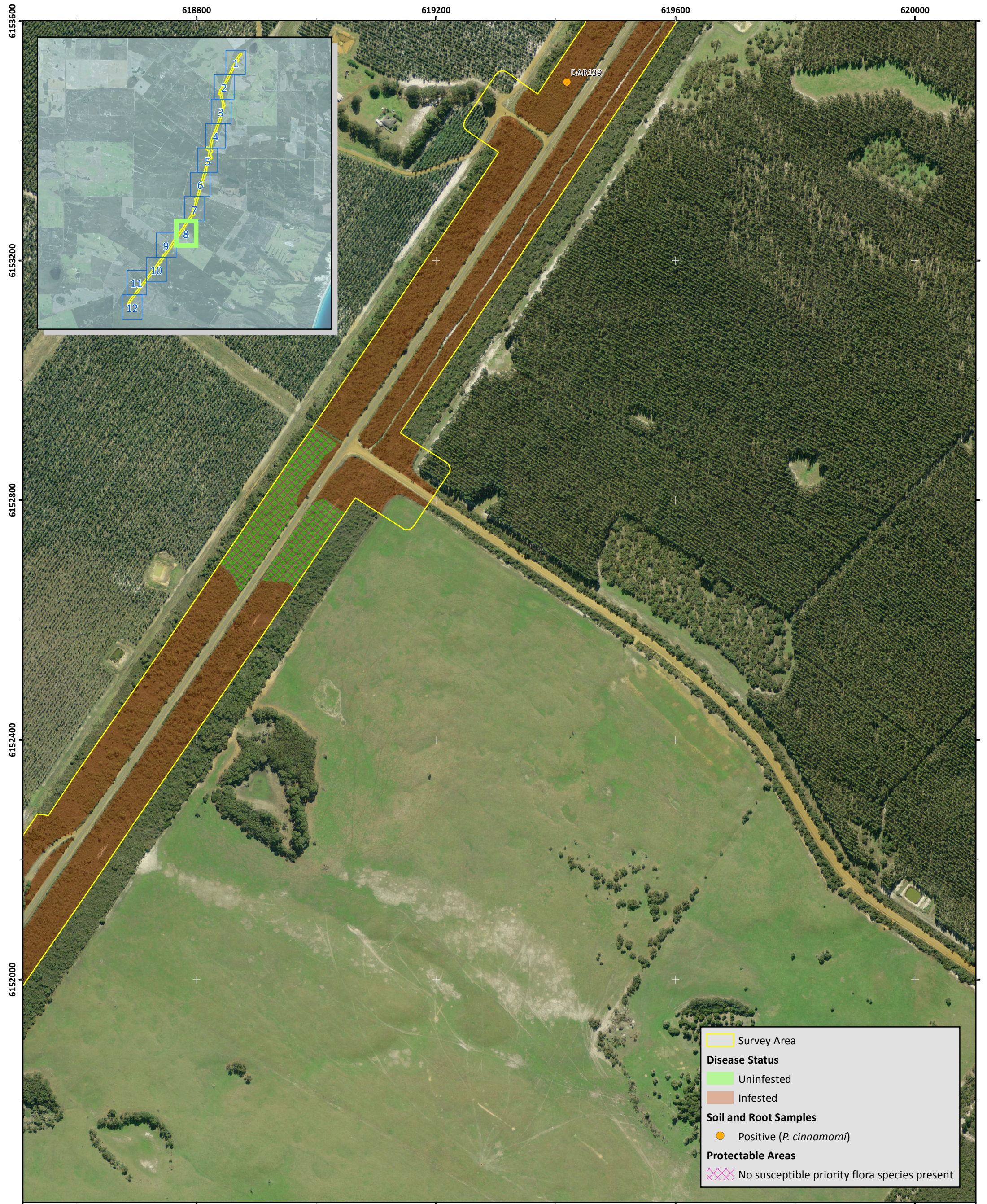
Figure Ref: 8602-18-BISR-2Rev0_190701_FigD_Dieback

Coordinate System: GDA 1994 MGA Zone 50
Scale: 1:5000 at A3

0100200300400

Metres

N



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Figure D.8: Dieback Disease Status and Protectability Mapping



Author: J. Johnston	Date: 01-07-2019
Drawn: L. Robinson	Figure Ref: 8602-18-BISR-2Rev0_190701_FigD_Dieback

Coordinate System: GDA 1994 MGA Zone 50
Scale: 1:5000 at A3

0100200300400

Metres

N



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Figure D.9: Dieback Disease Status and Protectability Mapping



Author: J. Johnston	Date: 01-07-2019
Drawn: L. Robinson	Figure Ref: 8602-18-BISR-2Rev0_190701_FigD_Dieback

Coordinate System: GDA 1994 MGA Zone 50
Scale: 1:5000 at A3

0100200300400

Metres

N