ALKIMOS WATER ALLIANCE

ALKIMOS WASTEWATER TREATMENT SCHEME

TERRESTRIAL CONSTRUCTION MANAGEMENT PLAN

MANP016

18 April 2008	5	Changes to address DEC requirements	JDH	GN	
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Date	Revision	Description of Revision	Originator	Review	Project Approval

EXECUTIVE SUMMARY

In December 2006, the Water Corporation announced the Alkimos Water Alliance (AWA) as the successful Alliance partner to undertake design and construction works associated with the Alkimos Wastewater Scheme. The team comprises Alliance partners Multiplex, Züblin and Macmahon and sub-contract partners Worley Parsons, Connell Wagner, Land and Marine and Cardno BSD.

The AWA was formed specifically to progress the design and construction of:

- Earthworks for the wastewater treatment plant (WWTP) to be located at Site B;
- The ocean outfall including the launch site at Site 1B;
- A land based connection between the WWTP site and the launch site/ocean outfall; and
- The remaining section of the Quinns Main Sewer to connect established residential areas to the WWTP site.

This Terrestrial Construction Management Plan (TCMP) has been prepared by the AWA for terrestrial (onshore) works associated with the Alkimos Wastewater Scheme. This TCMP details how the AWA will manage the environmental aspects of construction activities associated with the Alkimos Wastewater Scheme. It has been prepared to address Ministerial Condition 6-2 associated with Ministerial Statement 755, which was issued in accordance with the provisions of Part IV of the *Environmental Protection Act 1986* (See Appendix A).

Since the time of the submission of the Public Environmental Review (PER) (Water Corporation, 2005), AWA has developed a refined detailed design for the launch site at both Site 1B and Site 1A, Site 1B is outlined in Section 11. A key facet of this has been finalising the design based on the Launch Site 1B option that was one of three launch site options outlined in the PER. Any reference to the "launch site" within this document refers to the Launch Site 1B option, and this option was specifically selected to minimise impacts on flora and vegetation following the Environmental Protection Authority's (EPA) assessment of the proposal.

The PER assessed two locations for the WWTP site, referred to as Site A and Site B. Site B was selected as the preferred option and has become the focus for detailed design. Approximately 2 million cubic metres of excavated material will need to be removed from the WWTP site and will be placed on land owned by LandCorp (Lot 102) to the south of the WWTP site. Haul roads have been designed to achieve safe transportation of the spoil to the fill site and access roads have been designed to provide safe access for staff and to minimise/avoid impacts to environmentally significant areas.

The design and construction approach for the Alkimos Wastewater Scheme, developed by the AWA on behalf of the Water Corporation, reflects with the guiding overall principle of minimising impact on the existing environment. The management measures detailed in this TCMP are considered to be the most appropriate to achieve the objectives stated, given the environment in which construction is to occur.

The TCMP document is separated into two main components, the first contained in Section 4 which specifies project wide environmental management principles, including:

- Section 4.1 Construction Management;
- Section 4.2 Dieback Management;
- Section 4.3 Weed Management;
- Section 4.4 Fire Management;
- Section 4.5 Hydrology Management;
- Section 4.6 Landform Management ; and

- Section 4.7 Rehabilitation Management.

The second component deals with the detailed implementation of these environmental management principles. The management controls and responsibilities associated with the terrestrial construction works for each element of the project are contained separately within Section 5 to Section 12. These have been developed by AWA in order to minimise environmental impacts and meet the objectives specified within this document the Water Corporations PER and he Ministerial Conditions. These sections are as follows:

- Section 5 Access roads;
- Section 6 Site offices/compound areas;
- Section 7 Haul roads;
- Section 8 Quinns main sewer;
- Section 9 WWTP site excavation;
- Section 10 Land based connection from WWTP to the launch site;
- Section 11 Launch site; and
- Section 12 Launch site dune crossing (through Bush Forever) and beach access corridor.

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ABBREVIATIONS

AHD	Australian Height Datum
AWA	Alkimos Water Alliance
DEC	Department of Environment and Conservation
DEH	Department of Environment and Heritage
DPI	Department of Planning and Infrastructure
DRF	Declared Rare Flora
EPA	Environmental Protection Authority
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999 (commonwealth)
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
FMP	Fauna Management Plan
MRS	Metropolitan Regional Scheme
OOPCMP	Ocean Outlet Pipeline Construction Management Plan
PER	Public Environmental Review
PF	Priority Flora
RL	Reduced Level
TBM	Tunnel Boring Machine
TCMP	Terrestrial Construction Management Plan
TEC	Threatened Ecological Community
WA	Western Australia
WWTP	Wastewater Treatment Plant

1 INTRODUCTION

1.1 BACKGROUND

The Alkimos Wastewater Scheme is to be implemented approximately 40km north-west of Perth's CBD, within the future suburb of Alkimos as shown in Figure 1.

The Water Corporation commenced planning for the Alkimos Wastewater Scheme in the 1970s to provide for the planned continued residential growth in the Perth metropolitan north-west corridor. The Water Corporation is the proponent for the Alkimos Wastewater Scheme and the project/proposal has been subject to the Western Australian (WA) Environment Impact Assessment (EIA) process and was assessed at the level of Public Environmental Review. (Alkimos Wastewater Treatment Plant – Public Environmental Review. Water Corporation, 2005).

In December 2006, the Water Corporation announced the Alkimos Water Alliance (AWA) as the successful Alliance partner to undertake design and construction works associated with the Alkimos Wastewater Scheme on behalf of the Water Corporation. It comprises Alliance partners Multiplex, Züblin and Macmahon and sub-contract partners Worley Parsons, Connell Wagner, Land and Marine and Cardno BSD.

The AWA was formed specifically to progress the design and construction of:

- Earthworks for the wastewater treatment plant (WWTP) to be located at Site B;
- The 3.7 km ocean outfall including the launch site at Launch Site 1B;
- A land based connection between the WWTP site and the launch site/ocean outfall; and
- The remaining section of the Quinns Main Sewer to connect established residential areas to the WWTP site.

It is also envisaged that the AWA may be contracted to integrate the design and construction of the WWTP itself once the earthworks have been completed, however it will not be responsible for the ongoing operation of the scheme.

The Alkimos Wastewater Scheme components, listed above (except for the Quinns Main Sewer), received Ministerial approval on 12 November 2007 (see Appendix A) pursuant to Part IV of the *Environmental Protection Act 1986* (EP Act). The Quinns Main Sewer section of the scheme from the suburb of Butler to the edge of the buffer boundary falls under the jurisdiction of the *Water Agencies (Powers) Act 1984* as general works and received Clearing Permit (CPS 1064/2) pursuant to Part V of the of the *Environmental Protection Act 1986* on 9 August 2007, and hence was not assessed under Part IV (see Appendix B).

The Construction and Operation of the Alkimos Wastewater Treatment Plant has been considered pursuant to Section 75 of the *Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act)*. On the 26 February 2007 it was deemed 'not a controlled action' and, as such, did not require further assessment by the Australian Government (EPBC 2007/3259) (refer to Appendix C).

Since the formation of the AWA, the project design has progressed and has been refined from the design presented in the PER and as shown in Figure 2. Based on discussions held between the Water Corporation and the EPA Service Unit, it has been agreed that a number of changes to the scope of the original proposal will be progressed though a *Section 45c* process, and that the proposed changes are considered "non substantial".

This primarily relates to the original proposal requiring 29Ha of clearing and the revised proposal will necessitate the clearing of approximately 50Ha in total.

The Alkimos – Eglington Metropolitan Regional Scheme Amendment No. 1029/33 was formally reviewed by the EPA and through this process, Area 9 to the north of the WWTP was identified as having high east-west ecological linkage values. To assist in the finalisation of the MRS assessment, the Water Corporation proposed two areas within the buffer zone to be protected and managed for conservation purposes, as an offset to taking a portion of Area 9 for the location of the WWTP Site B. These are referred to as Area 10b which is located to the south of the WWTP site and Area 10a which is the portion of land north of Area 9 as shown in Figure 3. A key aspect of the design process and this management plan has been avoiding and managing impacts to Area 9, Area 10a and Area 10b.

1.2 PURPOSE OF THIS DOCUMENT

This Terrestrial Construction Management Plan (TCMP) has been prepared by the AWA for construction works associated with the Alkimos Wastewater Scheme. It details how the AWA will manage the environmental aspects associated with the construction of the Alkimos Wastewater Scheme, primarily potential impacts to flora/vegetation and landforms.

The primary objective of the TCMP is:

To protect native vegetation and landforms on the site outside the authorised area of permanent disturbance as defined in Figure 3 in Schedule 2 and Figure 4 in Schedule 3 of Ministerial Statement 755.

The TCMP has been prepared to satisfy Condition 6 as specified in Ministerial Statement 755 (November, 2007).

Specific requirements for the TCMP have been recommended by the EPA (2007) and within Ministerial Statement 755, and these recommendations have been addressed within various sections of this document. For ease of reference, the issues identified by the EPA and the Ministerial Conditions and corresponding section references for this document are provided below in Table 1.2.

Table 1.2 Terrestrial construction issues and relevant section references

Issue	References
Modification and configuration (dimension and gradient) of the launch site as far as practicable, to minimise the impact on the terrestrial vegetation and formation of the launch site dimensions	Section 11
Access roads	Section 5
Sheds, amenities and other facilities to be installed	Section 6
Management of activities in areas outside the area of disturbance (as defined in Figure 3 in Schedule 2 and Figure 4 in Schedule 3)	Section 4
Depth of pipe burial sufficient to withstand a one-in-one hundred year storm	Section 2.1.3
Impacts on the beach profile	Section 2.1.3
Bush forever site, including *Frankenia pauciflora*	Section 12

Threatened Ecological Communities	Section 2.2.3
Rehabilitation of the launch site/s	Section 11.2.7, Section 12.2.7

1.3 DOCUMENT FORMAT

The remainder of this report is comprised of the following components:

- Section 2 – Existing environment;
- Section 3 – Management standards and objectives ;
- Section 4 – Project wide terrestrial management principles;
- Section 5 – Access roads;
- Section 6 – Site offices and compounds;
- Section 7 – Haul roads;
- Section 8 – Quinns main sewer;
- Section 9 – WWTP site excavation;
- Section 10 – Land based connection from the WWTP to the launch site;
- Section 11 – Launch site;
- Section 12 – Launch site dune crossing through Bush Forever;
- Section 13 – Operational monitoring;
- Section 14 – Reporting;
- Section 15 – Summary; and
- Section 16 – References.

2 EXISTING ENVIRONMENT

The existing terrestrial environment of the project area is summarised in the following sections.

2.1 SOILS AND LANDFORMS

Geomorphically, the dunes at the Alkimos site represent the Holocene Safety Bay Sand portion of the Quindalup and Spearwood Dune Systems. These dune systems belong to a larger system of former coastal dunes that are a prominent feature over much of the coastal plain of the Perth Metropolitan area.

The dunes on site are predominantly linear systems following the coastline with flat to gently sloping sandy beaches. The large dunes have steep slopes extending to the beach, which grade to a lower undulating beach ridge characterised by inter-dune depressions and karstic features (GHD, 2005).

2.1.1 Soils

As indicated the landforms and soils within the project area are part of the Quindalup Dune and Spearwood Dune Systems. The Quindalup Dunes are parabolic and coastal calcareous sand dunes and associated undulating landscapes, of differing ages and with minimal soil profile development (McArthur and Bartle, 1980).

There are six Quindalup dune system units in the study area: Q1, Q2, Q3, Q4, Qp and Qs (see Figure 4). The launch site is situated within an inter-dune depression of Q1 (the oldest phase of Quindalup dune system) directly behind the foredune, which is a thin section of Q4 (the youngest phase) (Weston, 2005).

The oldest phase (Q1) is known to comprise dunes or remnants with low relief, organic staining down to about 30cm and definite cementation below one metre. The Q1 phase has a flattened profile and is largely covered by vegetation and soil organic matter to depths of 30 to 50cm. These dunes are completely stable and are of the order of 6000 years old (Lemmon, T.C, Gee, R.D, Morgan, WR and Elkington, C.R.1979).

The WWTP site predominantly falls within the inter-dune depression of Q3 phase with a small section through Q2. The WWTP excavation site is located within the swale surrounded by dune systems. Quindalup dune systems consist of Safety Bay Sand, which consists of fine to medium grained quartz sand and shell fragments and overlies calcareous sand and limestone of the Tamala Limestone, which is Karstic in nature and has a naturally high permeability. The majority of the haul roads traverse though Q3, and the QMS section passes though a mixture of landforms.

2.1.2 Landforms of the Alkimos area

Geoheritage is known as a complex expression of the geological and geographical landforms and the historical development of all ecological systems upon them. The parabolic dune feature at Alkimos is 2km wide, extending inland for 4km. Three individual dune types occur within this feature including parallel dunes, nested parabolic dunes and blow-outs. The landforms underlying the study area are shown in Figure 4.

The Semeniuk Research Group (2004) describes the Quindalup Dunes encompassing the footprint areas as nested parabolic dunes perched on coastal limestone. They recognise the entire Alkimos nested dune system as unusual, being perched on a limestone plateau and having arms with fretted margins. In 1979, the coastal dune formations in the Alkimos area were identified as having national and world geoheritage significance.

Blow outs form when the parallel dunes along the beach front are breached during heavy storms, with the resultant gap creating a wind tunnel through which the sand is transported. These blow outs are usually highly degraded and generally continue to erode over time. A blow out occurs through the foredune within the launch site foot print as shown in Plate 1 and Plate 2.

2.1.3 Beach profile and processes

Littoral drift (also referred to as longshore drift) occurs at the Alkimos site and is the process by which sediments move along a beach shore. The process occurs as a result of waves approaching the shore obliquely, which is in turn driven by factors such as the direction and fetch of the prevailing winds. Waves striking the shore at an angle cause the waves to 'swash' up the beach at an angle. The swash moves sediment particles up the beach at this angle, while the backwash returns them (solely under the influence of gravity) directly down the beach. This has the net effect of gradual movement of the sand particles along the shore. The water molecules are among the particles moved in the process, so there is a net movement of water in the same direction, referred to as longshore current (Beer, 1997).

Natural coastline movements in the area adjacent to Lot 101 over the last half century have ranged from receding (45m to 55m) to mostly stable or accreting. Some areas of erosion have occurred, particularly where dune vegetation has become degraded or damaged (Oceanica, 2006). The shoreline, for approximately 1km south of the proposed launch site, was characterised as eroding at an estimated 7,300m^3/yr with the sediment moving predominately to the North. The shoreline for 1.5km to the north of the launch site was estimated to be accumulating sediment at 15,000m^3/yr (Oceanica, 2006).

In 2007, Worley Parsons conducted a metocean and coastal study along the ocean outfall alignment. The investigation concluded that the pipeline is likely to be lying under rock for the majority of the progression to 5m below sea level. It was concluded that of predicted patterns of storm induced erosion around the Alkimos pipeline shore crossing above 0m AHD (landward of Ch 100), the risk of the pipeline becoming exposed is low and armouring is not required. From -4m AHD (seaward of Ch 180), the trend is for deposition rather than erosion and consequently the risk of the pipeline becoming exposed is low and armouring is not required.

Between Ch 100 and Ch 180 the rock profile undulates, refer to Section 11. As the modelling has predicted, it is likely the sandy bottom would erode back to the rock profile and probably beyond, armouring should be provided where the rock profile is less than 0.5m above the top of the pipeline; that is approximately Ch 110 to 140 and Ch 150 to Ch 175. Armouring or coarse backfill should also be used in this zone (Ch100 to Ch180) where the total depth of cover to the top of the pipeline will be less than 2 metres (Worley Parsons, 2007).

During modelled 100 year storm events, there was no erosion of the profile predicted at the -5m level. There was some accretion due to the erosion of the upper profile. At the shoreline, a limestone platform is present and this will limit the shoreline recession to where the rock intersects the mean sea level. The pipeline will be trenched through rock in this section.

Based on the available information, the vertical alignment of the pipeline should not be undermined (Worley Parsons, 2007). The pipeline will be exposed in the trench, therefore the use of backfilling will be required with a suitably designed fill and armouring in order to stabilise the foredune, for all areas to -5m where the cover to natural seabed is less than 1.5m will be required.

2.2 FLORA AND VEGETATION

A number of previous floristic surveys have targeted the Alkimos and/or the neighbouring Eglinton areas. These surveys include:

- In 1990, Trudgen and Keighery (1990) surveyed the Alkimos area and mapped the vegetation units associated with variously aged dunes in the Quindalup System as well as limestone areas and sand surface areas of the Spearwood System.
- ATA Environmental surveyed and mapped the vegetation of selected areas of the Alkimos and Eglinton district in 2002, which was followed by in-fill surveys by Bennett in 2004 (ATA Environmental, 2004). The information attained during these surveys was used to produce more detailed mapping of the vegetation units and condition in the Alkimos area.
- The ATA mapping was used by Dr Arthur Weston on behalf of Syrinx (2005) when they conducted a targeted survey of the two proposed WWTP sites, their buffer zones and the proposed ocean outfall sites.
- In June 2007 AWA undertook further detailed survey. The survey was organised to further clarify vegetation specific to the launch site area and to establish reference sites outside the launch site and record plant densities within the launch site.

These reports provide the basis for the detailed description of the existing site flora and vegetation provided in the following sections.

2.2.1 General site flora

Generally, the vegetation of the Alkimos area was described by Dr Arthur Weston to be representative of two vegetation complex systems known as the Cottesloe Complex Central and South system and the Quindalup Complex System.

The Cottesloe system is the part of the study area north (and east) of the parabolic dunes, and the Quindalup System represents the remainder of the study area. The Cottesloe System supports Spearwood scrubs and heaths dominated by species of *Dryandra, Melaleuca* and *Acacia* on shallow sand, and limestone and low woodlands dominated by species of *Banksia* and *Eucalyptus* on deeper sands.

The Quindalup System supports grasslands, herblands and shrublands dominated by species of *Cakile, Spinifex, Tetragonia, Scaevola*, *Acacia, Myoporum* and *Spyridium* on the strand, fore dunes and adjacent mobile dunes, shrublands and heaths dominated by *Melaleuca systena* and species of *Acacia*, over *Lomandra maritima* herblands. On crests and middle to upper slopes of stable dunes; heaths of *Acacia rostellifera* and *Acacia saligna* and weedy grasslands and herblands on flats, swales and gentle slopes; and enclaves of Cottesloe vegetation and, in some places, Tuart trees on Spearwood sands and limestone (Weston 2005) as shown in Figure 5 and Figure 6.

The Cottesloe System vegetation is in the best condition ("Very Good" to "Good" and "Very Good" to "Excellent"), while the vegetation of the dunes in the Quindalup system is in "Good" to "Very Good" condition. Most of the other Quindalup vegetation is in a more degraded condition, with much of the vegetation on flats and gentle slopes being weedy and "Degraded" or "Completely Degraded".

The WWTP excavation site has a combination of flats, broad swales and valleys with weedy vegetation and weed infested native vegetation, as shown in Plate 3. The vegetation condition ranges from "Very Good" to "Completely Degraded" as shown in Figure 7 and Figure 8. *Melaleuca systena* Open Low Heath over

Lomandra maritime Herbland (MsLm) is present on over 50% of the dunes around the flats (Weston, 2005). *Melaleuca systena* Low Shubland to Shrubland (Ms) is also prevalent through the western portion of the site footprint. Haul roads and access roads traverse through a variety of vegetation units, predominantly through MsLm, Ms and AsMs *Acacia saligna – Melaleuca systena* shrubland.

The WWTP buffer zone supports Spearwood *Dryandra sessilis* Open to Closed Heath to Scrubs (Ds) and *Banksia* woodlands (Bam and BamET), which provides a feeding and foraging habitat for Carnaby's Cockatoos.

Weston (2005) found about 60% of the vegetation of the launch site to be previously cleared areas, with the vegetation condition ranging from "Good" to "Completely Degraded" with the majority of the area being "Completely Degraded" (shown in Plate 4 and Plate 5). The most significant remnant vegetation was a *Melaleuca systena* open low heath over *Lomandra maritima* herbland on the older dunes. The vegetation of the younger foredunes consisted mostly of a *Spyridium globulosum – Scaevola crassifolia* closed low heath to shrubland (SgSc). An area of exposed limestone also occurs in the launch site and this contains a *Dryandra sessilis* (Ds) open to closed heath and *Melaleuca huegelii – Melaleuca systena* low shrubland to open low heath, with *Acacia truncate* (MhMs). The remainder of the older Quindalup Dune sands have been historically cleared of their native vegetation but most likely supported MsLm. The foredunes are largely vegetated with a *Spyridium globulosum – Scaevola crassifolia* shrubland (SgSc) with a small area of *Frankenia pauciflora* low shrubland (Fpls) near the foredune. Figure 9 and Figure 10 show the vegetation communities and vegetation condition respectively for the launch site area that was generated from the Weston (2005) survey.

2.2.2 Declared Rare Flora and Priority Listed Flora

Weston (2005) reported that there were no species of Declared Rare Flora (DRF) identified in the study area, and that none were likely to be found in the area.

The previous surveys of the Alkimos area identified a number of Priority Flora (PF) as well as Locally Significant Flora that occur within the project area. *Conostylis pauciflora* subsp. *euryrhipis* (P3) occurs between Alkimos and Cervantes on Quindalup dunes and is common in the *Melaleuca systena* open low heath over *Lomandra maritima* herbland.

Sarcozona bicarinata (P3) is a succulent herb of coastal dunes and limestone and has been recorded as common in limestone outcrops within the launch site (Weston 2005). *Stylidium maritimum* (P3) is a tufted herb of sand over limestone in coastal heath and shrublands or woodlands of the Swan Coastal Plain. This species was recorded in *Melaleuca huegelii – Melaleuca systena* heath at one site by Weston (2005) and may occur in similar vegetation at the launch site however circumstances of this vegetation unit is unlikely to occur so close to the coast.

Hibbertia spicata subsp. *leptotheca* (P3) is a small shrub of near coastal limestone between Yalgorup National Park and Lancelin. Weston (2005) recorded this taxon within the *Melaleuca huegelii – Melaleuca systena-Acacia truncata* Open Low Heath and *Melaleuca huegelii – Melaleuca systena* Closed Heath, with the largest population recorded north of the launch site. *Astroloma microcalyx* is no longer a priority taxon.

The locally significant flora *Frankenia pauciflora, Leucophyta brownii* and *Olax benthamiana* were recorded by Weston (2005) on the limestone cliffs to the west of the launch site. The vegetation within the Bush Forever area was surveyed in March 2007, and of the DRF and PF previously identified, only *Frankenia pauciflora* was recorded on the limestone outcropping on the edge of the pegged launch site area. A total of 12 plants of *Frankenia pauciflora* were recorded in this section.

Frankenia pauciflora is often associated with coastal limestone but is uncommon in the Alkimos area and can therefore be considered locally significant. The proposed outlet construction is only likely to impact up to 12 plants and therefore the impact on this species is considered to be minor.

2.2.3 Threatened Ecological Communities

The area was originally surveyed by E.M. Bennett for ATA Environmental in 2004 but the area had been burnt less than a year before the survey was conducted. Dr Arthur Weston also visited the Alkimos area in 2004 and 2005. It was observed that one TEC, FCT 26a listed as "Endangered" by the Department of Environment and Conservation is probably represented within the study area north of Lot 101 within the Site A buffer boundary (Weston, 2005).

In March 2007 it was observed that the limestone vegetation within the launch site was very similar in dominant species and structure to that of the limestone ridge north of the buffer zones, which has been classified as FCT 26a '*Melaleuca huegelii – Melaleuca systena* shrublands of limestone ridges'. The degree of uncertainty remains regarding the conservation significance of the *Melaleuca huegelii – Melaleuca systena* low shrubland to open low heath with *Acacia truncata* on the limestone areas of the launch site. It was concluded that the representation of FCT 26a so close to the coast would be unusual (Weston, 2005).

The work of Bennett for ATA Environmental (2004) covered the launch site area. Two sampling points were located and studied within the launch site. These sites were originally inferred to be Floristic Community Type 26a (FCT 26a), *Melaleuca huegelii – Melaleuca systena* shrublands of limestone ridges, a Threatened Ecological Community (TEC). However, the site had been burnt in late 2003 and the vegetation sampled less than a year later. Therefore, the vegetation had not yet recovered to its pre-fire condition. The analysis of the ATA data by Weston (2005) indicated these sites were probably not FCT 26a, but were closer to either FCT 29 or FCT 24.

Plate 4 and Plate 5 show the general vegetation types and condition at the launch site, and in particular the contrast between the cleared areas and the vegetated limestone outcrop.

2.2.4 Bush Forever

The area proposed for the ocean outfall trench, comprises the dune between the beach and to the larger launch site area, has been survey pegged across the coastal dunes and through Bush Forever Site 397 (which connects to Bush Forever Site 130).

Bush Forever Site 397 is described by Bush Forever Volume 2 (Government of WA, 2000) as having vegetation ranging from near "Pristine" to "Degraded", with areas of severe localised disturbance. Significant flora includes *Conostylis pauciflora* subsp. *euryrhipis, Stylidium maritimum*, *Melaleuca cardiophylla, Lechnaultia linarioides, Grevillea preissii, Diplopeltis huegelii* subsp. *huegelii, Trymalium ledifolium* subsp. *ledifolium*.

The corridor required though the Bush Forever site encompasses the foredune, which is an area of severe localised disturbance, as seen in Plate 1 and Plate 2. The foredune will need to be excavated but then will be restored to a better condition once construction is complete. The foredune area within the Bush Forever site consists of both Q1 and Q4 representatives of the Quindalup dune system, both the youngest and oldest phases, refer to Figure 4.

2.3 HYDROLOGY

A number of geotechnical and hydrological surveys have previously targeted the Alkimos site area, including;

- A Hydro-geological assessment of the proposed Alkimos WWTP site in October 2004, conducted by Rockwater Pty Ltd; and
- Geotechnical drilling in the Alkimos onshore ocean outfall area and preparation of a brief factual report, undertaken in November 2005 by GHD Pty Ltd.

Golder Associates Pty Ltd has conducted further drilling and geophysics data within the project area in 2007.

2.3.1 Groundwater

The Safety Bay Sand and Tamala Limestone found at Alkimos make up part of a surficial aquifer complex in the Perth area. This is a complex, unconfined and multilayered aquifer (Davidson, 1995). The surficial aquifer has a maximum thickness of about 70m but an average thickness of approximately 45m in the northern Perth region. The upper surface of the unconfined aquifer is the watertable whose variations in depth depend mainly on topography but also permeability of the sediments. Groundwater levels fluctuate seasonally by about 0.5m in the limestone along the coast (Davidson, 1995).

The groundwater table configuration is dominated by the presence of a major groundwater mound, the Gnangara Mound (South). Groundwater flow radiates from the Gnangara Mound South (in the east) at approximately 70mAHD west towards the ocean to around 1mAHD at the coastline.

The Alkimos area is made up of Tamala Limestone, which is karstic in nature and has a high permeability. Groundwater in the Tamala Limestone is recharged by rainfall infiltration, and flows westward to discharge to the ocean. Variations in rainfall, tides, temperature and other factors affect the groundwater level in the area.

2.3.2 Surface water

Due to the highly permeable surface strata within the site there are no surface water features within the project area.

2.4 THREATENED FAUNA AND FAUNA HABITAT

The environment and fauna habitats within the project area are strongly influenced by dunal systems. The vegetation of the project area can broadly be described as coastal heathlands and woodlands overlying Quindalup and Spearwood dune systems.

Dryandra sessilis thickets and exposed limestone may support species with locally restricted distributions on the coastal plain, including *D. polyopthalmus* (a gecko) and the Barking Gecko. The Carpet Python also seems to favour rocky areas. Grass Trees almost certainly provide shelter for reptiles and some mammals. The foredune area in particular is home to a moderately rich reptile habitat such as the Bobtail, Dugite, Gould’s Goanna and species specialised for existence in loose sand.

A fauna assessment in accordance with EPA Guidance Statement No. 56 (EPA 2004) was carried out for the area as part of the preparation of the PER. The assessment consisted of a site inspection (conducted in January 2005 by Dr Mike Bamford and Dr Robert Davis of Bamford Consulting Ecologist), and a desktop review of available data, including publications and databases (CALM, EPBC, WA museum, Birds Australia).

The Alkimos site possibly supports up to 51 reptile species, 102 bird species, 22 species of mammals and 5 species of amphibian (Bamford, 2004). A separate Fauna Management Plan (FMP) has been developed to satisfy Condition 10-1 of the Ministerial Statement 755, and details how the AWA will manage the impacts on terrestrial fauna during construction activities associated with the Alkimos Wastewater Scheme. Consequently, fauna management has not been assessed in this TCMP.

3 MANAGEMENT OBJECTIVES AND STANDARDS

3.1 MANAGEMENT OBJECTIVES

As indicated in Section 1.2, the primary aim of preparing and implementing this TCMP is to protect native vegetation and landforms on the site outside of the authorised area of permanent disturbance.

There are a number of specific objectives for this TCMP, which are as follows:

- To provide additional information and detail to that contained within the PER, specifically pertaining to the relevant impacts on native vegetation and landforms;
- To provide detail as to how impacts on native vegetation and landforms will be managed consistent with the key objectives outlined in the PER, which include:
    - *Minimising the impacts on the abundance, species diversity, geographic distribution and productivity of vegetation units;*
    - *Protecting Declared Rare Flora (DRF) taxa consistent with the provisions of the Wildlife Conservation Act;*
    - *Protecting flora listed under the Schedules of the EPBC Act; if any are subsequently found in the Project area; and*
    - *Protecting flora of other conservation significance.*
- To provide a framework for the TCMP that is consistent with the recommendations provided by the EPA contained within EPA Bulletin 1239, and to satisfy Condition 6 of Ministerial Statement 755.

3.2 RELEVANT LEGISLATION, POLICIES AND STANDARDS

The relevant legislation, policies and standards in relation to managing the impacts associated with terrestrial construction are outlined below in Table 2.

Table 2: Relevant Legislation/Policies/Standards in relation to managing the impacts on the terrestrial environment

LEGISLATION / POLICY / STANDARD	PURPOSE	KEY AGENCY / DMA
Environmental Protection Act 1986 Environmental Protection Regulations 1987	Provides the statutory framework for environmental impact assessment and the placement of statutory conditions on approvals.	EPA, DEC
Wildlife Conservation Act 1950 Wildlife Conservation Regulations 1970	Provides protection for fauna and identifies fauna with conservation significance.	DEC
Environment Protection and Biodiversity Conservation Act 1999	Provides protection for matters of National Environmental Significance.	DEH
EPA Position Statement No. 3 (Terrestrial Biological Surveys as an Element of Biodiversity Protection in Western Australia, 2002)	Discusses the principles which the EPA will use when assessing proposals, which may impact on biodiversity values.	EPA
EPA Position Statement No. 2	Discusses the principles which the EPA will	EPA

(Environmental Protection of Native Vegetation in Western Australia 2000)	use when assessing proposals, which affect environmental processes at the landscape level and in its biodiversity.	

4 PROJECT WIDE TERRESTRIAL MANAGEMENT PRINCIPLES

This section outlines key issues to be managed for various elements relating to terrestrial construction. These details are then adopted for each aspect of the project to enable the AWA to meet the objectives specified in Section 3.1.

Specific management procedures (based on the general issues and management principles) for each element of the project are contained in Section 5 to Section 12 as follows:

- Section 5 Access roads;
- Section 6 Site offices/compound areas;
- Section 7 Haul roads;
- Section 8 Quinns main sewer;
- Section 9 WWTP site excavation;
- Section 10 Land based connection from WWTP to the launch site;
- Section 11 Launch site; and
- Section 12 Launch site dune crossing (through Bush Forever) and beach access corridor.

4.1 CONSTRUCTION MANAGEMENT

4.1.1 Background

Construction activities will be undertaken throughout the project area. At any one time there may be up to one hundred people on site working simultaneously. It is important that construction management procedures are in place to ensure that staff are conscious of the environmental constraints and that the necessary environmental management outcomes are achieved.

It will not be possible to protect the vegetation within areas of disturbance specified in Figure 3, as the use of the site necessitates clearing of all vegetation within the footprints outlined. However, the Alliance has sought to adopt designs that minimise clearing and will seek similar opportunities during construction to do the same. The entire site will be managed to ensure areas of disturbance remain within designated footprints so that the surrounding environment is kept in a condition which is representative of its pre-project condition.

4.1.2 Objectives

The objectives for construction management are;

- *Implement management measures within areas of disturbance to avoid impacts to the surrounding environment;*
- *to ensure that all construction activities remain within the specified footprints.*

4.1.3 Management framework

4.1.3.1 Management roles and responsibilities

The management roles and responsibilities are specified within Appendix D. The table outlines the management responsibilities and expectations of all key staff involved in carrying out the management procedures specified in the TCMP.

4.1.3.2 Staff inductions and training

Prior to works commencing, Package Managers and Site Supervisors will undertake an intensive site environmental induction program which will outline all the commitments and management measures contained in the following:

- Terrestrial Construction Management Plan;
- Fauna Management Plan;
- Seabed and Benthic Habitat Management and Monitoring Plan;
- Ocean Outfall Pipeline Construction Management Plan; and
- AWA Environmental Management Plan.

The Site Supervisors and Package Managers will be responsible for ensuring all site personnel have undertaken a general environmental induction and that they adhere to the conditions and commitments made in the above management plans.

The Site Environmental Coordinator will be on site to continuously offer environmental assistance and to interpret any commitments contained in management plans and guidelines, attend prestart meetings, complete regular internal audits to ensure that operational requirements are being undertaken and to alert management and implement management responses if audits indicate non-compliance. More information on the audit framework to be adopted during the project is contained in Section 14.

4.1.3.3 Boundary mark-out and fencing

Prior to ground disturbing activity the entire project area will be surveyed and pegged so that the extents of the project are clearly delineated. It is a requirement that all vehicles operate within the project boundaries and within fencing. All vehicles are to remain on designated access and haul roads when traversing to the various areas of operation.

Site fencing will be erected around the site to prevent recreational vehicles entering the site and driving through the project area, and the alignment for site fencing is shown in Figure 11. Fencing will be maintained to restrict recreational vehicles from entering the project area.

4.1.3.4 Ground disturbing works permit procedure

The Alkimos Wastewater Scheme will involve the progression of a number of working areas, often concurrently. Given these will be coordinated by separate supervisors it will be important to ensure that clearing is undertaken in a manner that complies with the various statutory approvals, detailed design and management plans.

A formal internal Ground Disturbing Works Permit (GDWP) procedure has been established and will be relevant for all aspects of the project. Within the GDWP form the Environment and Community Relations Manager and the Alliance Manager have the opportunity to apply conditions to the works. For example, the GDWP may stipulate the requirement for supervision during clearing or for clearing to be conducted using a particular method. These conditions must be adhered to when undertaking the ground disturbing activity.

Any works involving clearing of vegetation or excavation will always constitute ground disturbing works and the following procedure will be adopted.

- Prior to any ground disturbing works being undertaken a GDWP is to be approved. A copy of the GDWP form is contained in Appendix E. The GDWP form will be completed by the Works Supervisor representing the AWA or the contractor/subcontractor undertaking works on behalf of the AWA.
- GDWP form is to be submitted to the Environment and Community Relations Manager for review and approval/refusal (with or without specific conditions).
- GDWP form to be forwarded by Environment and Community Relations Manager to Alliance Manager for approval/refusal (with or without specific conditions).
- Approved GDWPs to be provided a unique GDWP number (for future reference and records purposes). The GDWP is to be uploaded onto the GDWP register and a copy is to be retained and filed by the Environment and Community Relations Manager.
- A copy of the signed GDWP is to be supplied to all relevant parties undertaking ground disturbing works (including sub contractors) and the conditions specific to the GDWP must be adhered to during the ground disturbing activities.
- Any non-compliance events are to be immediately reported to the Environment and Community Relations Manager and the Environmental Incident reporting process is to be initiated. A copy of the AWA Environmental Incident Form is attached in Appendix F.
- The Environment and Community Relations Manager will coordinate a monthly review of the GDWP's lodged, close out these when works are completed and audit the implementation of GDWPs to ensure compliance with GDWP conditions.

4.1.3.5 Staff contact details

A register of contact details for all site based staff will be established, maintained up to date and available to ensure quick resolution of emerging issues. A copy of the staff contact details is attached in Appendix G.

4.2 DIEBACK MANAGEMENT

4.2.1 Background

Dieback (*Phytophthora cinnamomi)* is a microbe that invades and destroys the function of the root system in a range of plants. Human activity causes the most significant, rapid and widespread distribution of the pathogen. Road construction, earthmoving, driving unclean vehicles and stock movement all contribute to the increased spread of Dieback.

Some of the vegetation surrounding the footprints is in "Excellent" condition and provides a habitat for local fauna. The Alkimos buffer zone will allow for the conservation of over 43 Ha of good quality Banksia woodland which is extremely susceptible to Dieback, and it is therefore important that every effort is made to prevent the spread of Dieback within the area during the time that the AWA is working there.

4.2.2 Objective

The primary objectives in relation to Dieback are;

- *to identify and manage infected areas (if any) so as to prevent the spread of Dieback further around the site area;*
- *to protect the areas that are Dieback free and to ensure they stay that way during the life of the project; and*
- *comply with any hygiene requirements as specified by DEC.*

4.2.3 Management framework

4.2.3.1 Plant and equipment hygiene procedure

A wide range of plant and equipment will be mobilised to the site. Given that plant and equipment may come from diverse locations and may potentially be carrying Dieback, it will be important to monitor the movements of vehicles and equipment and ensure that any dirty vehicles are decontaminated before entering the site. It will also be important to ensure that all equipment leaving the site is clean and free from any potentially deleterious materials prior to mobilising to the next destination. The procedure to be adopted is described below.

- All plant and equipment being mobilised to site will need to be washed down and cleaned of all soil and vegetation material prior to dispatch to site. The cleaning needs to be organised by the relevant Package Manager and Work Supervisors. Works Supervisors are to inspect plant and equipment ensuring that it is completely free of soil and vegetation and complete a Vehicle Hygiene Declaration Form (as shown in Appendix H). A copy of this form will be sent into the Site Environmental Coordinator via facsimile and a copy is to be retained with the plant/equipment for display upon arrival.
- All completed Vehicle Hygiene Declaration Forms need to arrive with the Site Environmental Coordinator at least 24 hours prior to plant/equipment arriving at the site.
- Upon arrival of plant/equipment to site will be inspected by the Site Environmental Coordinator or a representative appointed by the Site Environmental Coordinator to verify that assurances provided by the signed Vehicle Hygiene Declaration form are correct. If satisfied, the plant and equipment will be allowed entry. If the plant and equipment has not been cleaned to an appropriate standard it will not be permitted to be unloaded on to site, and it will need to be cleaned at a location off site and then reinspected upon return.

- A register is to be maintained by the Site Environmental Coordinator which contains all the completed Vehicle Hygiene Declaration forms.
- The Plant and Equipment Hygiene procedure is to be adopted for all plant and equipment when it is deployed offsite, and a wash down bay is to be installed at the main site office to facilitate this.

4.2.3.2 Dieback survey

Prior to any ground disturbing activities a reconnaissance Dieback survey will be undertaken by a qualified Dieback interpreter to ensure that all areas affected by Dieback are appropriately quarantined and that the pathogen is not spread across the site and particularly into areas where vegetation will be retained in the long term or into rehabilitated areas.

On completion of the Dieback survey, specific Dieback management protocols will be actioned to ensure vehicle movements are controlled and materials are managed to avoid the spread of the pathogen around the site (should identifiable infections be recorded). Specifically, Dieback infected areas will be clearly delineated on the ground and vehicle and personnel movements controlled in and out of these areas.

A Dieback Management Plan has been prepared following Dieback interpretation of the project area as recommended above (see Appendix I). The Dieback Management Plan outlines hygiene procedures which will be implemented during the project.

4.2.3.3 Wash down facilities

If Dieback is detected where site vehicles and plant/equipment must traverse a wash down facility will be installed and all plant/vehicles moving through the area will be required to go through a wash down station.

The wash down stations will remove and capture any Dieback infected soil attached to vehicles/plant and prevent Dieback spreading into Dieback free areas throughout the project area. A high pressure hose will be used to remove any attached soil, the runoff and sediment will be contained in a drain/sump situated within infected areas only, and not diverted into areas which are Dieback free.

4.2.3.4 Infected topsoil

Materials sourced from within infected areas, such as topsoil, vegetation brush and excavated soil will be managed to ensure they are stockpiled and reused within the designated infection area. Based on the existing earthworks schedule, the haul and access roads will be constructed in the summer and early autumn months, before significant autumn and winter rainfall is expected, therefore minimising transmission risks since site conditions should be reasonably dry during construction.

4.3 WEED MANAGEMENT

4.3.1 Background

The key principle for weed management during the project will be to ensure that areas retaining remnant vegetation in "Very Good" condition or better and have been subject to less weed invasion, are managed such that weed invasion is not increased to the extent that poses a threat to the ongoing viability of remnant vegetation.

The areas that will be most susceptible to weed infestation will be areas near existing weed infestation that are also adjacent to areas where works will be undertaken. Disturbance to the ground surface such as clearing without appropriate hygiene procedures can lead to rapid weed spread. Dr Arthur Weston's study of the Alkimos area in 2004-2005 found that approximately a quarter of the taxa recorded during field work were weed species.

Weeds, especially grasses, are abundant in the areas that have been cleared, where they have totally replaced the native vegetation, but several species are also common, and sometimes abundant, in the native vegetation. Most are Priority 3 (minor weeds), some are Priority 2 (nuisance weeds), and eight are Priority 1 (major weeds).

The Priority 1 species in the WWTP study area are *Avena spp., Ehrharta calycina*, *Euphorbia terracina, Gladiolus caryophyllaceus, Moraea flaccida, Lupinus cosentinii, Pelargonium capitatum* and *Romulea rosea*. A number of conspicuous, taller weeds, such as *Avena barbata, Ehrharta calycina, Euphorbia terracina* and *Gladiolus caryophyllaceus* are established in some bushland vegetation sparsely or in restricted areas, but some of the smaller weeds are widespread and abundant. These smaller weeds include *Briza maxima, Petrorhagia dubia, Hypochaeris glabra,Romulea rosea* and *Ursinia anthemoides* (Weston, 2005).

Due to the significant extent of weed invasion within the project area the only areas which will require control measures will be the rehabilitated areas and areas which currently have "Very Good" condition native vegetation and low density of weed infestation.

4.3.2 Objective

The primary objectives in relation to weed control are;

- *to ensure that the spread of weeds is minimised during construction; and*
- *to ensure that the spread of additional weed species is prevented.*

4.3.3 Management framework

A Plant and Equipment Vehicle Hygiene procedure is in place and is described in Section 4.2.3.1, which is relevant for controlling the dispersal of weeds.

Prior to works, a survey will be undertaken throughout the project area, specifically in areas adjacent to construction works. The survey will determine and demarcate areas that have been already subject to weed infestation and areas that are in "Very Good" condition or better.

For the duration of project, the areas in "Very Good" condition or better will be monitored to ensure that weed invasion is not increasing and that weeds are not affecting the condition of the intact remnant vegetation. Should weed invasion be occurring, appropriate weed control will be deployed involving chemical and/or physical control methods.

Prior to vegetation clearing and topsoil being stripped for site works, areas will be identified for topsoil management based on the degree of weed invasion (i.e. areas with low weed invasion will need to be carefully managed to preserve the native seed bank, whereas areas subject to high weed invasion will either be stockpiled to destroy the weed seed bank or deep buried at fill sites).

Outbreaks of larger woody and perennial weed species will be controlled through physical (manual removal) methods where possible, although should larger outbreaks occur, some chemical control may be required using spot spray or wick/wipe application techniques. In cases where surface disturbance could result from manual removal that could contribute to wind and/or water erosion, chemical control would be the preferred approach.

To be effective, the monitoring and control of weeds will need to extend outside of the directly affected areas of work and will need to include areas undisturbed by works that are already affected by weed invasion.

During the rehabilitation process weed management measures will be implemented as detailed in Section 4.7.3.4.

Site fencing is to be erected around the site to prevent recreational vehicles entering the site and driving through the project area, which will assist in the control of weed dispersal across the site.

4.4 FIRE MANAGEMENT

4.4.1 Background

There is a potential for a combination of natural fire fuel levels, high temperatures and strong winds during the construction of the Alkimos Wastewater Scheme, which could increase the fire risk. Frequent fires could lead to the decline in remnant vegetation values of surrounding areas.

The main factors for fire management include the prevention of ignition caused by human activity, site vehicles and weather, the deployment of fire fighting strategies, and the availability of suitably serviced equipment and trained personnel for fire response.

4.4.2 Objective

The objective for controlling fire out breaks during the project is:

- *to ensure that project activities do not lead to the out break of fires that pose a risk to the project activities or lead to the decline in remnant vegetation values in surrounding areas.*

4.4.3 Management framework

4.4.3.1 Firebreaks

There will be a number of firebreaks established around project where fences are to be situated, which is shown in Figure 11. These firebreaks will be a minimum of three metres wide and can be used for fire control access during any fire incidents.

4.4.3.2 Control of high risk activities

There will be no lighting of fires during any aspects of the works. This includes during clearing (i.e. no burning of cleared vegetation) or the disposal of waste materials.

Smoking of cigarettes will be prohibited within vehicles or other enclosed places. Smoking will be restricted to endorsed/designated smoking areas that are not vegetated (i.e. presenting a fire hazard). Cigarette butts are to be fully extinguished and not disposed of as litter. Smoking of cigarettes will not occur in areas outside the designated smoking areas. Purpose “butt disposal bins” will be provided at the designated smoking areas.

4.4.3.3 Plant equipment maintenance

All site plant and equipment will be regularly maintained and serviced to ensure that it is in good running order and its operation does not pose a fire risk. This will be particularly relevant for exhaust systems and moving parts that could become hot from wear and friction. All site personnel will be informed of the need to monitor plant and equipment during works and particularly at the beginning and end of each shift. Any issues should be reported immediately to Site Supervisors for further inspection and maintenance/servicing where necessary.

4.4.3.4 Weather conditions

In situations where weather conditions are particularly conducive to fire out break (i.e. very hot, dry and windy) Site Supervisors, in consultation with Package Managers and the Construction Manager, will review works scheduled to be undertaken during the shift and determine whether this needs to be altered in light of the increased fire risk posed. Should certain activities be postponed/ceased because of fire risk, all relevant site personnel and the Site Environmental Coordinator will be notified immediately and then notified again once the high fire risk has subsided.

4.4.3.5 Fire control

Fire extinguishers will be located in vehicles and all offices/workshops. These will be placed at strategic locations and site personnel will be informed of these locations and the appropriate use of these should a fire incident arise.

During the summer months the earthworks water cart will always be left full of water should this need to be mobilised quickly for fire control purposes.

4.4.3.6 Reporting fires

All project personnel will be required to immediately report any incidence of fire outbreak to the relevant Site Supervisor. The site supervisor will then be responsible for determining the appropriate response action.

In the event of a fire event being reported to any Site Supervisor, after ensuring that there are no immediate risks to human health or safety or site infrastructure and undertaking any immediate control actions, the Works Supervisor will immediately report this to the Construction Manager, and contact will also be made with the Fire and Emergency Services Authority (FESA), local Bush Fire Brigade and Local Emergency Management Advisory Committee (LEMAC). This notification will make these agencies aware of the incident and seek additional response assistance if required.

4.5 HYDROLOGY

4.5.1 Background

Surface water (runoff) generation is unlikely to be an issue during construction due to the permeable nature of the underlying soils. Given there are no existing surface water features on the site, potential impacts would be limited to disruptions to the existing water balance of the site, and potential impacts to groundwater quality from runoff contaminated by construction and support activities.

Four production bores for groundwater abstraction will be active to assist with dust suppression and compaction of the soil during earthworks. Surface runoff will not be directed outside of working areas, and will either infiltrate to groundwater or evaporate. Therefore, it is not anticipated there will be any significant impacts to the existing water balance of the site.

4.5.2 Objectives

The primary objectives in relation to hydrology management are:

- *to minimise changes to the water balance; and*
- *to manage potential impacts to groundwater quality.*

4.5.3 Management Framework

4.5.3.1 Table drains

Small table drains will be placed to redirect water from the site facilities/hardstand areas during heavy rainfall. Runoff will not be directed outside working areas to areas of remnant vegetation. Therefore, given that runoff water will not be exported from the site there are subsequently no anticipated impacts to the water balance of the site. The table drains will be maintained as necessary throughout the duration of the project.

4.5.3.2 Refuelling activities

Refuelling of equipment will either be carried out at the main site office and the earthworks workshop area or by mobile refuelling vehicles according to accepted industry practices. These activities will be undertaken on limestone hardstand areas only.

Spill response kits will be available in all site areas and with refuelling trucks for use in the event of a spill.

4.5.3.3 Ground water monitoring

There will be a total of four production bores within the site at various locations. The water from the production bores will be used for site offices and for construction works including compaction and dust suppression. The *Licence to Take Water* allows for the abstraction of 1 Gigalitre per year of groundwater.

As a requirement of the *Licence to Take Water* GWL NO.162181(1) (attached in Appendix J) issued by the Department of Water in April 2007, ground water levels in monitoring bores located around the site are to be measured on a monthly basis.

This will be the responsibility of the Site Environmental Coordinator or an appropriate delegate. The information collected will be forwarded to the Department of Water by 28 February each year that the licence is active.

Levels data collected from seven bores around the site will be stored in a spreadsheet and plotted to ensure that they remain consistent and that no significant drops in the water table occur during construction. If bores have dropped significantly it may be necessary to cease water abstraction in the area or to minimise the use of the production bore.

4.6 LANDFORM

4.6.1 Background

Landforms and soils within the project area are part of the Quindalup Dune Systems and Spearwood Dune Systems. The Quindalup Dunes are parabolic and coastal calcareous sand dunes and associated undulating landscapes, of different ages and with minimal soil profile development (McArthur and Bartle, 1980). There are six Quindalup dune system units in the study area: Q1, Q2, Q3, Q4, Qp and Qs, (see Figure 4). The Alkimos dune system has been identified as having geoheritage significance.

Due to the susceptibility to erosion by wind and water action coastal foreshores and dune systems require careful management. Areas of current instability already occur in the launch site area in the immediate coastal zone where the Q4 formation exists as shown in Plate 1 and Plate 2. Areas that are currently stable are so because of the vegetative cover, however this is highly susceptible to pressures such as recreational activities which occur regularly in the area. During the project it will be important to ensure that interfaces between working and adjacent areas are stable and do not cause the progression of landform instability into areas outside the working footprints.

4.6.2 Objectives

The objectives in relation to landform is:

- *to limit and minimise impacts to the dune features where practicable;*
- *to ensure that the dunes (within Bush Forever and Area 10b) are restored to a condition as good as if not better than the present condition; and*
- *ensure the stability of landforms at the interface between the working footprints and undisturbed areas.*

4.6.3 Management Framework

4.6.3.1 Design considerations

Modification of the landforms within the project area will be unavoidable, however, careful consideration has been given to the design and placement of the various footprints. Specifically the launch site and haul/access road locations have been selected to minimise impacts to significant landform features. In order to locate the outfall pipeline through an existing highly degraded blow-out area in the fore dune, the ocean outfall alignment was adjusted from that presented in the PER to an area 10 metres to the north. This also has the benefit of reducing the impact on limestone cliffs to the south of the excavation.

The design of the haul road aimed to minimise the impacts to Area 10b by reducing the footprint of disturbance. This was achieved by removing the access road and steepening the cut batters. The haul road will be constructed as a temporary road for use during construction activities and will be fully restored through re-contouring and rehabilitation to pre-disturbed levels upon completion of WWTP construction. The access road for entry to the WWTP was designed to avoid Area 10b as shown in Figure 3.

4.6.3.2 Management of landform instability and erosion

Monthly site inspections will identify areas being affected by wind or water erosion. Depending on the location and nature of the resultant erosion effects, one of a number of erosion control responses will be deployed. These would include heavy vegetation brushing, the installation of wind trap fencing (1.2m high fences made of shade cloth), use of liquid surface binding agents, or in the most severe cases the use of erosion matting.

This will be particularly relevant at the edges of disturbed areas where erosion has the potential to impact areas outside the delineated extent of works. A high priority will be placed on identifying and treating these areas to avoid such indirect impacts outside works areas.

4.7 REHABILITATION

4.7.1 Background

The scope for rehabilitation works varies depending on the long term goal for the various areas of the project. Some areas will be restored to achieve long-term biodiversity values and some areas will be revegetated to achieve short term landform stability given the long-term land use will not facilitate the retention of vegetation. The designated works footprints will be completely cleared of vegetation and the rehabilitation will begin from a bare site. Details of species lists and procedures specific to the various elements of the project can be found in Section 5 to Section 12.

Rehabilitation will only be applied to areas which will not contain permanent infrastructure, and AWA will not be rehabilitating the entire site. In some cases rehabilitation will be for stabilisation purposes as these areas will be required again for operations or for permanent infrastructure in the future (i.e. the launch site area and the base of the WWTP excavation).

Actions relating to minimising impacts have been detailed in the previous sections. Some measures that are outlines as part of clearing management, such as stockpiling portions of the topsoil and cleared vegetation separately will also provide benefits to improve the success of the rehabilitation program. In these instances the measures are outlined, however they may also have been previously addressed in clearing management. There are also measures that are specific to rehabilitation management.

The general approach for rehabilitation is as follows:

- Avoid disturbances wherever possible to minimise the amount of rehabilitation required.
- Topsoil and vegetative material will be managed (as outlined in Section 5B Section 12) to ensure the highest degree of reproductive material is preserved, which will minimise topsoil stockpiling and avoid vegetation mulching.
- Provenance seed will be collected from the pre-disturbance areas and across the wider WWTP buffer site and beyond.
- A combination of tubestock seedlings and direct seeding will be adopted to ensure the best outcomes in terms of both rapid establishment and botanical diversity.
- Revegetation will be undertaken without irrigation so planting of seedlings and direct seeding will be carried out between Autumn and early winter (depending on rainfall).
- Follow-up monitoring and maintenance will be required to ensure that revegetation is successful.

4.7.2 Objectives

The overall rehabilitation objective will be:

- *to rapidly stabilise with a vigorous cover of endemic vegetation areas where short term landform stabilisation is required; and*
- *to restore the previously existing flora characteristics to a state as good, if not exceeding previous condition in areas where future land use will allow the retention of remnant vegetation and conservation values.*

4.7.3 Management framework

4.7.3.1 Seed collection

Provenance seed will be collected from the project footprint areas. These areas can be collected at the highest rate. In other areas where vegetation will be retained in the long term, seed collection will need to be undertaken in a sustainable manner that does not affect the ongoing reproductive viability of that vegetation.

Seed collection contractors have already been engaged to collect local provenance seed during 2006 and 2007. Tubestock will be propagated by nurseries (ideally based in the local area) from provenance seed collected from the site. Nurseries will be accredited to ensure that tubestock is appropriately prepared and hardened and are free from pests and disease.

Due to schedule constraints there may be situations where it is not possible to collect adequate provenance seed and/or propagate sufficient tubestock from provenance seed supplies to satisfy the full annual rehabilitation requirements. In this case seed will be sourced from native seed suppliers who have sourced seed in the wider local area and this will be used to propagate tubestock and for direct seeding operations.

4.7.3.2 Brush Management

Brushing is when vegetation is added to eroding surfaces, such as dune surfaces, to increase stability and to reduce the wind velocity at the land surface. It also provides protection for young seedlings and helps to retain soil moisture.

Cleared vegetation will be pushed up and “raked” into stockpiles at the edge of the disturbed areas. It will be retained as brush and not mulched due to its beneficial properties in this form and ease to work with. Larger trees will be kept relatively intact and placed back into rehabilitation areas to provide a rougher surface to minimise wind and water erosion and also to provide ground dwelling fauna habitat.

Brushing material will be free from any weed material and applied to the site using appropriate placement techniques and methods. Stockpiled vegetation in “brush” form will then be applied back to the rehabilitation surface, which will provide some surface protection and also potentially provide some native seed bank. As the brush is applied the areas will be “track-rolled” using a dozer to ensure the profile is sufficiently compacted to achieve surface stability and that brush is secured.

The integrity of the brushing will need to be monitored and documented through the ongoing monitoring process.

4.7.3.3 Topsoil

A pre-disturbance topsoil assessment will be undertaken prior to earthworks commencing. This will identify the areas of best quality topsoil in terms of organic matter content, likely native seed bank, and avoidance of weed infested areas that are likely to carry high weed seed banks.

Sufficient topsoil will be identified to treat post-earthworks areas. Residual topsoil that is of lesser quality will not be retained and given its low organic matter content will be disposed of in fill areas. Better quality topsoil will be stripped (between 50 and 100mm), stockpiled in shallow windrows of no deeper than 1500 mm to preserve its biological properties and returned to rehabilitation areas as quickly as practical.

Topsoil will be stockpiled close to the works and within the construction footprint. The purpose of direct return and/or re-use of topsoil is to maximise the productivity of the seed bank that may be present.

Topsoil will be applied to the rehabilitated sites at a depth of up to 50 mm depending on the rehabilitation outcome required.

4.7.3.4 Direct seeding and tubestock

Once sufficient autumn/winter rain has been received and the soil profile is moist, direct seeding will be undertaken and tubestock seedlings planted. Direct seeding will be applied at a heavy rate that will ensure that post-germination emergence is reasonably dense and there is sufficient seed remaining for a following season germination.

Tubestock will be used in only those areas that require a high level of rehabilitation and restoration. Tubestock will be representative of the same species mix as the direct seeding and planted at a high density. Tubestock will also be planted with a slow release fertiliser to provide sufficient nutrients to establish the seedlings and develop healthy root systems. Any nurseries that supply tubestock to the project will be required to hold a current accreditation under the Nursery Industry Accreditation Scheme Australia (NIASA).

Tree-guards will not be used at the majority of the sites, given the windy environment and the likelihood of the tree-guards being blown away as experienced at other similar sites in the area. At Tamala Park tree guards have not been used and this has not had a negative impact on rehabilitation outcomes.

4.7.3.5 Weed control

Pre-revegetation weed invasion is not expected to be a major issue given the relatively short period of time the rehabilitated areas will be left bare and susceptible to weed invasion. However, there may be some areas where selective weed management is required to control grass weed species.

If necessary, initial weed control will be undertaken prior to the first rehabilitation planting/seeding. This will occur immediately after the first autumn/winter rains following construction and placement of vegetation brushing.

In all areas, chemical control will be used. A combination of selective spraying of grasses with Fusilade® and general spraying of glyphosphate will generally be adopted.

4.7.3.6 Herbivore control

Rehabilitation monitoring will involve tracking seed germination, evidence of water and/or wind erosion and investigating impacts to rehabilitated areas from herbivores (such as Kangaroos and Rabbits). Revegetated areas which are impacted by herbivores will be targeted during infill planting.

Rabbits are traditionally problematic and occur in high numbers along the coast. To minimise damage to rehabilitated areas from grazing Rabbits a baiting program using either Pindone or 1080 (sodium monofluroacetate) will be implemented the summer before planting occurs, this program will be conducted annually if required. The program will be undertaken by a suitably qualified animal and pest controller. The baiting regime and agent will be selected in consultation with relevant government departments and baiting will be completed with the objective of minimising the risk to native fauna in the area.

5 ACCESS ROADS

This section outlines the specific details and management measures for the site access roads. The general management measures outlined in Section 4 have been used as the basis and incorporated in the environmental management framework for the access roads.

A summary of the requirements for the specific management of the access roads including timing and the designation of responsibility for ensuring that these requirements are implemented is provided within various tables in Section 5.1 to Section 5.7.

5.1 DESIGN

The project will require site access to construction areas, which will be in operation simultaneously. There will be three access roads in operation throughout the project area. The access road from Romeo Rd to the WWTP will necessitate the clearing of an area of 1.55 Ha (within the buffer zone). An access road will be constructed connecting the WWTP to the launch site necessitating the clearing of approximately 0.8 Ha and an access road for the Quinns Main Sewer section within the buffer will also be required. The access roads are shown in Figure 3 and the specific area of disturbance for the access road to the WWTP is shown in Figure 12.

The WWTP access road and the launch site access road will consist of twin 3.5 metre unsealed individual lanes with a 0.5 metre hard shoulder. Clearing of the access road will be completed incrementally. The Quinns Main Sewer access road will consist of a 3 metre unsealed road.

The majority of the access road will be 'cut to fill' and therefore will not require large areas for spoil storage. The brush and topsoil collected from the access road will be stockpiled to the edge of the clearing limits along the access road and within other footprints of disturbance such as the launch site. The brush and topsoil removed from the road will be used for the rehabilitation of the area when required as outlined in Section 5.2.1.

The access road into the WWTP is a temporary road which has been designed to follow the alignment of the Romeo Road reserve and will remain only until surrounding development installs permanent east-west and north-south access and hence will require decommissioning and rehabilitation in accordance with the *Management and Rehabilitation of the Haul Road, Including Area 10b Management Plan*. The access roads were designed to avoid areas that support significant environmental values and to take advantage of the natural contours of the land, minimising disturbance from construction and earthworks. The access road to the WWTP was specifically designed to avoid Area 10b, which was recognised through the Alkimos Eglington Metropolitan Regional Scheme as having geomorphological significance and was subsequently offered up as conservation estate by the Water Corporation.

5.2 CONSTRUCTION

5.2.1 Disturbance management

The access roads will need to be cleared of all vegetation and this will necessitate the clearing of approximately 1.55ha (within the WWTP buffer zone). In order to comply with statutory approvals clearing for the access roads must remain within the allocated footprint approved. Specifically, the access road footprint into the WWTP has been designed and coordinates specified as shown in Figure 12.

Table 5.2.1 below specifically outlines the implementation schedule and responsibilities for ground disturbance management which will be followed to ensure the objectives specified in Section 4.1.2 are met.

Table 5.2.1 Implementation schedule and responsibilities for disturbance management for site access roads

Action Item Reference	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
AR-GD-PC-1	Undertake survey of the access roads and peg out alignment and boundaries	Earthworks Supervisor	At least one month before ground disturbing activity.	Environment and Community Relations Manager	Upon receiving the GDWP for the access roads.
AR-GD-PC-2	Conduct inductions for operational/management personnel.	Environment and Community Relations Manager	Prior to commencement of works.	Construction Manager	Prior to commencement of works.
AR-GD-PC-3	Prepare a GDWP and submit it to the Environment and Community Relations Manager as outlined in Section 4.1.2.	Site Supervisor	At least a week prior to ground disturbing activity.	Environment and Community Relations Manager	Upon receiving the GDWP.
Construction					
AR-GD-C-1	Clearly mark-out the extent of disturbance/clearing along the access road with fencing/signage.	Earthworks Supervisor	At least two weeks prior to commencement of vegetation clearing.	Earthworks Package Manager	At least one week prior to the intended commencement of vegetation clearing.
AR-GD-C-2	Review clearing is being completed as authorised within the GDWP.	Earthworks Supervisor	During ground disturbing activities.	Site Environmental Coordinator	During ground disturbing activities and at the completion of ground disturbing activities.
AR-GD-C-3	Review of vehicle movements to ensure that vehicles remain within fencing.	Earthworks Supervisor	Daily during construction works.	Site Environmental Coordinator	Daily during construction works.
AR-GD-C-4	Review GDWP to ensure that disturbance was within the approved boundary, mark up any variances with the permit. Follow up internally regarding the identified non-compliance with GDWP and report to the Alliance Manager.	Site Environmental Coordinator	At completion of construction.	Environment and Community Relations Manager	At completion of construction of the WWTP.
Operation					
AR-GD-O-1	Review vehicle movements to ensure that vehicles remain within areas authorised for disturbance only. If transgressions occur and vegetation is damaged notify the Site Environmental Coordinator who will advise on restoration measures where appropriate.	Earthworks Supervisor	Weekly during operations.	Site Environmental Coordinator	Weekly during operations.
AR-GD-O-2	Monitor and maintain of access road batters to ensure stability and deployment of further	Earthworks Supervisor	Weekly during operations.	Site Environmental Coordinator	Weekly during operations.

	stabilisation and management where required.				
Decommissioning					
AR-GD-D-1	Remove any signs/fencing installed.	Earthworks Supervisor	At completion of construction of the WWTP.	Site Environmental Coordinator	At completion of construction of the WWTP.

5.2.2 Dieback management

The access roads will facilitate the movement of light and heavy vehicles during the operational stage of the project. The movement of vehicles could potentially transport Dieback into other areas and/or spread existing infection within the project area. The major risk will be during the construction of the access roads.

Plant and equipment will be mobilised to site for construction of the access roads and without management there is the potential for Dieback to be transmitted to areas within the site. It is important to put in place management measures prior to site entry to reduce the risk of Dieback transmission.

On completion of works for the WWTP a post construction Dieback survey will be undertaken so that the effort to minimise any further spread of the pathogen along the access roads is maintained through appropriate quarantine procedures.

Table 5.2.2 below specifically outlines the implementation schedule and responsibilities for Dieback management to ensure the objectives specified in Section 4.2.2 are met.

Table 5.2.2 Implementation schedule and responsibilities for Dieback management for the access roads

Action Item Reference	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
AR-D-PC-1	Commission a Dieback interpreter to complete an preliminary Dieback survey across the project area.	Site Environmental Coordinator	Prior to any construction vehicle movements inside the WWTP buffer zone.	Environment and Community Relations Manager	Prior to the construction of the access roads.
AR-D-PC-2	Following advice from the Dieback interpreter implement management measures if not already specified within the management plan.	Site Environmental Coordinator	Prior to any construction vehicle movements inside the WWTP buffer zone.	Environment and Community Relations Manager	Following advice from Dieback interpreter.
AR-D-PC-3	Clearly delineate any areas infected with Dieback.	Site Environmental Coordinator	Prior to any construction vehicle movements inside the WWTP buffer zone.	Environment and Community Relations Manager	Weekly throughout project duration.
Construction					
AR-D-C-1	Ensure all plant and equipment have undertaken a Plant and Equipment Hygiene procedure as outlined in Section 4.2.1.	Work Supervisor	At least 24 hours prior to site entry.	Site Environmental Coordinator	Upon plant/ equipment arrival.
AR-D-C-2	If Dieback exists along access roads ensure that appropriate wash down facilities are installed as outlined in Section 4.2.3.3.	Earthworks Package Manager	Prior to vehicle movements along roads.	Environment and Community Relations Manager	Prior to vehicle movements along roads.
AR-D-C-3	If Dieback exists ensure infected topsoil kept separate from uninfected areas.	Earthworks Supervisor	During topsoil stripping.	Site Environmental Coordinator	Weekly during topsoil stripping.
AR-D-C-4	Construct table drains so that water is not diverted from infected areas into uninfected areas (if Dieback exists).	Earthworks Supervisor	During table drain construction.	Site Environmental Coordinator	Weekly during road construction.
Operation					
AR-D-O-1	Review vehicle movements to ensure that vehicles remain within areas authorised for disturbance only.	Earthworks Supervisor	Daily during operation of access roads.	Site Environmental Coordinator	Daily during operation of access roads.
AR-D-O-2	Monitor the vegetation condition, especially surrounding infected areas and if Dieback is spreading review Dieback management framework.	Site Environmental Coordinator	Monthly throughout the project duration.	Environment and Community Relations Manager	Monthly throughout the project duration.
AR-D-O-3	Commission a Dieback interpreter to undertake an annual Dieback survey	Site Environmental Coordinator	Annually throughout the project duration.	Environment and Community relations Manager	Annually throughout the project duration.

Decommissioning					
AR-D-D-1	Topsoil from infected areas is to remain within infected areas (if any).	Earthworks Supervisor	At completion of construction activities.	Site Environmental Coordinator	At completion of construction activities.
AR-D-D-2	Commission a Dieback interpreter to complete a Dieback survey post works and document results.	Site Environmental Coordinator	After rehabilitation.	Environment and Community relations Manager	After rehabilitation.

5.2.3 Weed management

Similar potential exists for the transportation and spread of weeds as for Dieback. The access roads will facilitate the movement of light and heavy vehicles during the operational stage of the project. The movement of vehicles along the access roads could potentially transport weeds from other site areas and/or spread existing weed species within the project area.

Plant and equipment will be mobilised to site for construction of the access roads with the potential for weeds to be introduced to surrounding vegetation. The access road into the WWTP is in close proximity to Area 10b as shown in Figure 3, therefore it is important to put in place management measures prior to site entry to reduce the spread of weeds into this area.

Table 5.2.3 below specifically outlines the implementation schedule and responsibilities for weed management to ensure the objectives specified in Section 4.3.2 are met.

Table 5.2.3 Implementation schedule and responsibilities for weed management for the access roads

Action Item Ref	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
AR-W-PC-1	Undertake a survey of the weed invasion within and surrounding the site, document findings.	Site Environmental Coordinator	Prior to any construction works commencing.	Environment and Community Relations Manager	Following survey and prior to any construction works commencing.
AR-W-PC-2	Establish and map areas which currently have "Very Good" quality vegetation and low weed infestation.	Site Environmental Coordinator	Prior to any construction works commencing.	Environment and Community Relations Manager	Following survey and prior to any construction works commencing.
Construction					
AR-W-C-1	Ensure all plant and equipment have undertaken a Plant and Equipment Hygiene procedure as outlined in Section 4.2.1.	Works Supervisor	At least 24 hours prior to site entry.	Site Environmental Coordinator	Upon plant/ equipment arrival.
AR-W-C-2	Review vehicle movements to ensure that vehicles remain on the access road alignment.	Earthworks Supervisor	Daily during road construction works.	Site Environmental Coordinator	Weekly during access road construction works.
Operation					
AR-W-O-1	Review vehicle movements to ensure that vehicles remain within areas authorised for disturbance.	Earthworks Supervisor	Daily during use of access roads.	Site Environmental Coordinator	Weekly during operations.
AR-W-O-2	Monitor the vegetation condition of areas specified in AR-W-PC-2 and implement weed control measures if necessary as outlined in Section 4.3.	Site Environmental Coordinator	Weekly throughout the project duration.	Environment and Community relations Manager	Monthly throughout the project duration.
Decommissioning					
AR-W-D-2	Monitor the vegetation condition of areas specified in AR-W-PC-2 and implement weed control measures if necessary as outlined in Section 4.3.	Site Environmental Coordinator	Spring after completion of works.	Environment and Community Relations Manager	Spring after completion of works.

5.2.4 Fire management

Fire management is particularly relevant to areas where works are taking place within or adjacent to vegetation and bushland areas. The majority of the access roads will be surrounded by vegetation, especially the access road into the WWTP and from the WWTP to the launch site.

Fire management measures will need to be implemented and monitored throughout the duration of the project, and all staff will need to understand evacuation procedures and site requirements specified in Section 4.4.3.2.

Table 5.2.4 below specifically outlines the implementation schedule and responsibilities for fire management which must be followed to ensure the objectives specified in Section 4.4.2 are met.

Table 5.2.4. Implementation schedule and responsibilities for fire management for the access roads

Action Item Ref	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
AR-PC-FM-1	Inductions of operational/management personnel, outline fire procedures as described in Section 4.4.	Environment and Community Relations Manager	Prior to commencement of works.	Construction Manager	Prior to commencement of works.
Construction					
AR-C-FM-1	Ensure that all vehicles in operation have a fire extinguisher on board.	Earthworks Supervisor	During road construction.	Site Environmental Coordinator	Monthly during construction.
AR-C-FM-2	Ensure that smoking is not occurring inside vehicles or outside designated smoking areas.	Site Supervisor	During road construction.	Site Environmental Coordinator	Weekly during road construction.
Operation					
AR-O-FM-1	During summer months water cart is to be left full of water.	Earthworks Supervisor	Daily during summer months throughout the project duration.	Site Environmental Coordinator	Daily during summer months throughout the project duration.
AR-O-FM-2	Ensure that smoking is not occurring inside vehicles or outside designated smoking areas.	Site Supervisor	During road operation.	Site Environmental Coordinator	Weekly during road operation.

5.2.5 Hydrology management

The Alkimos area is made up of coastal calcareous sand dunes which are highly permeable. The access roads will have a limestone hardstand surface which necessitates the construction of table drains to divert surface run-off away from the road surface during heavy rainfall events.

Construction water for dust suppression and compaction will be used along the alignment of the access roads throughout the duration of the project, construction water is sourced from ground water production bores at four locations within the project area. Abstraction from these production bores will be monitored monthly.

Table 5.2.5 below specifically outlines the implementation schedule and responsibilities for hydrology which must be followed to ensure the objectives specified in Section 4.5.2 are met.

Table 5.2.5 Implementation schedule and responsibilities for hydrology management for the access roads

Action Item Ref	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
AR-PC-H-1	Measure Department of Water monitoring bores as specified in the 'Licence to Take Water' as specified in Section 4.5.3.3.	Site Environmental Coordinator	Prior to production bore construction.	Site Environmental Coordinator	Monthly.
AR-PC-H-2	Order and allocate spill kits for plant/equipment which will be working along the access roads during construction.	Earthworks Supervisor	Prior to construction activities.	Environment and Community Relations Manager	Prior to construction activities.
Construction					
AR-C-H-1	Construct table drains along the hardstand areas to direct water away from the road surface during heavy rainfall events, ensure table drains do not divert water into adjacent vegetation.	Earthworks Supervisor	During road construction.	Site Environmental Coordinator	During road construction.
AR-C-H-2	Undertake refuelling on limestone hardstand areas only.	Earthworks Supervisor	During road construction.	Site Environmental Coordinator	Daily during construction.
AR-C-H-3	Install spill response kits in allocated plant and equipment.	Earthworks Supervisor	During road construction.	Site Environmental Coordinator	Weekly during construction.
Operation					
AR-O-H-1	Monitor and maintain table drains to ensure that they are free of debris and are providing adequately drainage for the access roads.	Earthworks Supervisor	Weekly after table drain construction.	Site Environmental Coordinator	Weekly throughout project duration.
HR-O-H-2	Measure Department of Water monitoring bores as specified in the 'Licence to Take Water' as specified in Section 4.5.3.3.	Site Environmental Coordinator	Monthly during ground water abstraction.	Environment and Community Relations Manager	Monthly.
AR-O-H-3	Ensure spill kits are located within close proximity to operations at all times.	Earthworks Supervisor	Weekly during operations.	Site Environmental Coordinator.	Monthly during operations.
AR-O-H-4	If spill kits are used/damaged replace immediately.	Earthworks Supervisor	Immediately after a spill kit has been used.	Site Environmental Coordinator	Monthly throughout project duration.

5.2.6 Landform management

Once the WWTP construction is complete the access roads will remain temporary for the purpose of construction and initial operation but will be replaced by the developers as and when the District Structure Plan/development front reaches the area south and west of the WWTP.

The access roads align predominantly through Q3 sections of the Quindalup dune formations. There will be a strong focus on maintaining the stability and structure of the dune systems so that they are not adversely affected by wind and water erosion during construction activities.

Table 5.2.6 below specifically outlines the implementation schedule and responsibilities for landform management which must be followed to ensure the objectives specified in Section 4.6.2 are met.

Table 5.2.6 Implementation schedule and responsibilities for landform management for the access roads

Action Item Ref	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
AR-PC-L-1	Undertake survey of the access roads and peg out alignment and boundaries.	Site Surveyor	At least one month before ground disturbing activity.	Environment and Community Relations Manager	Upon receiving the GDWP.
AR-PC-L-2	Install flagging around Area 10b (to the north of the access road) to prevent access.	Construction Manager	Prior to the construction of the access road.	Environment and Community Relations Manger	Prior to the construction of the access road.
Construction					
AR-C-L-1	Review vehicle movements and construction activities to ensure that vehicles remain within areas authorised for disturbance only. If transgressions occur and landform is undermined notify the Site Environmental Coordinator who will implement restoration measures as appropriate.	Earthworks Supervisor	Daily during construction works.	Site Environmental Coordinator	Daily during construction works.
AR-C-L-2	Stabilise construction batters using liquid stabilisers, matting and/or brush.	Earthworks Supervisor	At completion of access road construction	Environment and Community Relations Manager	At completion of access roads.
Operation					
AR-O-L-1	Review vehicle movements to ensure that vehicles remain within areas authorised for disturbance only. If transgressions occur and landform is undermined notify the Site Environmental Coordinator who will implement restoration measures as appropriate.	Earthworks Supervisor	Daily during operations.	Site Environmental Coordinator	Weekly during operations.
AR-O-L-2	Monitor and maintain access road batters to ensure the stability and deploy further stabilisation where required.	Earthworks Supervisor	Daily during operations.	Site Environmental Coordinator	Weekly during project duration.

5.2.7 Rehabilitation management

The access roads into the WWTP will be decommissioned and therefore re-establishing stable and diverse vegetation communities will be the long-term objective. The access road to the launch site, the QMS manhole and the recovery shaft for the land based WWTP and launch site connection may need to remain to allow for safe access to these areas for future maintenance purposes.

Rehabilitation of the access roads will involve:

- Spreading of topsoil;
- brushing;
- weed control;
- direct seeding; and
- monitoring and maintenance.

The road surfaces will be deep ripped to approximately 500 mm in order to break up the surface and relieve soil profile compaction. Rip line spacing will need to be sufficiently close enough to achieve full treatment of the road surfaces, and ideally a winged tyne would be used.

Direct seeding will be applied at a rate of 6kg/Ha. The quantity of seeds required is listed in Table 5.2.7a.

Table 5.2.7a Seed to be used in rehabilitation of the access roads

	Species	**% seed mix + tubestock (Tubestock used only in sewer areas within WWTP buffer)**
Tree	*Eucalyptus gomphocephalla*	1
Shrubs	*Acacia lasiocarpa*	10
	Acacia saligna	5
	Acanthocarpus preissii	10
	Hibbertia hypericoides	3
	Hibbertia subvaginata	3
	Leucopogon pauciflora	3
	Melaleuca systena	10
	Melaleuca huegelli	8
	Trymalium ledifolium	5
Herbs	*Phyllanthus calycinus*	5
	Gompholobium tomentosa	15
	Hardenbergia comptoniana	5
	Lepidosperma pubesquameum	5
	Conostylis pauciflora subsp. eury	2
	Desmocladus flexuosa	1
	Sarcozona bicarinata	3
	Threlkeldia diffusa	

Follow-up monitoring and maintenance will be required to ensure that revegetation is successful and batters have been effectively stabilised. This will continue for 12 months after the completion of the rehabilitation and revegetation and would identify issues such as weed invasion, wind or water erosion, and be the basis for maintenance activities.

Table 5.2.7 below specifically outlines the implementation schedule and responsibilities for rehabilitation which must be followed to ensure the objectives specified in Section 4.7.2 are met.

Table 5.2.7 Implementation schedule and responsibilities for rehabilitation management for the access roads

Action Item Ref	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
AR-PC-R-1	Collection of provenance seed material from areas within Lot 101 and surrounding areas.	Site Environmental Coordinator	Annually depending on seeding times for target species.	Environment and Community Relations Manager	At least six months prior to revegetation commencing.
Construction					
AR-C-R-1	Undertake topsoil quality assessment and formulate topsoil segregation/management approach accordingly.	Site Environmental Coordinator	Prior to clearing commencing.	Environment and Community Relations Manager	After topsoil assessment has been undertaken and prior to clearing commencing.
AR-C-R-2	Clear existing vegetation and push into brush piles at the edge of the road alignment. Aim to keep vegetation intact.	Earthworks Supervisor	Once topsoil assessment is completed.	Site Environmental Coordinator	During vegetation clearing.
AR-C-R-3	Strip topsoil and place into stockpiles at the edge of the road alignment and within defined area of disturbance. Aim to keep stockpiles less than 1,500mm deep.	Earthworks Supervisor	Once vegetation has been cleared.	Site Environmental Coordinator	During topsoil stripping.
Decommissioning					
AR-D-R-1	Undertake deep ripping of any hardstand areas along the road surface.	Earthworks Supervisor	At completion of the construction of the WWTP.	Site Environmental Coordinator	At completion of earthworks program.
AR-D-R-2	Spread topsoil and provide surface stabilisation measures where required.	Earthworks Supervisor	Following re-contouring.	Site Environmental Coordinator	Once topsoil has been spread.
AR-D-R-3	Spread brush on top-soiled landform and provide other surface stabilisation measures where required.	Earthworks Supervisor	Following spreading of topsoil.	Site Environmental Coordinator	Once brush has been placed and other surface stability measures have been deployed.
Rehabilitation					
AR-R-R-1	Undertake direct seeding.	Site Environmental Coordinator	After the break of the season (top 300mm of soil profile is wet).	Environment and Community Relations Manager	After direct seeding has taken place.
AR-R-R-2	Undertake the first monitoring event to track seed germination and evidence of water and/or wind erosion.	Site Environmental Coordinator	Following end of Spring (November) after direct seeding.	Environment and Community Relations Manager	Following end of Spring (November) after direct seeding.

AR-R-R-3	Undertake post works maintenance as required (including weed control).	Site Environmental Coordinator	December following direct seeding.	Environment and Community Relations Manager	Following end of Spring (November) after direct seeding.
AR-R-R-4	Undertake second monitoring event to track seed germination, evidence of water and/or wind erosion and/or impacts from herbivores. If necessary schedule infill direct seeding for late autumn/early winter.	Site Environmental Coordinator	Following end of Summer (February).	Environment and Community Relations Manager	Following end of Summer (February).
AR-R-R-5	Undertake maintenance as required.	Site Environmental Coordinator	February to March.	Environment and Community Relations Manager	February to March.
AR-R-R-6	Undertake any infill direct seeding as required.	Site Environmental Coordinator	Immediately following first autumn/winter rain event.	Environment and Community Relations Manager	Immediately following first autumn/winter rain event.

6 SITE OFFICES, WORKSHOP AND AMENITIES

This section outlines the specific details and management measures for the site office and compound areas. The general management measures outlined in Section 4 have been referred to and incorporated in the environmental management framework for the site office areas and compounds/workshops.

A summary of the requirements for the specific management of the site offices/compounds/workshops including timing and the designation of responsibility for ensuring that these requirements are implemented is provided within various tables in Section 6.1 to Section 6.7.

6.1 DESIGN

To safely accommodate all the staff during the life of the project, there will be three site offices installed. The AWA main site office is located at the end of the existing Romeo Road outside of the WWTP buffer area. The main site office was installed under the authority of a Development Approval (DA07/0219). A workshop and earthworks office, the marine office and a QMS site office will need to be installed within the project area.

The earthworks site office will be located at the north-west corner of the WWTP along with workshop/fuel store taking up an area of approximately 100m x 150m. A temporary marine site office and laydown area for pipe sections and equipment will be located within the launch site footprint with dimensions of 12m x 3m. The QMS laydown area will also house a site office. Both the QMS and launch site offices will have pump out ablution facilities, where as the earthworks site office will be serviced with septic tanks and leach drains.

Office areas will be graded and levelled and will be constructed to provide appropriate drainage. On completion of the works, the offices will be removed and the areas will be rehabilitated. The locations of the various offices is shown in Figure 11.

6.2 CONSTRUCTION

6.2.1 Disturbance management

People, vehicles and materials will be entering and exiting the site offices/workshop on a daily basis. It will be important to ensure that the works are maintained within the boundaries specified and that construction activity does not encroach into adjacent remnant vegetation.

Table 6.2.1 below specifically outlines the implementation schedule and responsibilities for the management of ground disturbance which must be followed to ensure the objectives specified in Section 4.1.2 are met.

Table 6.2.1 Implementation schedule and responsibilities for disturbance management for the site office, workshop and amenities

Action Item Reference	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
SO-GD-PC-1	Undertake survey of the site office/workshop areas and peg out boundaries.	Earthworks Supervisor	At least one month before ground disturbing activity.	Environment and Community Relations Manager	Prior to ground disturbing activities.
SO-GD-PC-2	Conduct inductions for operational/management personnel.	Environment and Community Relations Manager	Prior to commencement of works.	Construction Manager	Prior to commencement of works.
SO-GD-PC-3	Prepare a GDWP and submit it to the Environment and Community Relations Manager as outlined in Section 4.1.2.	Site Supervisor	At least a week prior to ground disturbing activity.	Environment and Community Relations Manager	Upon receiving the GDWP.
Construction					
SO-GD-C-1	Clearly mark-out the extent of disturbance/clearing with fencing, install signage.	Earthworks Supervisor	At least two weeks prior to commencement of vegetation clearing.	Earthworks Package Manager	At least one week prior to the intended commencement of vegetation clearing.
SO-GD-C-2	Review clearing is being completed as authorised within GDWP.	Earthworks Supervisor	During ground disturbing activities.	Site Environmental Coordinator	During ground disturbing activities and at the completion of ground disturbing activities.
SO-GD-C-3	Review GDWP to ensure that disturbance was within the approved boundary, mark up any variances with the permit and undertake rehabilitation of those areas as specified in Section 5.2.7. Follow up internally regarding the identified non compliance with the GDWP and report it to the Alliance Manager.	Site Environmental Coordinator	At completion of construction.	Environment and Community Relations Manager	At completion of earthworks program.
Operation					
SO-GD-O-1	Review of vehicle movements, placement of materials to ensure that disturbance remains within fenced areas. If transgressions occur and vegetation is damaged notify the Site Environmental Coordinator who will advise on restoration measures where appropriate.	Earthworks Supervisor	Weekly during operations.	Site Environmental Coordinator	Weekly during operations.
Decommissioning					

SO-GD-D-1	Remove any signs/fencing that was installed.	Earthworks Supervisor	At completion of construction of the WWTP.	Site Environmental Coordinator	At completion of construction of the WWTP.

6.2.2 Dieback management

The site office and compound areas, in particular the earthworks workshop will have vehicles, plant and equipment frequently passing through on a daily basis. It is therefore important that measures are in place within these areas to prevent the transmission of Dieback into and around the site.

Table 6.2.2 below specifically outlines the implementation schedule and responsibilities for Dieback management which must be followed to ensure the objectives specified in Section 4.2.2 are met.

Table 6.2.2 Implementation schedule and responsibilities for Dieback management for the site office, workshop and amenities

Action Item Reference	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
SO-D-PC-1	Commission a Dieback interpreter to complete an preliminary Dieback survey across the project area.	Site Environmental Coordinator	Prior to any vehicle movements within WWTP buffer zone.	Environment and Community Relations Manager	Prior to construction of site office areas.
SO-D-PC-2	Following advice from the Dieback interpreter develop management measures if not already specified within the management plan.	Site Environmental Coordinator	Prior to any vehicle movements within WWTP buffer zone.	Environment and Community Relations Manager	Prior to any vehicle movements along the access road.
SO-D-PC-3	Clearly delineate any areas infected with Dieback.	Site Environmental Coordinator	Prior to any vehicle movements within WWTP buffer zone.	Environment and Community Relations Manager	Weekly throughout project duration.
Construction					
SO-D-C-1	Ensure all plant and equipment have undertaken a Plant and Equipment Hygiene procedure as outlined in Section 4.2.1	Work supervisor	At least 24 hours prior to site entry.	Site Environmental Coordinator	Upon plant/ equipment arrival.
SO-D-C-2	Construct table drains so that water is not diverted from infected areas into an uninfected areas (if Dieback exists).	Earthworks Supervisor	During table drain construction.	Site Environmental Coordinator	Weekly throughout the project duration.
SO-D-C-3	Ensure water from wash down bays is captured and contained in a sump and does not run off into adjacent Dieback free vegetation.	Environment and Community Relations Manager.	During construction of the wash-down.	Site Environmental Coordinator.	Weekly throughout the project duration.
Operation					
SO-D-O-1	Review vehicle movements and material lay-down areas to ensure that vehicles remain within fenced areas.	Earthworks Supervisor	Daily during operation of site office area.	Site Environmental Coordinator	Daily during operation of site office area.
SO-D-O-2	Monitor the vegetation condition, especially surrounding infected area. If Dieback is spreading review Dieback management framework.	Site Environmental Coordinator	Monthly throughout the project duration.	Environment and Community relations Manager	Monthly throughout the project duration.
Decommissioning					
SO-D-D-1	Commission a Dieback interpreter to complete a post-works dieback survey and document results.	Site Environmental Coordinator	After rehabilitation and prior to handover to Water Corporation	Environment and Community relations Manager	After rehabilitation and prior to handover to Water Corporation

6.2.3 Weed management

Site office and workshop areas are predominantly within central locations for ease of movement around the site. It is therefore important that these areas remain clean and free of invasive weed species which may be transferred from vehicles and spread throughout the site.

There are sections of significant vegetation and landforms which have been marked for conservation purposes, especially to the north of the earthworks site office and workshop which is to be protected for the long term (Area 9), and it will extremely important to maintain control of weed proliferation, especially within the “Very Good” quality vegetation areas.

Table 6.2.3 below specifically outlines the implementation schedule and responsibilities for weed management which must be followed to ensure the objectives specified in Section 4.3.2 are met.

Table 6.2.3 Implementation schedule and responsibilities for weed management for the site office, workshop and amenities

Action Item Ref	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
SO-W-PC-1	Undertake a weed survey within and surrounding the site and document findings.	Site Environmental Coordinator	Prior to any works commencing.	Environment and Community Relations Manager	Following survey and prior to any works commencing.
SO-W-PC-2	Determine and map areas which currently have "Very Good" quality vegetation.	Site Environmental Coordinator	Prior to any works commencing.	Environment and Community Relations Manager	Following survey and prior to any works commencing.
Construction					
SO-W-C-1	Ensure all plant and equipment have undertaken a Plant and Equipment Hygiene procedure as outlined in Section 4.2.1.	Work supervisor	At least 24 hours prior to site entry.	Site Environmental Coordinator	Upon plant/ equipment arrival.
Operation					
SO-W-O-1	Review vehicle movements to ensure that vehicle and material lay-down areas remain within site office/compound boundaries	Construction Manager	Daily during use of the site office areas.	Site Environmental Coordinator	Weekly during use of the site office areas.
SO-W-O-2	Monitor the vegetation condition and weed intrusion (if any) and implement weed control measures if necessary as outlined in Section 4.3.	Site Environmental Coordinator	Monthly when required.	Environment and Community relations Manager	Monthly throughout the project duration.
SO-D-O-4	Ensure sediment from wash-down bays is captured and does not run off into adjacent vegetation.	Site Environmental Coordinator.	During operation of wash-down bays.	Environment and Community Relations Manager.	Monthly throughout the project duration.
Decommissioning					
SO-D-D-1	Monitor the vegetation condition and weed intrusion (if any) and implement weed control measures if necessary as outlined in Section 4.3.	Site Environmental Coordinator	Spring after completion of works.	Environment and Community Relations Manager	Spring after completion of works.

6.2.4 Fire management

Fire management is particularly relevant in areas where works are taking place that are within or adjacent to vegetation and bushland areas. Site office areas will be adjacent to vegetation and may house ignition sources such as chemicals, fuels etc.

Fire management measures will need to be implemented and monitored throughout the duration of the project, and all staff will need to understand any evacuation procedures and site requirements specified in Section 4.4.3.2.

Table 6.2.4 below specifically outlines the implementation schedule and responsibilities for fire management at site offices and workshops which must be followed to ensure the objectives specified in Section 4.4.2 are met.

Table 6.2.4 Implementation schedule and responsibilities for fire management for the site office, workshop and amenities

Action Item Ref	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
SO-PC-FM-1	Inductions of operational/management personnel, outline fire procedures as described in Section 4.4.	Environment and Community Relations Manager	Prior to commencement of works.	Construction Manager	Prior to commencement of works.
Construction					
SO-C-FM-1	Ensure that all vehicles in operation have a fire extinguisher on board.	Earthworks Supervisor	Weekly.	Site Environmental Coordinator	Weekly during construction.
SO-C-FM- 3	Allocate smoking areas and provide ash trays for cigarette butts	Environmental Coordinator	Prior to staff locating to the site office.	Environment and Community Relations Manager Site	First week of staff entering site office.
SO-C-FM- 4	Install smoke alarms in site office.	Construction Manager	Prior to staff entering the site office.	Site Environmental Coordinator	Prior to staff entering the site office.
Operation					
SO-O-FM-1	Ensure that smoking is restricted to authorised areas only and ensure cigarette butts are placed in cigarette buckets located on site and removed regularly.	Site Environmental Coordinator	Weekly during project duration.	Environment and Community Relations Manager	Monthly during operations.
SO-O-FM-2	Maintain firebreaks, ensure that they are clear of vegetation/waste.	Site Environmental Coordinator	Weekly during the time that the fence is in place.	Environment and Community Relations Manager	Monthly during the time that the fence is in place.
SO-O-FM-3	During summer months water cart is to be left full of water.	Earthworks Supervisor	Daily during summer months throughout the project duration.	Site Environmental Coordinator	Weekly during summer months throughout the project duration.
SO-O-FM-5	Ensure site office smoke alarms are in working order.	Site Office Manager	Monthly.	Site Environmental Coordinator	Quarterly.
SO-O-FM-6	Ensure fire extinguishers are present on site.	Site Environmental Coordinator	Weekly during project duration.	Environment and Community Relations Manager	Monthly during project duration.

6.2.5 Hydrology management

The site office areas are small in comparison to other elements of the project. It is unlikely that the construction of the site office areas will cause any detrimental effects to the overall hydrology of the area. Activities within the site office areas will need to be managed so that hydrocarbons and chemicals are adequately contained with the appropriate bunding and storage facilities and that the area is kept clean and does not pose any threat to the quality of the ground water.

Table 6.2.5 below specifically outlines the implementation schedule and responsibilities for hydrology management which must be followed to ensure the objectives specified in Section 4.5.2 are met.

Table 6.2.5 Implementation schedule and responsibilities for hydrology management for the site office, workshop and amenities

Action Item Ref	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
SO-PC-H-1	Order and allocate spill kits for offices and the workshop.	Earthworks Supervisor	Prior to construction activities.	Environment and Community Relations Manager	Prior to construction activities.
AR-C-H-3	Install spill response kits within the site office/workshop areas.	Earthworks Supervisor	Prior to construction works.	Site Environmental Coordinator	Prior to construction works.
Construction					
SO-C-H-1	Construct table drains to direct water away during heavy rainfall events, ensure table drains do not divert water into from working areas adjacent vegetation.	Earthworks Supervisor	During site office /compound construction.	Environment and Community Relations Manager	During site office /compound construction.
SO-C-H-2	Undertake refuelling on limestone hardstand areas only.	Earthworks Supervisor	During site office /compound construction.	Site Environmental Coordinator	Weekly during construction
Operation					
SO-O-H-1	Monitor and maintain table drains to ensure that they are free of debris and are providing adequate drainage.	Earthworks Supervisor	Weekly after table drain construction.	Site Environmental Coordinator	Weekly throughout the project duration.
SO-O-H-2	Ensure spill kits are in close proximity to operations at all times.	Earthworks Supervisor	Weekly during operations.	Site Environmental Coordinator.	Monthly during operations.
SO-O-H-3	If spill kits are used/damaged replace immediately.	Earthworks Supervisor	Immediately after a spill kit has been used.	Site Environmental Coordinator	Weekly throughout project duration.

6.2.6 Landform management

The marine site office will be within Q1 of the Quindalup Dune system and the earthworks workshop and site office falls within Q3. The marine office and the QMS site office will be within the existing footprint for the launch site and within the laydown area for the sewer. All site office areas will be fenced, however, it will be important to monitor any disturbance beyond the boundaries of the specific site office areas.

Table 6.2.6 below specifically outlines the implementation schedule and responsibilities for landform management for site offices and workshops which must be followed to ensure the objectives specified in Section 4.6.2 are met.

Table 6.2.6 Implementation schedule and responsibilities for landform management for the site office, workshop and amenities

Action Item Ref	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
SO-PC-L-1	Undertake survey of designated office/workshop areas and peg out boundaries	Earthworks Supervisor	At least one month before ground disturbing activity	Environment and Community Relations Manager	Upon receiving the GDWP
SO-PC-L-2	Install fencing around the site office and workshop areas.	Earthworks Supervisor	After survey and clearing has taken place	Environment and Community Relations Manager	Once fencing is installed.
Construction					
SO-C-L-1	Review vehicle movements and construction activities to ensure that works remain within areas authorised for disturbance only. If transgressions occur and landform is undermined notify the Site Environmental Coordinator who will direct restoration measures as appropriate.	Earthworks Supervisor	Daily during construction works.	Site Environmental Coordinator	Weekly during construction works
Operation					
SO-O-L-1	Review of vehicle movements, to ensure that vehicles remain within fenced areas. If transgressions occur and landform is undermined notify the Site Environmental Coordinator who will direct restoration measures as appropriate.	Earthworks Supervisor	Daily during operations.	Site Environmental Coordinator	Weekly during operations.
Decommissioning					
SO-D-L-1	Undertake restoration on the site areas, remove fencing and restore landform as much as practical.	Earthworks Supervisor	After the completion of the earthworks program	Environment and Community Relations Manager	After the completion of the earthworks program and prior to rehabilitation of the area

6.2.7 Rehabilitation management

The rehabilitation management of the site office areas has been incorporated into the rehabilitation management of various elements within the vicinity of the site offices.

The marine site office will be within the launch site footprint area, as a result of this rehabilitation seed density and species information will be the same as that specified for the rehabilitation of the launch site area as discussed in Section11.2.7.

Similarly, the QMS site office and earthworks site office and workshop will be rehabilitated as discussed in Section 8.2.7 and 9.2.7 respectively.

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7 HAUL ROADS

This section outlines the specific details and management measures for the haul roads. The general management measures outlined in Section 4 have been referred to and incorporated in the environmental management framework for the haul roads.

A summary of the requirements for the specific management of the haul roads including timing and the designation of responsibility for ensuring that these requirements are implemented is provided within various tables in Section 7.1 to Section 7.7.

7.1 DESIGN

Haul roads are required to transport excavated material from the WWTP and the launch site to the LandCorp fill site to the south of the excavation. The haul roads have been designed for 85 tonne haul trucks and the alignment (vertical and horizontal) of the haul roads was designed to achieve the necessary road design specifications in terms of vertical and horizontal sight lines and road geometries. For safety and efficiency, the haul roads need to be separated from general site traffic on the access roads. The haul roads consist of twin 8.5 metre unsealed individual lanes. The design speed for the haul roads will be 40km/hr for loaded trucks and 60km/hr for unloaded trucks. A total area of 3.69 ha will be cleared for haul roads within the WWTP buffer zone.

The haul roads were designed to minimise impacts to areas that support significant environmental values, in particular Area 10b, which forms part of a prominent landform associated with the third phase of the Quindalup Dune system. While the haul roads will involve clearing and disturbance to landform, the areas will be restored to its original condition through re-contouring the landform to pre-disturbed levels and conducting extensive revegetation of the area. The management of Area 10b has been addressed in a separate Management Plan (*Management and Rehabilitation of Haul Roads, including Area 10b).*

Clearing for the haul roads will be completed in a step-wise fashion. As the haul roads are temporary, stockpiling of cleared material and topsoil will be undertaken and rehabilitation will be undertaken once the WWTP construction phase has been completed. Further details on the rehabilitation of the haul roads is contained in the document *Management and Rehabilitation of Haul Roads, including Area 10b*.

7.2 CONSTRUCTION

7.2.1 Disturbance management

The design for the haul road aimed to minimise the inputs on Area 10b by reducing the footprint of disturbance. This was achieved by removing the access road and steepening the batters of the cut through the dune system. The haul road will be constructed as a temporary road for use during construction activities and will be fully restored through re-contouring to pre-disturbed levels and rehabilitation upon completion of WWTP construction.

Table 7.2.1 below specifically outlines the implementation schedule and responsibilities for disturbance management which must be followed to ensure the objectives specified in Section 4.1.2 are met.

Table 7.2.1 Implementation schedule and responsibilities for disturbance management for the haul road

Action Item Reference	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
HR-GD-PC-1	Undertake survey of the haul road areas and peg out alignment and boundaries.	Earthworks supervisor	At least one month before ground disturbing activity.	Environment and Community Relations Manager	Upon receiving the GDWP for the haul roads.
HR-GD-PC-2	Conduct inductions for operational/management personnel.	Environment and Community Relations Manager	Prior to commencement of works.	Construction Manager	Prior to commencement of works.
HR-GD-PC-3	Prepare a GDWP and submit it to the Environment and Community Relations Manager as outlined in Section 4.1.2.	Site Supervisor	At least a week prior to ground disturbing activity.	Environment and Community Relations Manager	Upon receiving the GDWP for the haul roads.
Construction					
HR-GD-C-1	Clearly mark-out the extent of disturbance/clearing with fencing/flagging, and erect signage.	Earthworks Supervisor	At least two weeks prior to commencement of vegetation clearing.	Earthworks Package Manager	At least one week prior to the intended commencement of vegetation clearing.
HR-GD-C-2	Review clearing is being completed as authorised within the GDWP.	Site Supervisor	During ground disturbing activities.	Site Environmental Coordinator	During ground disturbing activities and at the completion of ground disturbing activities.
HR-GD-C-3	Review GDWP to ensure that disturbance was contained within the approved boundary, mark up any variances with the permit and conduct rehabilitation of those areas as specified in Section 5.2.7. Follow up internally regarding the identified non-compliance with GDWP and report to the Alliance Manager.	Site Environmental Coordinator	At completion of construction.	Environment and Community Relations Manager	At completion of earthworks program.
Operation					
HR-GD-O-1	Review vehicle/plant movements to ensure that vehicles remain within areas authorised for disturbance only. If transgressions occur and vegetation is damaged notify the Site Environmental Coordinator who will advise on restoration measures where appropriate.	Earthworks Supervisor	Weekly during operations.	Site Environmental Coordinator	Weekly during operations.
HR-GD-O-2	Monitor and maintain of access road batters to ensure stability and deploy further stabilisation and management	Earthworks Supervisor	Weekly during operations.	Site Environmental Coordinator	Weekly during operations.

	where required.				
Decommissioning					
HR-GD-D-1	Remove any signs/fencing that was installed.	Earthworks Supervisor	At completion of construction of the WWTP.	Site Environmental Coordinator	At completion of construction of the WWTP.

7.2.2 Dieback management

The haul roads will facilitate the movement of earthmoving vehicles/equipment during the operation stage of the project, and movement of vehicles could potentially transport Dieback into other areas and/or spread existing infection within the project area. The main risk of Dieback transmission will be during the construction of the haul roads.

Plant and equipment will be mobilised to site for construction of the haul roads and for the movement of spoil from the WWTP excavation area into the fill site. The haul road into the WWTP goes though Area 10b as shown in Figure 3, therefore it is important to put in place management measures prior to site entry to reduce the risk of transmission.

Once the WWTP has been commissioned, the haul roads will be removed and the area will be re-contoured and rehabilitated back to the original condition. It will be important to undertake a post construction Dieback survey to ensure that the pathogen has not spread or been introduced into the surrounding areas.

Table 7.2.2 below specifically outlines the implementation schedule and responsibilities for Dieback management to ensure the objectives specified in Section 4.2.2 are met.

Table 7.2.2 Implementation schedule and responsibilities for Dieback management for the haul road

Action Item Reference	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
HR-D-PC-1	Commission a Dieback interpreter to complete an preliminary Dieback survey/ recommendations.	Site Environmental Coordinator	Prior to any construction vehicle movements within WWTP buffer zone.	Environment and Community Relations Manager	Prior to construction of the haul roads.
HR-D-PC-2	Following advice from the Dieback interpreter develop management measures if not already specified within the management plan.	Site Environmental Coordinator	Prior to any construction vehicle movements within WWTP buffer zone.	Environment and Community Relations Manager	Following advice from a Dieback interpreter.
HR-D-PC-3	Clearly delineate any areas infected with Dieback.	Site Environmental Coordinator	Prior to any construction vehicle movements within WWTP buffer zone.	Environment and Community Relations Manager	Prior to any construction vehicle movements within WWTP buffer zone.
Construction					
HR-D-C-1	Ensure all plant and equipment have undertaken a Plant and Equipment Hygiene procedure as outlined in Section 4.2.1	Work supervisor	At least 24 hours prior to site entry.	Site Environmental Coordinator	Upon plant/ equipment arrival.
HR-D-C-2	If Dieback exists along the haul road ensure that appropriate wash down facilities are installed as outlined in Section 4.2.3.3.	Earthworks Package Manager	Prior to vehicle movements along roads.	Environment and Community Relations Manager	Prior to vehicle movements along roads.
HR-D-C-3	If Dieback exists ensure infected topsoil is stripped and kept separate from uninfected spoil.	Earthworks Supervisor	During topsoil stripping.	Site Environmental Coordinator	Weekly during topsoil stripping.
HR-D-C-4	Construct table drains so that water is not diverted from an infected are into an uninfected area (if Dieback exists).	Earthworks Supervisor	During table drain construction.	Site Environmental Coordinator	Weekly during road construction.
Operation					
HR-D-O-1	Review vehicle movements to ensure that vehicles remain within areas authorised for disturbance only.	Earthworks Supervisor	Daily during operation of haul roads.	Site Environmental Coordinator	Weekly during operation of haul roads
HR-D-O-2	Monitor vegetation condition, especially surrounding infected areas and if Dieback is spreading review Dieback management framework	Site Environmental Coordinator	Monthly throughout the project duration.	Environment and Community Relations Manager	Monthly throughout the project duration.
Decommissioning					
HR-D-D-1	Topsoil from infected areas is to remain within	Earthworks Supervisor	At completion of construction	Site Environmental	At completion of

	infected areas (if any).		activities.	Coordinator	construction activities.
HR-D-D-2	Commission a Dieback interpreter to complete a Dieback survey post works and document results.	Site Environmental Coordinator	After rehabilitation	Environment and Community relations Manager	After rehabilitation.

7.2.3 Weed management

Similar potential exists for the transportation and spread of weeds as exist for Dieback. The haul roads will facilitate the movement of heavy vehicles and equipment during the operation stage of the project and the movement of vehicles along the haul roads especially during construction could potentially transport weeds from other site areas and/or spread existing weed species within the project area.

Plant and equipment will be mobilised to site for construction of the haul roads and for the excavation of the WWTP site with the potential for weeds to be introduced to surrounding vegetation. The haul road into the WWTP runs through Area 10b as shown in Figure 3, therefore it is important to put in place management measures prior to site entry to reduce the spread of weeds.

Table 7.2.3 below specifically outlines the implementation schedule and responsibilities for weed management to ensure the objectives specified in Section 4.3.2 are met.

Table 7.2.3 Implementation schedule and responsibilities for weed management for the haul road

Action Item Ref	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
HR-W-PC-1	Undertake a weed survey within and surrounding the haul roads and document findings.	Site Environmental Coordinator	Prior to any construction works commencing.	Environment and Community Relations Manager	Following survey and prior to construction works commencing.
HR-W-PC-2	Establish and map areas which currently have "Very Good" condition vegetation around haul roads.	Site Environmental Coordinator	Prior to any construction works commencing.	Environment and Community Relations Manager	Following survey and prior to any construction works commencing.
Construction					
HR-W-C-1	Ensure all plant and equipment have been subject to the Plant and Equipment Hygiene procedure as outlined in Section 4.2.1.	Work supervisor	At least 24 hours prior to site entry.	Site Environmental Coordinator	Upon plant/ equipment arrival.
HR-W-O-1	Review all vehicle movements to ensure that vehicles remain on the haul road alignment.	Earthworks Supervisor	Daily during haul road construction.	Ste Environmental Coordinator	Weekly during haul road construction.
Operation					
HR-W-O-1	Review vehicle movements to ensure that vehicles/plant remain within areas authorised for disturbance.	Earthworks Supervisor	Daily during operation of the haul road.	Site Environmental Coordinator	Weekly during operation of the haul road.
HR-W-O-2	Monitor the vegetation condition as outlined in HR-W-PC-2 and implement weed control measures if necessary as outlined in Section 4.3.	Site Environmental Coordinator	Weekly throughout operation of the haul road.	Environment and Community relations Manager	Monthly throughout operation of the haul road.
HR-D-O-4	Ensure sediment from wash-down bays is captured and does not run of into adjacent vegetation.	Environment and Community Relations Manager.	During operation of wash-down bays	Site Environmental Coordinator	Weekly throughout the project duration.
Decommissioning					
HR-D-D-1	Monitor the vegetation condition of areas specified in HR-W-PC-2 and implement weed control measures if necessary as outlined in Section 4.3.	Site Environmental Coordinator	Spring after completion of works.	Environment and Community relations Manager	Spring after completion of works.

7.2.4 Fire management

Fire management is particularly relevant in areas where works are taking place within or adjacent to vegetation and bushland areas. The majority of the haul road will be surrounded by vegetation and fire management measures will need to be implemented and monitored throughout the duration of the project. All staff will need to understand any evacuation procedures and site requirements specified in Section 4.4.3.2.

Table 7.2.4 below specifically outlines the implementation schedule and responsibilities for fire management for haul roads which must be followed to ensure the objectives specified in Section 4.4.2 are met.

Table 7.2.4 Implementation schedule and responsibilities for fire management for the haul road

Action Item Ref	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
HR-PC-FM-1	Inductions of operational/management personnel, outline fire procedures as described in Section 4.4.	Environment and Community Relations Manager	Prior to commencement of works.	Construction Manager	Prior to commencement of works.
Construction					
HR-C-FM-1	Ensure that all vehicles in operation have a fire extinguisher on board.	Earthworks Supervisor	During road construction.	Site Environmental Coordinator	Monthly during construction.
HR-C-FM-2	Ensure that smoking is not occurring inside vehicles or outside designated smoking areas.	Site Supervisor	During road construction.	Site Environmental Coordinator	Weekly during road construction.
Operation					
HR-O-FM-1	During summer months water cart is to be left full of water.	Earthworks Supervisor	Daily during summer months throughout the project duration.	Site Environmental Coordinator	Weekly during summer months throughout the project duration.
HR-O-FM-2	Ensure that smoking is not occurring inside vehicles or outside designated smoking areas.	Site Supervisor	During road operation.	Site Environmental Coordinator	Weekly during road operation.

7.2.5 Hydrology management

The haul roads will require the clearing of 3.69Ha of vegetation and once constructed will be repeatedly utilised by heavy vehicles and machinery. It is therefore important for safety reasons that the haul roads are effective in directing surface runoff away from the road surface.

Table drains and drainage measures will be constructed to divert surface runoff away from the road. All machinery and equipment are to be kept in good working order and management measures are in place to avoid any spills which may impact the quality of the ground water.

Table 7.2.5 below specifically outlines the implementation schedule and responsibilities for hydrology management for haul roads which must be followed to ensure the objectives specified in Section 4.5.2 are met.

Table 7.2.5 Implementation schedule and responsibilities for hydrology management for the haul roads

Action Item Ref	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
HR-PC-H-1	Measure Department of Water monitoring bores as specified in the 'Licence to Take Water' and described in Section 4.5.3.3.	Site Environmental Coordinator	Prior to bore construction.	Site Environmental Coordinator	Monthly.
HR-PC-H-2	Order and allocate spill kits to plant/equipment which will be working along the haul road during construction.	Earthworks Supervisor	Prior to construction activities.	Environment and Community Relations Manager	Prior to construction activities.
Construction					
HR-C-H-1	Construct table drains along roads to direct water away from the road surface during heavy rainfall events.	Earthworks Supervisor	During road construction.	Site Environmental Coordinator	During road construction.
HR-C-H-2	Undertake refuelling on limestone hardstand areas only.	Earthworks Supervisor	During road construction.	Site Environmental Coordinator	Daily during construction.
HR-C-H-3	Install spill response kits in allocated plant and equipment.	Earthworks Supervisor	During road construction.	Site Environmental Coordinator	Weekly during construction.
Operation					
HR-O-H-1	Monitor and maintain table drains to ensure that they are free of debris and are providing adequate drainage for the haul roads.	Earthworks Supervisor	Weekly after table drain construction.	Site Environmental Coordinator	Weekly throughout project duration.
HR-O-H-2	Measure Department of Water monitoring bores as specified in the 'Licence to Take Water' and described in Section 4.5.3.3.	Site Environmental Coordinator	Monthly during ground water abstraction.	Environment and Community Relations Manager.	Annually.
HR-O-H-2	If spill kits are used/damaged replace immediately.	Earthworks Supervisor	Immediately after a spill kit has been used.	Site Environmental Coordinator	Weekly throughout project duration.

7.2.6 Landform management

Based on the environmental assessment undertaken for both the Alkimos-Eglington MRS amendment and the Alkimos Wastewater Scheme PER, Area 10b does not support any regionally significant environmental vegetation. However as discussed above in Section 7.1 Area 10b was identified by the Water Corporation as having geomorphologic values, since the area forms part of a prominent landscape feature associated with the Quindalup Dune system (second phase, Q2). The haul road alignment was designed to avoid the most prominent and elevated parts of the dune within the Area10b and remaining alignment of the haul roads not within Area 10b.

Upon decommissioning of the haul road re-contouring of the land through Area 10b will take place. The haul roads will need to be monitored and managed to ensure that disturbance is restricted to the authorised footprint only.

Table 7.2.6 below specifically outlines the implementation schedule and responsibilities for landform management for the haul roads which must be followed to ensure the objectives specified in Section 4.6.2 are met.

Table 7.2.6 Implementation schedule and responsibilities for landform management for the haul road

Action Item Ref	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
HR-PC-L-1	Undertake a survey of the haul road and peg out alignment and boundaries.	Earthworks Supervisor	Prior to construction of the haul roads.	Environment and Community Relations Manager	Upon receiving the GDWP.
HR-PC-L-2	Prepare a GDWP and submit it to the Environment and Community Relations Manager as outlined in Section 4.1.2.	Site Supervisor	At least a week prior to ground disturbing activity.	Environment and Community Relations Manager	Upon receiving the GDWP for the haul roads.
HR-PC-L-3	Install flagging around Area 10b to prevent access.	Construction Manager	Prior to construction of the haul road.	Environment and Community Relations Manager	Prior to construction of the haul road.
Construction					
HR-C-L-1	Mark out clearing/disturbance extent for haul road through Area 10b.	Earthworks supervisor	At least two weeks prior to intended commencement of vegetation clearing.	Earthworks package manager	At least one week prior to intended commencement of vegetation clearing.
HR-C-L-2	Confirmation of marked-out clearing/disturbance extent.	Environment and Community Relations Manager	At least two days prior to intended commencement of vegetation clearing	Construction Manager	Prior to vegetation clearing commencing.
HR-C-L-3	Installation of fences along defined edge of disturbance.	Earthworks supervisor	Daily during clearing works.	Site Environmental Coordinator	During topsoil stripping.
HR-C-L-4	Daily review of clearing to ensure that clearing and other disturbances are retained within marked-out areas.	Earthworks Supervisor	Daily during clearing works.	Site Environmental Coordinator	Daily during clearing works.
HR-C-L-5	Stabilise construction batters using liquid stabilizers, matting and/or brush.	Earthworks Supervisor	At completion of haul road construction.	Environment and Community Relations Manager	At completion of haul road construction.
Operation					
HR-O-L-1	Review vehicle movements to ensure that vehicles remain within areas of authorised disturbance only. If transgressions occur and landform is undermined notify the Site Environmental Coordinator who will advise restoration measures as appropriate.	Earthworks Supervisor	Daily during operations.	Site Environmental Coordinator	Weekly during operations.
HR-O-L-2	Monitor and maintain haul road batters to ensure stability and	Site Environmental	Weekly during	Environment and	Monthly during

	deployment of further stabilisation/maintenance where required.	Coordinator	earthworks program.	Community Relations Manager	earthworks program.
Decommissioning					
HR-D-L-1	Remove fencing without causing clearing or disturbance to landform outside previously cleared areas.	Earthworks Supervisor	At completion of construction of the WWTP.	Site Environmental Coordinator	At completion of earthworks program.
HR-D-L-2	Undertake deep ripping of road surface.	Earthworks Supervisor	At completion of construction of the WWTP.	Site Environmental Coordinator	At completion of earthworks program.
HR-D-L-3	Backfill haul road profile to achieve contours of pre-disturbance landform (Area 10b section).	Earthworks Supervisor	Following deep ripping.	Earthworks Package Manager	Once backfill operations are completed.
HR-D-L-4	Monitor the area for erosion and implement erosion control measures as outlined in the *Management and Rehabilitation of the Haul Road, including Area 10b Plan.*	Site Environmental Coordinator	Monthly after re-contouring for 1year.	Environmental and Community Relations Manager	Quarter yearly after re-contouring for 1 year.

7.2.7 Rehabilitation management

The rehabilitation of the haul road will follow the detail specified in the *Management and Rehabilitation of the Haul Road, including Area 10b Plan.* Below are species lists as presented in the Area 10b management plan. For more specific details on rehabilitation of the haul road refer to this document.

Table 7.2.7a Species to be used in the rehabilitation of Area 10b and their mode of propagation

Species list	Mode of propagation
Acacia cochlearis	Direct seed and tubestock
Acacia lasiocarpa	Direct seed and tubestock
Acacia rostellifera	Direct seed and tubestock
Acacia saligna	Direct seed and tubestock
Banksia attenuata	Direct seed and tubestock
Desmocladus flexuosus	Direct seed and tubestock
Dryandra sessilis	Direct seed and tubestock
Eremophila glabra	Direct seed and tubestock
Exocarpos sparteus	Direct seed and tubestock
Hardenbergia comptoniana	Direct seed only
Hibbertia subvaginata	Tubestock only
Melaleuca huegelii	Direct seed only
Olearia axillaris	Direct seed and tubestock
Phyllanthus calycinus	Direct seed only
Rhagodia baccata	Direct seed and tubestock
Scaevola crassifolia	Direct seed and tubestock
Spyridium globulosum	Direct seed and tubestock
Threlkeldia diffusa	Direct seed and tubestock

Table 7.2.7b Species to be used in the rehabilitation of haul roads outside of Area 10b and their mode of propagation

Species list	**Mode of propagation**
Acacia cochlearis	Direct seed
Acacia lasiocarpa	Direct seed
Acacia rostellifera	Direct seed
Acacia saligna	Direct seed
Banksia attenuata	Direct seed
Desmocladus flexuosus	Direct seed
Dryandra sessilis	Direct seed
Eremophila glabra	Direct seed
Exocarpos sparteus	Direct seed
Hardenbergia comptoniana	Direct seed
Melaleuca huegelii	Direct seed
Olearia axillaris	Direct seed

Phyllanthus calycinus	Direct seed
Rhagodia baccata	Direct seed
Scaevola crassifolia	Direct seed
Spyridium globulosum	Direct seed
Threlkeldia diffusa	Direct seed

Follow-up monitoring and maintenance will be undertaken to ensure that revegetation is successful and the area has effectively stabilised. This will continue for 24-months after the completion of the initial rehabilitation and revegetation works and would identify issues such as weed invasion, wind or water erosion, and be the basis for maintenance activities.

Table 7.2.6 below specifically outlines the implementation schedule and responsibilities for rehabilitation which must be followed to ensure the objectives specified in Section 4.7.2 are met.

Table 7.2.6. Implementation schedule and responsibilities for rehabilitation management for the haul roads

Action Item Ref	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
HR-PC-R-1	Collection of provenance seed material from areas within Lot 101 and surrounding areas.	Site Environmental Coordinator	Annually depending on seeding times for target species.	Environment and Community Relations Manager	At least six months prior to revegetation commencing.
Construction					
HR-C-R-1	Undertake topsoil quality assessment and formulate topsoil segregation/management approach accordingly.	Site Environmental Coordinator	Prior to clearing commencing.	Environment and Community Relations Manager	After topsoil assessment has been undertaken and prior to clearing commencing.
HR-C-R-2	Clear existing vegetation and push into brush piles at the edge of the road alignment. Aim to keep vegetation intact.	Earthworks Supervisor	Once topsoil assessment is completed.	Site Environmental Coordinator	During vegetation clearing.
HR-C-R-3	Strip topsoil and place into stockpiles at the edge of the road alignment and within defined area of disturbance. Aim to keep stockpiles less than 1,500mm deep.	Earthworks Supervisor	Once vegetation has been cleared.	Site Environmental Coordinator	During topsoil stripping.
Decommissioning					
HR-D-R-1	Undertake deep ripping of any hardstand areas along the road surface.	Earthworks Supervisor	At completion of the construction of the WWTP.	Site Environmental Coordinator	At completion of earthworks program.
HR-D-R-2	Backfill haul road.	Earthworks Supervisor	Following deep ripping.	Earthworks Package Manager	Once backfill operations are completed.
HR-D-R-3	Spread topsoil over backfilled areas and provide other surface stabilisation measures where required.	Earthworks Supervisor	Following re-contouring.	Site Environmental Coordinator	Once topsoil has been spread.
HR-D-R-4	Spread brush on top-soiled areas and provide other surface stabilisation measures where required.	Earthworks Supervisor	Following spreading of topsoil.	Site Environmental Coordinator	Once brush has been place and other surface stability measures have been deployed.
Rehabilitation					
HR-R-R-1	Undertake direct seeding and tubestock planting.	Site Environmental Coordinator	After the break of the season (first 300mm of soil profile is wet).	Environment and Community Relations Manager	After direct seeding/planting has taken place.
HR-R-R-2	Undertake the first monitoring event to track seed germination and evidence of water and/or wind erosion.	Site Environmental Coordinator	Following end of Spring (November) after direct seeding.	Environment and Community Relations Manager	Following end of Spring (November) after direct seeding.

HR-R-R-3	Undertake post works maintenance as required (including weed control).	Site Environmental Coordinator	December following direct seeding.	Environment and Community Relations Manager	Following end of Spring (November) after direct seeding.
HR-R-R-4	Undertake second monitoring event to track seed germination, evidence of water and/or wind erosion and/or impacts from herbivores. If necessary schedule infill direct seeding for late autumn/early winter.	Site Environmental Coordinator	Following end of Summer (February).	Environment and Community Relations Manager	Following end of Summer (February).
HR-R-R-5	Undertake maintenance as required.	Site Environmental Coordinator	February to March.	Environment and Community Relations Manager	February to March.
HR-R-R-6	Undertake any infill direct seeding as required.	Site Environmental Coordinator	Immediately following first autumn/winter rain event.	Environment and Community Relations Manager	Immediately following first autumn/winter rain event.

8 QUINNS MAIN SEWER

This section outlines the specific details and management measures for the QMS within the WWTP buffer zone. The general management measures outlined in Section 4 have been referred to and incorporated in the environmental management framework for the Quinns Main Sewer. Clearing of native vegetation for the Quinns Main Sewer is authorised by the Part V Clearing Permit (CPS 1064/2) issued on the 9 August 2007.

A summary of the requirements for the specific management of the QMS including timing and the designation of responsibility for ensuring that these requirements are implemented is provided within various tables in Section 8.1 to Section 8.7.

8.1 DESIGN

The section of the Quinns Main Sewer situated within the WWTP buffer area will be constructed using both open cut trenching (cut and cover) and tunnelling techniques. Spoil will be excavated and placed on both sides of the trench. The sides of the trench will be battered.

A shaft (AC11) and lay-down area for pipe work will be installed at the conclusion of the trenched section for insertion of the Tunnel Boring Machine (TBM) which will facilitate tunnelling of the final section to the WWTP. The total area of disturbance within the WWTP buffer will be 6 Ha, which includes trenching and a lay down area required for the shaft. Once the sewer is constructed the trench will be backfilled and the areas within the WWTP buffer will be rehabilitated.

8.2 CONSTRUCTION

8.2.1 Disturbance management

Disturbance will be limited to areas designated in the Clearing Permit (CPS 1064/2) only (see Appendix B). Where tunnelling methods are adopted for installation of the sewer pipes, the degree of surface disturbance will be minimal and mostly restricted to the construction of access shafts and access roads. Tunnelling will be adopted for the majority of the alignment. There are sections of the Quinns Main Sewer that involve a cut and cover approach, and in these areas surface disturbance will be higher than for tunnelling.

Table 8.2.1 below specifically outlines the implementation schedule and responsibilities for ground disturbance management for the QMS which must be followed to ensure the objectives specified in Section 4.1.2 are met.

Table 8.2.1 Implementation schedule and responsibilities for disturbance management for ground disturbance

Action Item Reference	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
QMS-GD-PC-1	Undertake survey of the QMS alignment and peg out alignment and boundaries.	Sewer Supervisor	At least one month before ground disturbing activity.	Environment and Community Relations Manager	Upon receiving the GDWP.
QMS-GD-PC-2	Conduct inductions for operational/management personnel.	Environment and Community Relations Manager	Prior to commencement of works.	Construction Manager	Prior to commencement of works.
QMS-GD-PC-3	Prepare a GDWP and submit it to the Environment and Community Relations Manager as outlined in Section 4.1.2.	Sewer Supervisor	At least a week prior to ground disturbing activity.	Environment and Community Relations Manager	Upon receiving the GDWP.
Construction					
QMS-GD-C-1	Review clearing is being completed as authorised within a GDWP.	Sewer Supervisor	During ground disturbing activities.	Site Environmental Coordinator	During ground disturbing activities and at the completion of ground disturbing activities.
QMS-GD-C-2	Clearly mark-out the extent of disturbance/clearing with fencing, install signage.	Sewer Supervisor	At least two weeks prior to commencement of vegetation clearing.	Sewer Package Manager	At least one week prior to the intended commencement of vegetation clearing.
QMS-GD-D-3	Review GDWP to ensure that disturbance was within the approved boundary. Mark up any variances with the permit and conduct rehabilitation of those areas as specified in Section 5.2.7. Follow up internally regarding the identified non compliance with GDWP and report to the Alliance Manager.	Site Environmental Coordinator	At completion of construction of the QMS.	Environment and Community Relations Manager	At completion of sewer construction program.
Operation					
QMS-GD-O-1	Review of vehicle movements to ensure that vehicles remain within areas authorised for disturbance only. If transgressions occur and vegetation is damaged notify the Site Environmental Coordinator who will advise on restoration measures where appropriate.	Sewer Supervisor	Weekly during operations.	Site Environmental Coordinator	Weekly during operations.
QMS-GD-O-2	Monitor and maintain of batters to ensure stability and deployment of further stabilisation and management where required.	Sewer Supervisor	Weekly during operations.	Site Environmental Coordinator	Weekly during operations.

Decommissioning					
QMS-GD-D-1	Remove any signs/fencing that were installed.	Sewer Supervisor	At completion of construction of the QMS.	Site Environmental Coordinator	At completion of construction of the QMS.

8.2.2 Dieback management

The Quinns Main Sewer area will be an area of activity and vehicles, machinery and equipment will be moving through on a regular basis during the construction stage. The movement of vehicles/equipment along the access roads into the laydown area and along the trenched section of tunnel could potentially transport Dieback into adjacent areas and/or spread existing infection within the project area.

Table 8.2.2 below specifically outlines the implementation schedule and responsibilities for Dieback management for the QMS which must be followed to ensure the objectives specified in Section 4.2.2 are met.

Table 8.2.2 Implementation schedule and responsibilities for Dieback management for the Quinns Main Sewer

Action Item Reference	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
QMS-D-PC-1	Commission a Dieback interpreter to complete preliminary Dieback survey/recommendations.	Site Environmental Coordinator	Prior to any clearing.	Environment and Community Relations Manager	Prior to construction of the QMS.
QMS-D-PC-2	Following advice from the Dieback interpreter develop management measures if not already specified within the management plan.	Site Environmental Coordinator	Prior to any vehicle movements along the access road.	Environment and Community Relations Manager	Following advice from a Dieback interpreter.
QMS-D-PC-3	Clearly delineate any areas infected with Dieback.	Site Environmental Coordinator	Prior to any vehicle movements into the area.	Environment and Community Relations Manager	Weekly throughout project duration.
Construction					
QMS-D-C-1	Ensure all plant and equipment have undertaken a Plant and Equipment Hygiene procedure as outlined in Section 4.2.1	Sewer supervisor	At least 24 hours prior to site entry.	Site Environmental Coordinator	Upon plant/ equipment arrival.
QMS-D-C-2	If Dieback exists within the QMS area ensure that appropriate wash down facilities and installed.	Sewer Package Manager	Prior to vehicle movements within QMS area.	Environment and Community Relations Manager	Prior to vehicle movements within QMS area.
QMS-D-C-3	If Dieback exists ensure infected topsoil is stripped and kept separate from uninfected topsoil.	Sewer Supervisor	During topsoil stripping.	Site Environmental Coordinator	Weekly during topsoil stripping.
QMS-D-C-4	Construct table drains so that water is not diverted from infected areas into uninfected areas (if Dieback exists).	Sewer Supervisor	During table drain construction.	Site Environmental Coordinator	Weekly throughout the project duration.
QMS-D-C-5	Review vehicle movements to ensure that vehicles remain within areas authorised for disturbance only	Sewer Supervisor	Daily during construction works.	Site Environmental Coordinator	Weekly during construction works.
Decommissioning					
QMS-D-D-1	Topsoil from infected areas is to remain within infected areas (if any).	Site Environmental Coordinator	At completion of earthworks program.	Environment and Community relations Manager	At completion of earthworks program.
QMS-D-D-2	Commission a dieback interpreter to complete a Dieback survey post works and document results.	Site Environmental Coordinator	After rehabilitation.	Environment and Community relations Manager	After rehabilitation.

8.2.3 Weed management

Similar potential exists for the transportation and spread of weeds as exist for Dieback. Light vehicles, equipment and machinery will be frequently moving throughout the area during the project, and the movement of vehicles could potentially transport weeds from other site areas and/or spread existing weed species within the project area.

Plant and equipment will be mobilised to site for the shaft construction and tunnelling works, with the potential for weeds to be introduced to surrounding vegetation. It is therefore important that management measures are in place prior to site entry to reduce the spread of weeds.

Table 8.2.3 below specifically outlines the implementation schedule and responsibilities for weed management for the QMS which must be followed to ensure the objectives specified in Section 4.3.2 are met.

Table 8.2.3 Implementation schedule and responsibilities for weed management for the Quinns Main Sewer

Action Item Ref	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
QMS-W-PC-1	Undertake a survey of the weed invasion within and surrounding the site, document findings.	Site Environmental Coordinator	Prior to any construction works commencing.	Environment and Community Relations Manager	Following survey and prior to any construction works commencing.
QMS-W-PC-2	Establish and map areas which currently have "Good" condition vegetation.	Site Environmental Coordinator	Prior to any construction works commencing.	Environment and Community Relations Manager	Following survey and prior to any works commencing.
Construction					
QMS-W-C-1	Ensure all plant and equipment have undertaken a Plant and Equipment Hygiene procedure as outlined in Section 4.2.1.	Work supervisor	At least 24 hours prior to site entry.	Site Environmental Coordinator	Upon plant/ equipment arrival.
QMS-W-C-2	Review vehicle movements to ensure that vehicles and material lay-down areas remain within areas authorised for disturbance.	Earthworks Supervisor	Daily during construction.	Site Environmental Coordinator	Weekly during construction.
QMS-W-C-3	Monitor the vegetation condition and weed intrusion of areas specified in QMS-W-PC-2 and implement weed control measures if necessary as outlined in Section 4.3.	Site Environmental Coordinator	Weekly throughout the project duration.	Environment and Community relations Manager	Monthly throughout the project duration.
Decommissioning					
QMS-D-D-1	Monitor the vegetation condition and weed intrusion of areas specified in QMS-W-PC-2 and implement weed control measures if necessary as outlined in Section 4.3.	Site Environmental Coordinator	Spring after completion of works.	Environment and Community relations Manager	Spring after completion of works.

8.2.4 Fire management

Fire management is particularly relevant to areas where works are taking place within or adjacent to vegetation and bushland areas.

Fire management measures will need to be implemented and monitored throughout the duration of the project, all staff will need to understand any evacuation procedures and site requirements specified in Section 4.4.3.2.

Table 8.2.4 below specifically outlines the implementation schedule and responsibilities for fire management for the QMS which must be followed to ensure the objectives specified in Section 4.4.2 are met.

Table 8.2.4 Implementation schedule and responsibilities for fire management for the Quinns Main Sewer

Action Item Ref	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
QMS-PC-FM-1	Inductions of operational/management personnel to address fire procedures as described in Section 4.4.	Environment and Community Relations Manager	Prior to commencement of works.	Construction Manager	Prior to commencement of works.
Construction					
QMS-C-FM-1	Install site fencing with the appropriate firebreak of at least 3 metres wide along the fence line.	Sewer Supervisor	During clearing operations	Site Environmental Coordinator	After clearing of site office area has been completed.
QMS-C-FM-2	Ensure that all vehicles in operation have a fire extinguisher on board	Sewer Supervisor	During road construction	Site Environmental Coordinator	Weekly during construction.
QMS-C-FM- 3	Designate smoking areas and provide ash trays for cigarette butts	Environment and Community Relations Manager	Prior to staff locating to the site office	Site Environmental Coordinator	Weekly during construction.
Operation					
QMS-O-FM-1	Ensure that smoking is restricted to smoking areas only and ensure cigarette butts placed in cigarette buckets located on site and removed regularly.	Site Environmental Coordinator	Weekly during operations.	Environment and Community Relations Manager	Monthly during operations.
QMS-O-FM-2	During summer months water cart is to be left full of water	Sewer Supervisor	Daily during summer months throughout the project duration	Site Environmental Coordinator	Daily during operations.
QMS-O-FM-3	Ensure fire extinguishers are present on site.	Site Environmental Coordinator	Weekly during operations.	Environment and Community Relations Manager	Monthly during operations.

8.2.5 Hydrology management

The Alkimos area comprises coastal calcareous sand dunes which are highly permeable. The QMS laydown area will have a limestone hardstand surface which necessitates table drains to divert surface run-off away from the hard surface during heavy rainfall events. The runoff will not be diverted into areas with existing remnant vegetation.

Construction water for dust suppression and compaction will be sourced from ground water production bores at four locations within the project area, abstraction from these production bores will be monitored monthly.

Table 8.2.5 below specifically outlines the implementation schedule and responsibilities for hydrology management for the QMS which must be followed to ensure the objectives specified in Section 4.5.2 are met.

Table 8.2.5 Implementation schedule and responsibilities for hydrology management for the site Quinns main sewer

Action Item Ref	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
QMS-PC-H-1	Order and allocate spill kits for QMS works.	Sewer Supervisor	Prior to construction activities.	Environment and Community Relations Manager	Prior to construction activities.
Construction					
QMS-C-H-1	Install spill response kits in allocated plant and equipment and within site laydown area. .	Sewer Supervisor	Prior to construction.	Site Environmental Coordinator	Prior to construction/d.
QMS-C-H-2	Construct table drains to direct water away during heavy rainfall events, ensure table drains do not divert water into and smother adjacent vegetation.	Sewer Supervisor	During site office /compound construction.	Environment and Community Relations Manager	During construction activities.
QMS-C-H-3	Undertake refuelling on limestone hardstand areas only.	Sewer Supervisor	During site office /compound construction.	Site Environmental Coordinator	Daily during construction
Operation					
QMS-O-H-1	Monitor and maintain table drains to ensure that they are free of debris and are providing adequate drainage.	Sewer Supervisor	Weekly after table drain construction.	Site Environmental Coordinator	Weekly throughout project duration.
QMS-O-H-2	Ensure spill kits are in close proximity to operations at all times.	Sewer Supervisor	Weekly during operations.	Site Environmental Coordinator	Monthly during operations.
QMS-O-H-3	If spill kits are used/damaged replace immediately.	Sewer Supervisor	Immediately after a spill kit has been used.	Site Environmental Coordinator	Weekly throughout project duration.

8.2.6 Landform management

The QMS area is in close proximity to Area 10b a predominant landform protected for its geomorphological significance. A portion of the QMS will involve open trenching.

Table 8.2.6 below specifically outlines the implementation schedule and responsibilities for ground disturbance management for the QMS which must be followed to ensure the objectives specified in Section 4.6.2 are met.

Table 8.2.6 Implementation schedule and responsibilities for landform management for the Quinns Main Sewer

Action Item Ref	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
QMS-PC-L-1	Undertake survey of designated alignment and laydown area and peg out alignment and boundaries	Sewer Supervisor	At least one month before ground disturbing activity	Environment and Community Relations Manager	Upon receiving the GDWP
QMS-PC-L-2	Install site fencing to ensure works do not impact the surrounding vegetation and landform.	Sewer Supervisor	After survey and clearing has taken place	Environment and Community Relations Manager	Once fencing is installed.
Construction					
QMS-C-L-1	Review of vehicle movements to ensure that vehicles and construction activities remain with areas authorised for disturbance only. If transgressions occur and landform is undermined notify the Site Environmental Coordinator who will implement restoration measures as appropriate.	Sewer Supervisor	Daily during construction works.	Site Environmental Coordinator	Daily during construction works
QMS-C-L-2	Stabilise batters using liquid stabilisers, matting and/or brush.	Sewer Supervisor	At the completion of the trenched sections of the QMS.	Environment and Community Relations Manager	At the completion of the trenched sections of the QMS.
Operation					
QMS-O-L-1	Review of vehicle movements, material laydown areas to ensure that they remain within areas authorised for disturbance only. If transgressions occur and landform is undermined notify the Site Environmental Coordinator who will direct restoration measures as appropriate.	Sewer Supervisor	Daily during operations.	Site Environmental Coordinator	Weekly during operations.
QMS-O-L-2	Monitor and maintain trenches to ensure stability and deploy further stabilisation and management where required.	Sewer Supervisor	Daily during operations.	Site Environmental Coordinator	Weekly during operations.
Decommissioning					
QMS-D-L-1	Undertake restoration on the site areas, remove fencing and restore landform as much as practicable.	Sewer Supervisor	After the completion of the earthworks program	Environment and Community Relations Manager	After the completion of the earthworks program and prior to rehabilitation of the area

8.2.7 Rehabilitation management

Rehabilitation of cut and cover areas for the QMS will involve:

- Spreading of topsoil;
- Brushing;
- Weed control;
- Direct seeding;
- Tubestock planting; and
- Monitoring and Maintenance.

On completion of the cut and cover sections of the QMS excavation the site will be backfilled. Direct seeding will be applied at a rate of 6 kg/Ha, and tubestock will be planted at a density of 1 plant for every 2 square metres. The proportion of seeds and the numbers of tubestock required is containedin Table 8.2.7a.

Table 8.2.7a Seed and tubestock to be used in rehabilitation of the cut and cover sewer

	Species	**% seed mix + tubestock**
Tree	*Eucalyptus gomphocephalla*	1
Shrubs	*Acacia lasiocarpa*	10
	Acacia saligna	5
	Acanthocarpus preissii	10
	Hibbertia hypericoides	3
	Hibbertia subvaginata	3
	Leucopogon pauciflora	3
	Melaleuca systena	10
	Melaleuca huegelli	8
	Trymalium ledifolium	5
Herbs	*Phyllanthus calycinus*	5
	Gompholobium tomentosa	15
	Hardenbergia comptoniana	5
	Lepidosperma pubesquameum	5
	Conostylis pauciflora subsp. eury	2
	Desmocladus flexuosa	1
	Sarcozona bicarinata	3
	Threlkeldia diffusa	

Note: Tubestock will only be used in the WWTP buffer and in areas to be retained in the long term.

Follow-up monitoring and maintenance will be required to ensure that revegetation is successful. This will continue for 12 months after the completion of the rehabilitation and revegetation and will identify issues such as weed invasion, wind or water erosion, and be the basis for maintenance activities. Table 8.2.7 below specifically outlines the implementation schedule and responsibilities for ground rehabilitation management which must be followed to ensure the objectives specified in Section 4.7.2 are met.

Table 8.2.7 Implementation schedule and responsibilities for rehabilitation management for the Quinns Main Sewer

Action Item Ref	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
QMS-PC-R-1	Collection of provenance seed material from areas within Lot 101 and surrounding areas	Site Environmental Coordinator	Annually depending on seeding times for target species	Environment and Community Relations Manager	At least six months prior to revegetation commencing
Construction					
QMS-C-R-1	Undertake topsoil quality assessment and formulate topsoil segregation/management approach accordingly	Site Environmental Coordinator	Prior to clearing commencing	Environment and Community Relations Manager	After topsoil assessment has been undertaken and prior to clearing commencing.
QMS-C-R-2	Clear existing vegetation and push into brush piles at the edge of the road alignment. Aim to keep vegetation intact.	Sewer Supervisor	Once topsoil assessment is completed	Site Environmental Coordinator	During vegetation clearing
QMS-C-R-3	Strip topsoil and place into stockpiles at the edge of the batters or lay down areas within defined area of disturbance. Aim to keep stockpiles less than 1,500mm deep	Sewer Supervisor	Once vegetation has been cleared	Site Environmental Coordinator	During topsoil stripping
Decommissioning					
QMS-D-R-1	Undertake deep ripping of any hardstand areas.	Sewer Supervisor	At completion of the construction of the QMS	Site Environmental Coordinator	At completion of earthworks program
QMS-D-R-2	Backfill trenched areas.	Sewer Supervisor	Following deep ripping	Earthworks Package Manager	Once backfill operations are completed
QMS-D-R-3	Spread topsoil (100mm) over backfilled areas and provide other surface stabilisation measures where required	Sewer Supervisor	Following re-contouring	Site Environmental Coordinator	Once topsoil has been spread
QMS-D-R-4	Spread brush on top-soiled landform and provide other surface stabilisation measures where required	Sewer Supervisor	Following spreading of topsoil	Site Environmental Coordinator	Once brush has been place and other surface stability measures have been deployed.
Rehabilitation					
QMS-R-R-1	Undertake direct seeding	Site Environmental Coordinator	After the break of the season (first 300mm of soil profile is wet)	Environment and Community Relations Manager	After direct seeding has taken place
QMS-R-R-2	Undertake the first monitoring event to track seed germination and evidence of water and/or wind erosion.	Site Environmental Coordinator	Following end of Spring (November) after direct seeding	Environment and Community Relations Manager	Following end of Spring (November) after direct seeding

QMS-R-R-3	Undertake post works maintenance as required (including weed control).	Site Environmental Coordinator	December following direct seeding	Environment and Community Relations Manager	Following end of Spring (November) after direct seeding
QMS-R-R-4	Undertake second monitoring event to track seed germination, evidence of water and/or wind erosion and/or impacts from herbivores. If necessary schedule infill direct seeding for late autumn/early winter.	Site Environmental Coordinator	Following end of Summer (February)	Environment and Community Relations Manager	Following end of Summer (February)
QMS-R-R-5	Undertake maintenance as require	Site Environmental Coordinator	February to March	Environment and Community Relations Manager	February to March
QMS-R-R-6	Undertake any infill direct seeding as required.	Site Environmental Coordinator	Immediately following first autumn/winter rain event	Environment and Community Relations Manager	Immediately following first autumn/winter rain event

9 WWTP SITE EXCAVATION

This section outlines the specific details and management measures for the site WWTP excavation area. The general management measures outlined in Section 4 have been referred to and incorporated in the environmental management framework for the WWTP excavation area

A summary of the requirements for the specific management of the WWTP excavation area including timing and the designation of responsibility for ensuring that these requirements are implemented is provided within various tables in Section 9.1 to Section 9.7.

9.1 DESIGN

The ultimate capacity of the WWTP is proposed to be 160ML/d, however this capacity is not expected to be required until beyond 2050. Initially a 20ML/d WWTP will be installed at the site, which will utilise a footprint approximately one quarter of the size of that required for a 160ML/d plant. Due to geotechnical conditions, drill and blast is required as part of the earthworks program. On this basis, a step-wise excavation of the WWTP site in line with plant expansion requirements would not be feasible as future blasting may affect the existing plant's structural integrity. Since the WWTP earthworks cannot be undertaken progressively, the WWTP site will be prepared for the ultimate capacity, requiring the excavation and removal of approximately 2 million cubic metres of spoil that will be fully cleared of vegetation. This will provide for holistic planning of the rehabilitation of the WWTP site batters and avoid putting the constructed WWTP plant at risk through blasting in close proximity in the future.

The site excavation works will require a fleet of earthmoving equipment including excavators, dozers, graders, dump trucks and water carts. Portions of the footprint will be excavated to floor levels founded at RL2.6m and RL5m AHD. The majority of the footprint will be excavated to between approximately RL11.5-15m AHD.

The site will be cleared of all vegetation and topsoil in a step-wise fashion. An area of approximately 29.5 Ha will be cleared over a period of approximately 25 days. The vegetation will not be mulched, rather it will be pushed into stockpiles remaining in "brush" form. Topsoil will be stripped within the WWTP site and used for rehabilitation of the batters. Where sequencing will allow, topsoil will be stripped from one location and immediately placed where rehabilitation works are active. In all other instances where immediate re-use is not possible, topsoil will be stockpiled for later re-spreading as required, or incorporated in the fill.

Excavated material from the WWTP site will be trucked via haul roads and disposed of as fill within LandCorp's development fill site to the south of the WWTP. Haul road alignments are shown in Figure 3. Ground water production bores as mentioned in Section 4.5.3.3 will be located within the area to assist with compaction and dust suppression.

The WWTP site final levels will be battered back to a grade that will vary depending on the geology, and it is proposed that the batters will have a final grade of 1V:2.5H in sand and 1V:1.75H in rock. This will provide a high degree of geotechnical stability and provide a sound basis for rehabilitation. These batters will comprise both loose course sand and consolidated limestone at depth.

Rehabilitation of the WWTP sand batters will be undertaken progressively as excavation proceeds. This will involve respreading topsoil and cleared vegetation in "brush" form, planting tubestock and direct seeding using provenance seed collected throughout the area in 2006 and 2007. Revegetating the sand batters will ensure long-term stability and prevent wind and water erosion onsite. Approximately 10 Ha of the WWTP footprint will be rehabilitated after works have been completed (not including WWTP floor area). A 1.2 metre high, ring-lock fence will be erected around the project area. The fencing alignment is shown in Figure 11.

9.2 CONSTRUCTION

9.2.1 Disturbance management

The WWTP excavation will cause the greatest amount of ground disturbance. It requires an estimated two million cubic metres of spoil to be removed and a total of approximately 29.5 Ha of clearing to be completed in a relatively short timeframe. It is therefore important that the disturbance is managed appropriately so that all disturbance remains in designated foot prints as outlined in Figure 13.

Table 9.2.1 below specifically outlines the implementation schedule and responsibilities for ground disturbance management for the WWTP earthworks which will be followed to ensure the objectives specified in Section 4.1.2 are met.

Table 9.2.1 Implementation schedule and responsibilities for disturbance management for the WWTP excavations

Action Item Reference	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
W-GD-PC-1	Undertake survey of the WWTP excavation area and mark out boundaries.	Earthworks Supervisor	At least one month before ground disturbing activity.	Environment and Community Relations Manager	Upon receiving the GDWP.
W-GD-PC-2	Conduct inductions for operational/management personnel.	Environment and Community Relations Manager	Prior to commencement of works.	Construction Manager	Prior to commencement of works.
W-GD-PC-3	Prepare a GDWP and submit it to the Environment and Community Relations Manager as outlined in Section 4.1.2.	Earthworks Supervisor	At least a week prior to ground disturbing activity.	Environment and Community Relations Manager	Upon receiving the GDWP.
Construction					
W-GD-C-1	Clearly mark-out the extent of disturbance/clearing with fencing, install signage	Earthworks Supervisor	Once clearing has been completed.	Earthworks Package Manager	Once week after clearing has been completed.
W-GD-C-2	Clear incrementally and do not create islands where fauna could potentially get stranded.	Earthworks Supervisor	Daily during ground disturbing activities.	Site Environmental Coordinator	Daily during ground disturbing activities
W-GD-C-3	Review clearing is being completed as authorised within the GDWP.	Earthworks Supervisor	During ground disturbing activities.	Site Environmental Coordinator	During ground disturbing activities and at the completion of ground disturbing activities.
W-GD-C-4	Review vehicle movements and construction activities to ensure that vehicles remain within areas authorised for disturbance only. If transgressions occur and vegetation is damaged notify the Site Environmental Coordinator who will advise on restoration measures where appropriate.	Earthworks Supervisor	Daily during construction works.	Site Environmental Coordinator	Daily during construction works.

9.2.2 Dieback management

During the implementation of the WWTP excavations vehicles will be moving in and out of the area. Haul trucks and equipment will travel from the WWTP excavation area along haul roads into the fill site and back again on a regular basis, new equipment will be mobilised to site and demobilised off site. There is potential for Dieback to spread into and throughout the project area if the pathogen is not properly managed during the excavation stage of the project.

Table 9.2.2 below specifically outlines the implementation schedule and responsibilities for Dieback management which must be followed to ensure the objectives specified in Section 4.2.2 are met.

Table 9.2.2 Implementation schedule and responsibilities for Dieback management for the WWTP excavation

Action Item Reference	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
W-D-PC-1	Commission a Dieback interpreter to complete an preliminary Dieback survey.	Site Environmental Coordinator	Prior to any vehicle movements inside WWTP buffer zone.	Environment and Community Relations Manager	Prior to the WWTP excavation.
W-D-PC-2	Following advice from the Dieback interpreter develop management measures if not already specified within the management plan.	Site Environmental Coordinator	Prior to any vehicle movements inside WWTP buffer zone.	Environment and Community Relations Manager	Following advise from Dieback interpreter.
W-D-PC-3	Clearly delineate any areas infected with Dieback.	Site Environmental Coordinator	Prior to any vehicle movements inside WWTP buffer zone..	Environment and Community Relations Manager	Weekly throughout project duration.
Construction					
W-D-C-1	Ensure all plant and equipment have been subject to the a Plant and Equipment Hygiene procedure as outlined in Section 4.2.1	Earthworks supervisor	At least 24 hours prior to site entry.	Site Environmental Coordinator	Upon plant/ equipment arrival.
W-D-C-2	If Dieback exists within the WWTP area ensure that appropriate wash down facilities are installed.	Earthworks Package Manager	Prior to vehicle movements within WWTP area.	Site Environmental Coordinator	Prior to vehicle movements within WWTP area.
W-D-C-3	If Dieback exists ensure infected topsoil is stripped and kept separate from uninfected areas.	Earthworks Supervisor	During topsoil stripping.	Site Environmental Coordinator	Weekly during topsoil stripping.
W-D-C-4	Construct drainage so that water is not diverted from infected areas into an uninfected area (if Dieback exists).	Earthworks Supervisor	During drainage construction.	Site Environmental Coordinator	Weekly throughout the project duration.
W-D-C-1	Review of vehicle movements, material lay-down areas to ensure they remain within areas authorised for disturbance only.	Earthworks Supervisor	Daily during operations.	Site Environmental Coordinator	Weekly during operations.
W-D-C-2	Monitor the vegetation condition, especially surrounding infected areas, if Dieback is spreading review Dieback management framework.	Site Environmental Coordinator	Monthly throughout the project duration.	Environment and Community Relations Manager	Monthly throughout the project duration.

9.2.3 Weed management

Similar potential exists for the transportation and spread of weeds as exist for Dieback. Light vehicles, haulage equipment and machinery will be frequently moving throughout the area during the WWTP excavations and the movement of vehicles could potentially transport weeds from other site areas and/or spread existing weed species within the project area. In particular the haulage equipment will be transporting spoil from the WWTP area along haul roads into the fill site several times a day.

Plant and equipment will be mobilised to site for excavation of the WWTP, with the potential for weed to be introduced to surrounding vegetation. The MhMs vegetation to the north of the WWTP site is currently vegetation which is in “Good” to “Very Good” condition and this will need to be maintained during the course of excavations for the WWTP site.

Table 9.2.3 below specifically outlines the implementation schedule and responsibilities for weed management for the WWTP excavations to ensure the objectives specified in Section 4.3.2 are met.

Table 9.2.3 Implementation schedule and responsibilities for weed management for the WWTP excavation

Action Item Ref	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
W-W-PC-1	Undertake a survey of the weed invasion within and surrounding the site and document findings.	Site Environmental Coordinator	Prior to any construction works commencing.	Environment and Community Relations Manager	Following survey and prior to any construction works commencing.
W-W-PC-2	Establish and map areas which currently have "Very Good" condition vegetation.	Site Environmental Coordinator	Prior to any construction works commencing.	Environment and Community Relations Manager	Following survey and prior to any construction works commencing.
Construction					
W-W-C-1	Ensure all plant and equipment have been subject to the Plant and Equipment Hygiene procedure as outlined in Section 4.2.1.	Earthworks supervisor	At least 24 hours prior to site entry.	Site Environmental Coordinator	Upon plant/ equipment arrival.
W-W-C-2	Review vehicle movements to ensure that vehicles and material lay-down areas remain within boundaries.	Construction Manager	Daily during WWTP excavation.	Site Environmental Coordinator	Weekly during WWTP excavation.
W-W-C-3	Monitor the vegetation condition and weed of areas specified in W-W-PC-2 and implement weed control measures if necessary as outlined in Section 4.3.	Site Environmental Coordinator	Weekly throughout the project duration.	Environment and Community relations Manager	Monthly throughout the project duration.

9.2.4 Fire management

Fire management is particularly relevant to areas where works are taking place within or adjacent to vegetation and bushland areas.

Fire management measures will need to be implemented and monitored throughout the duration of the WWTP excavations and all staff will need to understand evacuation procedures and site requirements specified in Section 4.4.3.2.

Table 9.2.4 below specifically outlines the implementation schedule and responsibilities for fire management for WWTP excavations which must be followed to ensure the objectives specified in Section 4.4.2 are met.

Table 9.2. Implementation schedule and responsibilities for fire management for the WWTP excavation site

Action Item Ref	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
W-PC-FM-1	Inductions of operational/management personnel, outline fire procedures as described in Section 4.4.	Environment and Community Relations Manager	Prior to commencement of works.	Construction Manager	Prior to commencement of works.
Construction					
W-C-FM-1	Install site fencing with the minimum firebreak width of 3 metres back along the fence line.	Earthworks Supervisor	During clearing operations.	Site Environmental Coordinator	After clearing of site office area has been completed.
W-C-FM-2	Monitor to ensure that all vehicles in operation have a fire extinguisher on board.	Earthworks Supervisor	During construction.	Site Environmental Coordinator	Weekly during construction.
W-C-FM-3	Ensure that smoking is restricted to designated areas only and ensure cigarette butts are placed in cigarette buckets located on site and removed regularly.	Site Environmental Coordinator	Weekly during works.	Environment and Community Relations Manager	Weekly during works.
W-C-FM-4	During summer months water cart is to be left full of water.	Earthworks Supervisor	Daily during summer months throughout the project duration.	Site Environmental Coordinator	Daily during summer months throughout the project duration.
W-C-FM-5	Ensure fire extinguishers are present on site.	Site Environmental Coordinator	Weekly during project duration.	Environment and Community Relations Manager	Monthly.

9.2.5 Hydrology management

The Alkimos area is made up of coastal calcareous sand dunes which are highly permeable. The water table is below the reduced level (RL) to be excavated so no dewatering is required. Due to the size of the site, surface runoff may be generated during heavy rainfall events. Cut-off bunding will be installed around the top of the excavation to ensure that run-off will not flow down excavation batters. Any surface run-off water within the excavation area will be contained within table drains which will allow for percolation through the soil profile and the permeable nature of the underlying soils will infiltrate water quickly. Runoff needs to be managed to avoid disturbance/impacts to adjacent remnant vegetation.

Construction water for dust suppression and compaction will be sourced from ground water production bores at four locations within the project area, abstraction from these production bores will be monitored monthly.

Given that there are no existing surface water features on the site, the potential impacts are limited to disruptions to the existing water balance of the site, and impacts to groundwater quality from runoff contaminated by construction and support activities.

Table 9.2.5 below specifically outlines the implementation schedule and responsibilities for hydrology for the WWTP excavations which must be followed to ensure the objectives specified in Section 4.5.2 are met.

Table 9.2.5. Implementation schedule and responsibilities for hydrology management for the WWTP excavation

Action Item Ref	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
W-PC-H-1	Measure Department of Water monitoring bores as specified in the 'Licence to Take Water' and described in Section 4.5.3.3.	Site Environmental Coordinator	Prior to production bore construction.	Site Environmental Coordinator	Monthly
W-PC-H-2	Order and allocate spill kits to plant/equipment which will be working within the WWTP excavation area.	Earthworks Supervisor	Prior to construction activities.	Environment and Community Relations Manager	Prior to construction activities.
Construction					
W-C-H-1	Construct appropriate bunding around top of the excavation to prevent any runoff from rainfall events cascading down batters.	Earthworks Supervisor	During the WWTP excavation.	Site Environmental Coordinator	During the WWTP excavation.
W-C-H-2	Construct table drains (if required) within the WWTP excavation area to contain any run-off generated during rainfall events.	Earthworks Supervisor	During the WWTP excavation.	Site Environmental Coordinator	During the WWTP excavation.
W-C-H-3	Undertake refuelling offsite or with mobile refuelling vehicles on hard stand areas and within workshop areas.	Earthworks Supervisor	During the WWTP excavation.	Site Environmental Coordinator	During the WWTP excavation.
W-C-H-4	Install spill response kits in allocated plant and equipment.	Earthworks Supervisor	During road construction.	Site Environmental Coordinator	Weekly during construction
W-C-H-5	Allow for surface runoff to infiltrate to groundwater within table drains.	Earthworks Supervisor	During construction.	Site Environmental Coordinator	During Construction.
W-C-H-6	Monitor and maintain table drains to ensure that they are free of debris and are providing adequately drainage for the access roads.	Earthworks Supervisor	Weekly after table drain construction.	Site Environmental Coordinator	Weekly during project duration
W-C-H-7	Measure Department of Water monitoring bores as specified in the 'Licence to Take Water' and described in Section 4.5.3.3.	Site Environmental Coordinator	Monthly whilst ground water abstraction is taking place.	Site Environmental Coordinator	Yearly whilst ground water abstraction is taking place.
W-C-H-8	Monitor cut-off bunding to ensure it is intact and in working order.	Site Environmental Coordinator	Weekly after bunding is installed.	Environment and Community Relations Manager	Monthly bunding is installed.
W-C-H-9	If spill kits are used/damaged replace immediately.	Earthworks Supervisor	Immediately after a spill kit has been used.	Site Environmental Coordinator	Weekly during project duration

9.2.6 Landform management

The WWTP site is located predominantly within the Q3 system the excavation severs the link between the Q3 and Q2 systems. The alliance has been working towards reducing the size of the excavation and minimising impacts to the dunal landforms.

To the north of the WWTP excavation is an area of outstanding regional significance known as Area 9. The area contains a consolidated vegetated area of Quindalup Dunes and it is also important habitat for Carnaby's Cockatoo. AWA will be particularly diligent to avoid any disturbance to the vegetation values of the area arising from construction activities.

The disturbed footprint will be permanent as it will be the location of the WWTP. The excavation batters will be rehabilitated to provide stability and to maintain native vegetation within the project area. Management will focus on maintaining the surrounding vegetation and landforms.

Table 9.2.6 below specifically outlines the implementation schedule and responsibilities for landform management for the WWTP excavations which must be followed to ensure the objectives specified in Section 4.6.2 are met.

Table 9.2.6 Implementation schedule and responsibilities for landform management for the WWTP excavation

Action Item Ref	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
W-PC-L-1	Undertake survey of the WWTP site area and peg out boundaries.	Earthworks Supervisor	At least one month before ground disturbing activity	Environment and Community Relations Manager	Prior to ground disturbing activities.
W-PC-L-1	Ensure the WWTP footprint is within the area specified for clearing within the GDWP.	Earthworks Supervisor	Prior to ground disturbing activities.	Environment and Community Relations Manager	Prior to ground disturbing activities.
Construction					
W-C-L-1	Review of vehicle movements to ensure that vehicles remain within fenced areas.	Earthworks Supervisor	Daily during the excavation.	Site Environmental Coordinator	Daily during the excavation.
W-C-L-2	Excavate down to design levels and ensure batters have correct gradient.	Earthworks Supervisor	Daily during the excavation.	Environment and Community Relations Manager	Weekly during the excavation.
W-C-L-3	Initially stabilise any batters using liquid stabilisers, matting and/or brush.	Earthworks Supervisor	Incrementally during the excavation.	Environment and Community Relations Manager	Weekly until the area is rehabilitated.
W-C-L-4	Monitor the surrounding area around the WWTP excavation for signs of erosion, and if any, report to the Environment and Community Relations Manager for stabilisation.	Earthworks Supervisor	Weekly during the excavation period.	Site Environmental Coordinator	Weekly during the excavation period.
W-C-L-5	Monitor and maintain batters to ensure the stability and deployment of further stabilisation and management where required.	Earthworks Supervisor	Daily during construction works.	Site Environmental Coordinator	Weekly during project duration.

9.2.7 Rehabilitation management of WWTP batters

The construction of the WWTP involves excavating into limestone. Geotechnical information indicates these batters will be situated in solid limestone with variably soft and partially cemented limestone above (at the limestone-sand interface) and in isolated pockets within the solid limestone, with course siliceous sand above Quindalup sands).

The primary objective for rehabilitation of this area is to stabilise the slopes, particularly from wind erosion using brushing and establishing locally occurring species that can tolerate exposed windy conditions.

The batters will not be restored to their original landform and it is likely the soil profile of the batters will be different from the original profile, due to excavation and construction required for the WWTP.

Rehabilitation of the excavation batters will involve:

- Spreading of topsoil;
- Brushing;
- Weed control;
- Direct seeding;
- Tubestock planting;
- Infill planting; and
- Monitoring and Maintenance.

The excavation batter areas will be revegetated as soon as practical to limit wind erosion. Direct seeding will be applied at a rate of 6 kg/Ha, and tubestock will be planted at a density of 1 plant for every 2 square metres. The proportion of seeds and tubestock required is illustrated in Table 9.2.7a.

Table 9.2.7a Seed and Tubestock to be used in rehabilitation of the excavation batters.

	Species	**% seed mix + tubestock**
Tree	*Eucalyptus gomphocephalla*	5
Shrubs	*Acacia cyclops*	5
	Acacia saligna	10
	Acacia lasiocarpa	5
	Melaleuca systena	8
	Rhagodia baccata	10
	Olearia axillaris	10
	Acanthocarpus preissii	7
	Spyridium globulosum	5
	Scaevola crassifolia	5
Herbs	*Hardenbergia comptoniana*	5
	Phyllanthus calycinus	5
	Gompholobium tomenstosum	5
	Threlkeldia diffusa	3
	Austrostipa flavescens	3
	Kennedia prostrata	4
	Conostylis candicans	5

Follow-up monitoring and maintenance will be required to ensure revegetation is successful and batters have been effectively stabilised. This will continue for two years following rehabilitation and revegetation and will identify issues such as weed invasion, death of seedlings, predation, wind or water erosion, and be the basis for maintenance activities.

Quadrats will be set up within the excavation batter area to cover approximately 4% of the area.

Infill planting and seeding will be conducted over two years, with the first year at 20% of the initial application rate (1.2 kg/Ha for direct seeding and 1 plant every 10 m² for tubestock). The second year infill planting and seeding will be conducted at 10% of the initial density (0.6 kg/Ha for direct seeding and 1 plant every 20 m² for tubestock).

9.2.8 Rehabilitation management of the WWTP floor areas

Once the earthworks for the Alkimos WWTP have been completed, there will be areas at the base of the excavation which will not be immediately used for the WWTP. This will be due to the staged WWTP construction and subsequent stages may not be constructed for more than 20 years.

On this basis, it is proposed that the best treatment for these areas will be temporary revegetation, persisting for up to 20 years for stabilisation and prevention of wind and/or water erosion.

This area will not be restored to its original landform and it is likely the soil profile will be different from the original profile, due to excavation and construction required for the WWTP.

Rehabilitation of the excavation floor areas will involve:

- Spreading of topsoil;
- Brushing;
- Weed control;
- Direct seeding; and
- Monitoring and Maintenance.

The rehabilitation of the site, including the office/workshop areas, will require the ripping of hard stand layers, respreading of excavated material and replacement of topsoil applied at a depth of approximately 50 mm.

Direct seeding will be applied at a rate of 6 kg/Ha. The quantity of seeds required is listed in Table 9.2.8a.

Table 9.2.8a Seed to be used in rehabilitation of the excavation floor areas

	Species	**% seed mix**
Shrubs	*Acacia cyclops*	20
	Acacia saligna	20
	Acacia truncata	10
	Acacia lasiocarpa	10
	Melaleuca systena	10
	Melaleuca cardiophylla	10
	Rhagodia baccatta	20

Table 9.2.7 Implementation schedule and responsibilities for rehabilitation management for the WWTP excavation

Action Item Ref	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
W-PC-R-1	Collection of provenance seed material from areas within Lot 101 and surrounding areas.	Site Environmental Coordinator	Annually depending on seeding times for target species.	Environment and Community Relations Manager	At least six months prior to revegetation commencing.
W-PC-R-2	Organise seedling propagation as required, at a local nursery.	Site Environmental Coordinator	Annually depending on tubestock times for target species.	Environment and Community Relations Manager	At least six months prior to revegetation commencing.
Construction					
W-C-R-1	Undertake topsoil quality assessment and formulate topsoil segregation/management approach accordingly.	Site Environmental Coordinator	Prior to clearing commencing.	Environment and Community Relations Manager	After topsoil assessment has been undertaken and prior to clearing commencing.
W-C-R-2	Clear existing vegetation and push into brush piles. Aim to keep vegetation intact.	Earthworks Supervisor	Once topsoil assessment is completed.	Site Environmental Coordinator	During vegetation clearing.
W-C-R-3	Strip topsoil and place into stockpiles within defined area of disturbance. Aim to keep stockpiles less than 1,500mm deep.	Earthworks Supervisor	Once vegetation has been cleared.	Site Environmental Coordinator	During topsoil stripping.
W-C-R-4	Bury weed contaminated vegetation and topsoil separately within the soil column at least 200mm below the surface.	Earthworks Supervisor	Once topsoil has been stripped.	Site Environmental Coordinator	Once topsoil has been stripped.
Decommissioning					
W-D-R-1	Undertake deep ripping of any hardstand areas.	Earthworks Supervisor	At completion of the construction of the ocean outfall pipe pull.	Site Environmental Coordinator	At completion of the construction of the WWTP.
W-D-R-3	Spread topsoil and provide other surface stabilisation measures where required.	Earthworks Supervisor	Following re-contouring.	Site Environmental Coordinator	Once topsoil has been spread.
W-D-R-4	Spread brush and track roll on top-soiled landform and provide other surface stabilisation measures where required.	Earthworks Supervisor	Following spreading of topsoil.	Site Environmental Coordinator	Once brush has been place and other surface stability measures have been deployed.

Rehabilitation					
W-R-R-2	Plant tubestock and undertake direct seeding at specified rates as shown in Table 9.2.7a and Table 9.2.8a.	Site Environmental Coordinator	After the break of the season (first 300mm of soil profile is wet).	Environment and Community Relations Manager	After tubestock planting and direct seeding has taken place.
W-R-R-3	Undertake the first monitoring event to track seed germination and evidence of water and/or wind erosion.	Site Environmental Coordinator	Following end of Spring (November) after direct seeding.	Environment and Community Relations Manager	Following end of Spring (November) after direct seeding.
W-R-R-4	Undertake post works maintenance as required (including weed control).	Site Environmental Coordinator	December following direct seeding.	Environment and Community Relations Manager	Following end of Spring (November) after direct seeding.
W-R-R-5	Prepare a progress report for following the first year of monitoring and maintenance.	Site Environmental Coordinator	December of the first calendar year following the completion of rehabilitation and revegetation works.	Environment and Community Relations Manager	December of the first calendar year following the completion of rehabilitation and revegetation works.
W-R-R-6	Undertake second monitoring event to track seed germination, evidence of water and/or wind erosion and/or impacts from herbivores. If necessary schedule infill direct seeding for late autumn/early winter and any maintenance required including weed control.	Site Environmental Coordinator	December of the first calendar year following the completion of rehabilitation and revegetation works.	Environment and Community Relations Manager	December of the first calendar year following the completion of rehabilitation and revegetation works.
W-R-R-7	Prepare a progress report for following the second year of monitoring and maintenance.	Site Environmental Coordinator	December of the second calendar year following the completion of rehabilitation and revegetation works.	Environment and Community Relations Manager	December of the second calendar year following the completion of rehabilitation and revegetation works.

10 LAND BASED CONNECTION FROM THE WWTP TO THE LAUNCH SITE

This section outlines the specific details and management measures for the land based connection. The general management measures outlined in Section 4 have been referred to and incorporated in the environmental management framework for the land based connection.

A summary of the requirements for the specific management of the land based connection including timing and the designation of responsibility for ensuring that these requirements are implemented is provided within various tables in Section 10.1 to Section 10.7.

10.1 DESIGN

The WWTP will be connected to the launch site (the start of the ocean outfall) by a 968 metre section of pipe. The connection will extend from the WWTP outlet flume to a chamber at the launch site.

In order to avoid surface disturbance associated with cut and cover techniques, the AWA proposes to use a Tunnel Boring Machine (TBM) that caters for the diverse nature of the geotechnical conditions that are expected to be encountered to install the pipeline and minimise surface disturbance.

The distance between the WWTP and the launch site will necessitate an intermediate shaft to be located between the two sites as the pipe jacking TBM cannot continuously tunnel for more than 700 metres. The necessary jacking forces beyond 700 metres exceeds the maximum force than can be delivered by a hydraulic jacking system and therefore the total connection distance of 968 metres cannot be jacked directly. Therefore there will be some ground disturbance along the alignment of this section of pipeline to construct and access a retrieval/jacking shaft. This disturbance will be significantly less than that incurred if the connection was installed through cut and cover (open trench) construction methods for the connection's full length. The area will be rehabilitated on the completion of tunnelling activities.

10.2 CONSTRUCTION

10.2.1 Disturbance management

The access road and the shaft/laydown area will need to be cleared of all vegetation. Ministerial Statement 755 (Condition 6-1) allowed for the clearing for an intermediate recovery chamber between the WWTP and the launch site. The location of the chamber was selected after a thorough review of the area and its biological values.

Table 5.2.1 below specifically outlines the implementation schedule and responsibilities for ground disturbance management for the land based connection which must be followed to ensure the objectives specified in Section 4.1.2 are met.

Table 10.2.1 Implementation schedule and responsibilities for ground disturbance management for the land based connection

Action Item Reference	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
LC-GD-PC-1	Undertake survey of the shaft area and access road.	Earthworks Supervisor	At least one month before ground disturbing activity.	Environment and Community Relations Manager	Upon receiving the GDWP.
LC-GD-PC-2	Conduct inductions for operational/management personnel.	Environment and Community Relations Manager	Prior to commencement of works.	Construction Manager	Prior to commencement of works.
C-GD-PC-3	Prepare a GDWP and submit it to the Environment and Community Relations Manager as outlined in Section 4.1.2.	Earthworks Supervisor	At least a week prior to ground disturbing activity.	Environment and Community Relations Manager	Upon receiving the GDWP.
Construction					
LC-GD-C-1	Clearly mark-out the extent of disturbance/clearing with fencing and install signage.	Earthworks Supervisor	At least two weeks prior to commencement of vegetation clearing.	Earthworks Package Manager	At least one week prior to the intended commencement of vegetation clearing.
LC-GD-C-2	Review clearing is being completed as authorised within the GDWP.	Earthworks Supervisor	During ground disturbing activities.	Site Environmental Coordinator	During ground disturbing activities and at the completion of ground disturbing activities.
LC-GD-C-3	Review of vehicle movements and placement of materials to ensure that disturbance remains within areas authorised for disturbance. If transgressions occur and vegetation is damaged notify the Site Environmental Coordinator who will advise on restoration measures where appropriate.	Earthworks Supervisor	Daily during construction works.	Site Environmental Coordinator	Weekly during construction works.
LC-GD-C-4	Review GDWP to ensure that disturbance is within the approved boundary, mark up any variances with the permit conduct rehabilitation of those areas as specified in Section 10.2.7.	Site Environmental Coordinator	At completion of the construction of land based connection.	Environment and Community Relations Manager	At completion of the construction of land based connection.
Decommissioning					
LC-GD-D-1	Remove any signs/fencing that was installed for the construction period.	Earthworks Supervisor	At completion of construction of the WWTP.	Site Environmental Coordinator	At completion of earthworks program.

10.2.2 Dieback management

Plant and equipment will be mobilised to site for construction of the shaft and laydown area, there is the potential for Dieback to be transmitted to areas within the site if this is not appropriately managed.

Once the tunnelling is complete and the shaft and laydown area has been decommissioned it will be important to undertake a Dieback survey post construction so to minimise any further spread of the pathogen through appropriate quarantine procedures.

Table 10.2.2 below specifically outlines the implementation schedule and responsibilities for dieback management to ensure the objectives specified in Section 4.2.2 are met.

Table 10.2.2 Implementation schedule and responsibilities for Dieback management for the land based connection

Action Item Reference	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
LC-D-PC-1	Commission a Dieback interpreter to complete a preliminary Dieback survey throughout the project area.	Site Environmental Coordinator	Prior to any vehicle movements inside the WWTP buffer zone.	Environment and Community Relations Manager	Prior to construction of the land based connection.
LC-D-PC-2	Following advice from the Dieback interpreter develop management measures if not already specified within the management plan.	Site Environmental Coordinator	Prior to any vehicle movements inside the WWTP buffer zone.	Environment and Community Relations Manager	Following advice from Dieback interpreter.
LC-D-PC-3	Clearly delineate any areas infected with dieback.	Site Environmental Coordinator	Prior to any vehicle movements inside the WWTP buffer zone.	Environment and Community Relations Manager	Weekly throughout project duration.
Construction					
LC-D-C-1	Ensure all plant and equipment have been subject to the Plant and Equipment Hygiene procedure as outlined in Section 4.2.1	Work Supervisor	At least 24 hours prior to site entry.	Site Environmental Coordinator	Upon plant/ equipment arrival.
LC-D-C-2	If Dieback exists along access roads ensure that appropriate washdown facilities are in place.	Earthworks Package Manager	Prior to vehicle movements along roads.	Environment and Community Relations Manager	Prior to vehicle movements along roads.
LC-D-C-3	If Dieback exists ensure infected topsoil is stripped and kept separate from uninfected areas.	Earthworks Supervisor	During topsoil stripping.	Site Environmental Coordinator	Weekly during topsoil stripping.
LC-D-C-4	Construct table drains so that water is not diverted from infected areas into uninfected areas (if Dieback exists).	Earthworks Supervisor	During table drain construction.	Site Environmental Coordinator	At completion of construction.
LC-D-C-5	Review vehicle movements to ensure that vehicles remain within the shaft laydown area and along the road to the shaft.	Earthworks Supervisor	Daily during construction works.	Site Environmental Coordinator	Weekly during construction works.
LC-D-C-6	Monitor the vegetation condition, especially surrounding infected areas, if Dieback is spreading review Dieback management framework.	Site Environmental Coordinator	Monthly throughout the project duration.	Environment and Community Relations Manager	Monthly throughout the project duration.
LC-D-C-7	Commission a dieback interpreter to undertake an annual dieback survey	Site Environmental Coordinator	Annually throughout the project duration.	Environment and Community relations Manager	Annually throughout the project duration.
Decommissioning					

LC-D-D-1	Topsoil from infected areas is to remain within infected areas (if any).	Earthworks Supervisor	At completion of construction activities.	Site Environmental Coordinator	At completion of construction activities.
LC-D-D-2	Commission a Dieback interpreter to complete a Dieback survey post works and document results.	Site Environmental Coordinator	After rehabilitation.	Environment and Community relations Manager	After rehabilitation.

10.2.3 Weed management

Similar potential exists for the transportation and spread of weeds as exist for Dieback. Light vehicles, equipment and machinery will be frequently moving throughout the area during the construction of the land based connections. The movement of vehicles could potentially transport weeds from other site areas and/or spread existing weed species within the project area.

Plant and equipment will be mobilised to site for the shaft construction, with the potential for weeds to be introduced to surrounding vegetation. It is therefore important to put in place management measures prior to site entry to reduce the spread of weeds.

Table 10.2.3 below specifically outlines the implementation schedule and responsibilities for weed management for the construction of the land based connection to ensure the objectives specified in Section 4.3.2 are met.

Table 10.2.3 Implementation schedule and responsibilities for weed management for the land based connection

Action Item Ref	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
LC-W-PC-1	Undertake a survey of the weed invasion within and surrounding the site and document findings.	Site Environmental Coordinator	Prior to any construction works commencing.	Environment and Community Relations Manager	Following survey and prior to any construction works commencing.
LC-W-PC-2	Establish and map areas which currently have "Very Good" condition vegetation and low weed infestation.	Site Environmental Coordinator	Prior to any construction works commencing.	Environment and Community Relations Manager	Following survey and prior to any construction works commencing.
Construction					
LC-W-C-1	Ensure all plant and equipment have been subject to the Plant and Equipment Hygiene procedure as outlined in Section 4.2.1.	Earthworks supervisor	At least 24 hours prior to site entry.	Site Environmental Coordinator	Upon plant/ equipment arrival.
LC-W-C-2	Review vehicle movements to ensure that vehicles remain on the road alignment footprints and within the laydown area.	Earthworks Supervisor	Daily during construction works.	Site Environmental Coordinator	Weekly during construction works.
LC-W-C-3	Monitor the vegetation condition of areas specified in LC-W-PC-2 and implement weed control measures if necessary as outlined in Section 4.3.	Site Environmental Coordinator	Weekly throughout the project duration.	Environment and Community relations Manager	Monthly throughout the project duration.
Decommissioning					
LC-W-D-2	Monitor the vegetation condition of areas specified in LC-W-PC-2 and implement weed control measures if necessary as outlined in Section 4.3.	Site Environmental Coordinator	Spring after completion of works.	Environment and Community relations Manager	Spring after completion of works.

10.2.4 Fire management

Fire management is particularly relevant to areas where works are taking place within or adjacent to vegetation and bushland areas. The shaft area for the land based connection will be surrounded by vegetation.

Fire management measures will need to be implemented and monitored throughout the duration of the project, and all staff will need to understand evacuation procedures and site requirements specified in Section 4.4.3.2.

Table 10.2.4 below specifically outlines the implementation schedule and responsibilities for fire management for the construction of the land based connection which must be followed to ensure the objectives specified in Section 4.4.2 are met.

Table 10.2.2 Implementation schedule and responsibilities for fire management for the land based connection

Action Item Ref	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
LC-PC-FM-1	Inductions of operational/management personnel to outline fire procedures as described in Section 4.4.	Environment and Community Relations Manager	Prior to commencement of works.	Construction Manager	Prior to commencement of works.
Construction					
LC-C-FM-1	Ensure that all vehicles in operation have a fire extinguisher on board.	Earthworks Supervisor	During construction of the land based connection.	Site Environmental Coordinator	Monthly during construction.
LC-C-FM-2	Ensure that no smoking is occurring inside vehicles or outside designated smoking areas.	Site Supervisor	During construction of the land based connection.	Site Environmental Coordinator	Weekly during road construction.
LC-C-FM-3	During summer months water cart is to be left full of water.	Earthworks Supervisor	Daily during summer months throughout the project duration.	Site Environmental Coordinator	Daily during summer months throughout the project duration.

10.2.5 Hydrology management

The Alkimos area is made up of coastal calcareous sand dunes which are highly permeable. The laydown area will have a limestone hardstand surface which necessitates table drains to divert surface run-off away from the road surface during heavy rainfall events, runoff will be managed to ensure it does not impact remnant vegetation outside of the working areas.

Construction water for dust suppression and compaction will be sourced from ground water production bores at four locations within the project area, abstraction from these production bores will be monitored monthly.

Table 10.2.5 below specifically outlines the implementation schedule and responsibilities for hydrology for the construction of the land based connection which must be followed to ensure the objectives specified in Section 4.5.2 are met.

Table 10.2.5. Implementation schedule and responsibilities for hydrology management for the land based connection

Action Item Ref	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
LC-PC-H-1	Measure Department of Water monitoring bores as specified in the 'Licence to Take Water' and described in Section 4.5.3.3.	Site Environmental Coordinator	Prior to production bore construction.	Site Environmental Coordinator	Monthly
LC-PC-H-2	Order and allocate spill kits to plant/equipment.	Earthworks Supervisor	Prior to construction activities.	Environment and Community Relations Manager	Prior to construction activities.
Construction					
LC-C-H-1	Construct table drains (if required) along site the hardstand areas to direct water away from the road surface during heavy rainfall events.	Earthworks Supervisor	During road construction.	Site Environmental Coordinator	During road construction.
LC-C-H-2	Undertake refuelling on limestone hardstand areas only.	Earthworks Supervisor	During road construction.	Site Environmental Coordinator	Daily during construction
LC-C-H-3	Install spill response kits in allocated plant and equipment.	Earthworks Supervisor	During road construction.	Site Environmental Coordinator	Weekly during construction
Operation					
LC-O-H-1	Monitor and maintain table drains to ensure that they are free of debris and are providing adequately drainage for the access roads.	Earthworks Supervisor	Weekly after table drain construction.	Site Environmental Coordinator	Weekly during project duration
LC-O-H-2	Measure Department of Water monitoring bores as specified in the 'Licence to Take Water' and described in Section 4.5.3.3.	Site Environmental Coordinator	Monthly whilst ground water abstraction is taking place.	Site Environmental Coordinator	Yearly whilst ground water abstraction is taking place.
LC-O-H-3	If spill kits are used/damaged replace immediately.	Earthworks Supervisor	Immediately after a spill kit has been used.	Site Environmental Coordinator	Weekly during project duration

10.2.6 Landform management

Once the shaft is complete access will need to remain open to the shaft area as a manhole will be constructed in its place to provide access for inspections and maintenance in the future.

Table 10.2.6 below specifically outlines the implementation schedule and responsibilities for landform management which must be followed to ensure the objectives specified in Section 4.6.2 are met.

Table 10.2.6 Implementation schedule and responsibilities for landform management for the land based connection

Action Item Ref	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
LC-PC-L-1	Undertake survey of the shaft laydown area and access road and peg out alignment and boundaries.	Earthworks Supervisor	At least one month before ground disturbing activity	Environment and Community Relations Manager	Upon receiving the GDWP
Construction					
LC-C-L-1	Review of vehicle movements to ensure that vehicles remain areas authorised for disturbance only. If transgressions occur and the landform is undermined notify the Site Environmental Coordinator who will specify restoration measures where appropriate.	Earthworks Supervisor	Daily during construction works.	Site Environmental Coordinator	Weekly during construction works
AR-C-L-2	Stabilise any construction batters using liquid stabilisers, matting and/or brush.	Earthworks Supervisor	At completion of access road and laydown area construction	Environment and Community Relations Manager	At completion of access road and laydown area construction
Operation					
LC-O-L-1	Review of vehicle movements to ensure that vehicles remain within fenced areas. If transgressions occur and the landforms is undermined notify the Site Environmental Coordinator who will specify restoration measures as appropriate.	Earthworks Supervisor	Daily during construction works.	Site Environmental Coordinator	Weekly during operations.
LC-O-L-2	Monitor and maintain batters to ensure the stability and deployment of further stabilisation and management where required.	Earthworks Supervisor	Daily during construction works.	Site Environmental Coordinator	Weekly during project duration
Decommissioning					
LC-D-L-1	Backfill area as much as practicable.	Earthworks Supervisor	After the completion of tunnelling to the beach access structure.	Environment and Community Relations Manager	After the completion of tunnelling to the beach access structure.

10.2.7 Rehabilitation management

The access road into the shaft will become permanent once construction is complete. The areas, adjacent to permanent roads will require rehabilitation. These areas will be rehabilitated for the long-term and therefore re-establishing stable and diverse vegetation communities will be the primary objective.

Rehabilitation of the access roads will involve:

- Spreading of topsoil;
- Brushing;
- Weed control;
- Direct seeding; and
- Monitoring and Maintenance.

The road surface and laydown area will be deep ripped to a depth of approximately 500 mm in order to break up the surface and relieve soil profile compaction. Rip line spacing will need to be sufficiently close enough to achieve full treatment of the road surfaces, and ideally a winged tyne would be used.

Direct seeding will be applied at a rate of 6kg/Ha. The quantity of seeds required is listed in Table 10.2.7a.

Table 10.2.7a Seed to be used in rehabilitation of the land based connection

	Species	**% seed mix + tubestock**
Tree	*Eucalyptus gomphocephalla*	1
Shrubs	*Acacia lasiocarpa*	10
	Acacia saligna	5
	Acanthocarpus preissii	10
	Hibbertia hypericoides	3
	Hibbertia subvaginata	3
	Leucopogon pauciflora	3
	Melaleuca systena	10
	Melaleuca huegelli	8
	Trymalium ledifolium	5
Herbs	*Phyllanthus calycinus*	5
	Gompholobium tomentosa	15
	Hardenbergia comptoniana	5
	Lepidosperma pubesquameum	5
	Conostylis pauciflora subsp. eury	2
	Desmocladus flexuosa	1
	Sarcozona bicarinata	3
	Threlkeldia diffusa	

Follow-up monitoring and maintenance will be required to ensure that revegetation is successful and batters have been effectively stabilised. This will continue for 12 months after the completion of the rehabilitation and revegetation and would identify issues such as weed invasion, wind or water erosion, and be the basis for maintenance activities.

Table 10.2.7 below specifically outlines the implementation schedule and responsibilities for rehabilitation for the land based connection which must be followed to ensure the objectives specified in Section 4.7.2 are met.

Table 10.2.7 Implementation schedule and responsibilities for rehabilitation management for the land based connection

Action Item Ref	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
LC-PC-R-1	Collection of provenance seed material from areas within Lot 101 and surrounding areas.	Site Environmental Coordinator	Annually depending on seeding times for target species .	Environment and Community Relations Manager	At least six months prior to revegetation commencing.
Construction					
LC-C-R-1	Undertake topsoil quality assessment and formulate topsoil segregation/management approach accordingly.	Site Environmental Coordinator	Prior to clearing commencing.	Environment and Community Relations Manager	After topsoil assessment has been undertaken and prior to clearing commencing.
LC-C-R-2	Clear existing vegetation and push into brush piles. Aim to keep vegetation intact.	Earthworks Supervisor	Once topsoil assessment is completed.	Site Environmental Coordinator	During vegetation clearing.
LC-C-R-3	Strip topsoil and place into stockpiles within defined area of disturbance. Aim to keep stockpiles less than 1,500mm deep.	Earthworks Supervisor	Once vegetation has been cleared.	Site Environmental Coordinator	During topsoil stripping.
Decommissioning					
LC-D-R-1	Undertake deep ripping of any hardstand areas.	Earthworks Supervisor	At completion tunnelling.	Site Environmental Coordinator	At completion tunnelling.
LC-D-R-2	Backfill access roads to where the permanent roads will be constructed.	Earthworks Supervisor	Following deep ripping.	Earthworks Package Manager	Once backfill operations are completed.
LC-D-R-3	Spread topsoil over backfilled areas and provide other surface stabilisation measures where required.	Earthworks Supervisor	Following re-contouring.	Site Environmental Coordinator	Once topsoil has been spread.
LC-D-R-4	Spread brush on top-soiled landform and provide other surface stabilisation measures where required.	Earthworks Supervisor	Following spreading of topsoil.	Site Environmental Coordinator	Once brush has been place and other surface stability measures have been deployed.
Rehabilitation					
LC-R-R-1	Undertake direct seeding.	Site Environmental Coordinator	After the break of the season (first 300mm of soil profile is wet).	Environment and Community Relations Manager	After direct seeding has taken place.
LC-R-R-2	Undertake the first monitoring event to track seed germination and evidence of water and/or wind erosion.	Site Environmental Coordinator	Following end of Spring (November) after direct seeding.	Environment and Community Relations Manager	Following end of Spring (November) after direct seeding.

LC-R-R-3	Undertake post works maintenance as required (including weed control).	Site Environmental Coordinator	December following direct seeding.	Environment and Community Relations Manager	Following end of Spring (November) after direct seeding.
LC-R-R-4	Undertake second monitoring event to track seed germination, evidence of water and/or wind erosion and/or impacts from herbivores. If necessary schedule infill direct seeding for late autumn/early winter.	Site Environmental Coordinator	Following end of Summer (February).	Environment and Community Relations Manager	Following end of Summer (February).
LC-R-R-5	Undertake maintenance as require.	Site Environmental Coordinator	February to March.	Environment and Community Relations Manager	February to March.
LC-R-R-6	Undertake any infill direct seeding as required.	Site Environmental Coordinator	Immediately following first autumn/winter rain event.	Environment and Community Relations Manager	Immediately following first autumn/winter rain event.

11 LAUNCH SITE

The launch site is situated within a Metropolitan Region Scheme "Public Purposes" Reserve, and part of this is also within Bush Forever Site 397. The Water Corporation will require access to the launch site in the future when a second ocean outfall is installed as the capacity of the WWTP expands. At this point in time the long-term management objectives of the wider launch site area (outside the Bush Forever site which is addressed separately in Section 12) has not been specified and is likely to be offered by the Water Corporation to the City of Wanneroo for a regional recreational facility. Given the discussions to finalise the long term use of the launch site have not taken place, the manner in which the site should be left after construction has also not been finalised.

It is intended, however, that the area within the Bush Forever site will be fully rehabilitated in line with its conservation status as a Bush Forever site. At this stage it is envisaged that the area of the launch site outside the Bush Forever boundary will not be re-contoured and will be revegetated to provide surface stability, however this revegetation may not remain in the longer term.

The entire launch site construction and string preparation will take up to 12 months to complete and will be undertaken prior to the pipe pull. Overall, the construction of the site will require the clearing of approximately 7.3 Ha of vegetation. The launch site has been engineered to optimise the storage, handling and welding of the pipe strings in preparedness for drawing the pipeline offshore to the ocean, and has been positioned to minimise impacts to vegetation occurring in the area, in particular, the vegetation community to the north of the site. The layout of the launch site is shown in Figure 14.

This section outlines the specific details and management measures for the site launch site. The general management measures outlined in Section 4 have been referred to and incorporated in the environmental management framework for the launch site.

A summary of the requirements for the specific management of the launch site including timing and the designation of responsibility for ensuring that these requirements are implemented is provided within various tables in Section 11.1 to Section 11.7.

11.1 DESIGN

The selection of the launch site during the PER phase compared two other sites Launch Site 2 and Launch Site 1A. Based on minimising impacts to significant vegetation, Launch Site 1B (as shown in Figure 15) was selected as the preferred site. The launch site has been positioned to minimise impacts to vegetation occurring in the area.

The site will be levelled, with some material being excavated to fill over the lower lying areas, as the site will need to form a level working platform for pipeline fabrication. A longitudinal profile of the constructed launch site is shown in Figure 16, and associated cross sections from a number of selected points along its long axis are shown in Figure 17. As shown in these figures, the entire launch site will be constructed with a slight fall of 4% towards the beach to assist in handling of the ocean outfall strings on the trestles.

The floor of the launch site will comprise a 300mm compacted limestone base to provide a hardstand. Scheduling of hardstand construction will be planned to take advantage of limestone material being excavated from the WWTP.

The launch site excavation will be undertaken using a 70-tonne excavator, a Cat D400 and 40-tonne articulated dump trucks. Clearing of the launch site will be completed incrementally. Vegetation will be cleared so that it remains in "brush" form and topsoil will be removed and stockpiled adjacent to both the north and south sides of the trench at the top of the launch site. Excavated material will be stockpiled within the launch site footprint as shown in Figure 15 and no stockpiling outside of this boundary will be undertaken.

Pipe plinths or base blocks will be constructed, and a temporary construction facility to receive pipe joints will be set out. The pipe will be assembled in the north of the launch site, where single joints of 12 metre long pipe will be welded into pipe strings.

Once the pipeline construction has been completed, the main pad of the launch site will remain level, and no re-contouring will be undertaken. The ground will be deep ripped and revegetated with the aim to stabilise the area. The launch site area will need to remain in a condition suitable to accommodate another pipe pull in the future if required. The remaining beach corridor sections through the Bush Forever site will be rehabilitated and re-contoured extensively as described in Section 12.

11.1.1 Pipeline construction

The pipeline construction will involve single sections of 12m long pipe being welded into pipe strings. The pipe strings will be assembled within the launch site. The pipeline will be assembled into 24 strings, each approximately 158m in length.

The pipe joints will be mobilised to site by truck via established access roads and offloaded at the launch yard, directly onto the pipe plinths. A project specific Traffic Management Plan will be developed for the mobilisation of the pipe sections and equipment to the site. The pipe joints will be aligned and welded by teams of pipe welders. The pipe welds (field joint) will be allowed to cool, and then undergo non-destructive testing to ensure the weld is acceptable. Plate 6 shows an indicative pipe stringing yard from a project undertaken in the United Kingdom.

A series of 20 tonne rollers will be installed along the pipeline alignment where the pipeline is above sea level. These rollers will be installed onto small pad footings (subject to ground conditions encountered in the trench floor). The rollers will be spaced along the route between CH100 and CH400, as required by the installation engineering, to avoid overstressing the pipe and reduce the pull loads.

A pull head will be installed to the front of the first pipe string, to which the pulling wire will be attached. This pull head will be bolted to a welded flange attached to the first pipe joint.

Blind flanges will be attached to the diffuser ports and the first pipe string will be hydro-tested prior to being pulled out by the barge. Buoyancy tanks will be installed to the pipe strings in preparation for the commencement of the pipe installation works. A buoyancy marker float will also be installed at the pull head to allow visual confirmation of the pipe position in relation to the pipe alignment during the installation.

The pipe strings will be assembled using field joints. As the pipe string is pulled out along the ocean outfall alignment the next section of pipe will be rolled out and welded to the end of the previous string. The field joint will be prepared for corrosion coating, and the heat shrink sleeve applied, ensuring a minimum of 25mm overlap onto the pipe corrosion coating. CANUSA type KLS heat shrink sleeve or equivalent will be used.

Once the shrink sleeve has been applied, reinforcing will be installed to the field joints, formwork applied to the outside face of the adjacent pipe weight coat and the joint concreted. Cement mortar lining will be applied from the inside of the pipe string using a field mixed mortar that will be trowelled onto the inside face of the primed steel pipe surface.

Further details in relation to the seabed preparation and the pipeline pull/installation are described in the OOPCMP.

11.2 CONSTRUCTION

11.2.1 Disturbance management

To the north of the launch site supports a locally significant vegetation community (MhMs and described in Section 2.2.3) which is in “Good” to “Very Good” condition as shown in Figure 10. Fencing will be placed along the boundary adjacent to this vegetation community to the north of the launch site to ensure that no impact occurs to the vegetation outside the designated footprint during site works.

Fencing will also be erected around the site as a barrier to recreational vehicles. Vehicular traffic and pedestrian access to the site will be controlled by appropriate signage and fencing. The fences will also serve to ensure that construction activities do not extend beyond the proposed footprint area.

Table 11.2.1 below specifically outlines the implementation schedule and responsibilities for disturbance management for the launch site to ensure the objectives specified in Section 4.2.2 are met.

Table 11.2.1 Implementation schedule and responsibilities for ground disturbance management for the launch site

Action Item Reference	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
LS-GD-PC-1	Undertake survey of the launch site area and peg out boundaries.	Earthworks Supervisor	At least one month before ground disturbing activity.	Environment and Community Relations Manager	Upon receiving the GDWP for the launch site area.
LS-GD-PC-2	Conduct inductions for operational/management personnel.	Environment and Community Relations Manager	Prior to commencement of works.	Construction Manager	Prior to commencement of works.
LS-GD-PC-3	Prepare a GDWP and submit it to the Environment and Community Relations Manager as outlined in Section 4.1.2.	Site Supervisor	At least a week prior to ground disturbing activity.	Environment and Community Relations Manager	Upon receiving the GDWP for the launch site area.
Construction					
LS-GD-C-1	Install fencing along the northern border of the launch site to protect the vegetation community.	Earthworks Supervisor	At least a week prior to ground disturbing activity.	Environment and Community Relations Manager	At least a week prior to ground disturbing activity.
LS-GD-C-2	Clearly mark-out the extent of disturbance/clearing with fencing, install signage	Earthworks Supervisor	At least two weeks prior to commencement of vegetation clearing.	Earthworks Package Manager	At least one week prior to the intended commencement of vegetation clearing.
LS-GD-C-3	Review clearing is being completed as authorised within the GDWP.	Site Supervisor	During ground disturbing activities.	Site Environmental Coordinator	During ground disturbing activities and at the completion of ground disturbing activities.
LS-GD-C-4	Review GDWP to ensure that disturbance was within the approved boundary, mark up any variances with the permit conduct rehabilitation of those areas as specified in Section 11.2.7. Follow up internally regarding any identified non-compliance with GDWP and report to the Alliance Manager.	Site Environmental Coordinator	At completion of construction of the launch site.	Environment and Community Relations Manager	At completion of the launch site. .
Operation					
LS-GD-O-1	Review of vehicle movements and placement of materials to ensure that disturbance remains within fenced areas. If transgressions occur and vegetation is damaged notify the Site Environmental Coordinator who will advise of restoration measures as appropriate.	Earthworks Supervisor	Daily during operations.	Site Environmental Coordinator	Weekly during operations.
Decommissioning					

LS-GD-D-1	Remove any signs/fencing that were installed.	Earthworks Supervisor	At completion of construction of the WWTP.	Site Environmental Coordinator	At completion of earthworks program.

11.2.2 Dieback management

Plant and equipment will be mobilised to site for construction of the launch site and the risk of Dieback transmission will be largest during the earthworks component of the launch site preparation.

The launch site will remain active during the operational stage up to when the pipe pull occurs. During this time, trucks will be delivering pipe segments and equipment continuously. Without adequate management there is the potential for Dieback to be transmitted to areas within the site. It is important to put in place management measures prior to site entry to reduce the risk of transmission.

Table 11.2.2 below specifically outlines the implementation schedule and responsibilities for dieback management to ensure the objectives specified in Section 4.2.2 are met.

Table 11.2.2. Implementation schedule and responsibilities for Dieback management for the launch site

Action Item Reference	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
LS-D-PC-1	Commission a Dieback interpreter to complete an preliminary Dieback survey across the project area.	Site Environmental Coordinator	Prior to any vehicle movements inside the WWTP buffer zone.	Environment and Community Relations Manager	Prior to the construction of the launch site.
LS-D-PC-2	Following advice from the Dieback interpreter develop management measures if not already specified within the management plan.	Site Environmental Coordinator	Prior to any vehicle movements inside the WWTP buffer zone.	Environment and Community Relations Manager	Following advice from Dieback interpreter.
LS-D-PC-3	Clearly delineate any areas infected with Dieback.	Site Environmental Coordinator	Prior to any vehicle movements inside the WWTP buffer zone.	Environment and Community Relations Manager	Weekly throughout project duration.
Construction					
LS-D-C-1	Ensure all plant and equipment have been subject to the Plant and Equipment Hygiene procedure as outlined in Section 4.2.1	Work Supervisor	At least 24 hours prior to site entry.	Site Environmental Coordinator	Upon plant/ equipment arrival.
LS-D-C-2	If Dieback exists along access roads leading into the launch site area ensure that appropriate washdown facilities are in place.	Earthworks Package Manager	Prior to vehicle movements along roads.	Environment and Community Relations Manager	Prior to vehicle movements along roads.
LS-D-C-3	If Dieback exists ensure infected topsoil is stripped and kept separate from uninfected areas.	Earthworks Supervisor	During topsoil stripping.	Site Environmental Coordinator	Weekly during topsoil stripping.
LS-D-C-4	Construct table drains so that water is not diverted from infected areas into uninfected areas (if Dieback exists).	Earthworks Supervisor	During table drain construction.	Site Environmental Coordinator	At completion of road construction.
LS-D-C-5	Review vehicle movements to ensure that vehicles remain within the launch site area.	Earthworks Supervisor	Daily during construction works.	Site Environmental Coordinator	Weekly during construction works.
Operation					
LS-D-O-1	Review vehicle movements to ensure they are within areas authorised for disturbance.	Earthworks Supervisor	Daily during operations.	Site Environmental Coordinator	Weekly during operations.
LS-D-O-2	Monitor the vegetation condition, especially surrounding infected areas and if Dieback is spreading review Dieback management framework.	Site Environmental Coordinator	Monthly throughout the project duration.	Environment and Community Relations Manager	Monthly throughout the project duration.
Decommissioning					

LS-D-D-1	Topsoil from infected areas is to remain within infected areas (if any).	Earthworks Supervisor	At completion of construction activities.	Site Environmental Coordinator	At completion of construction activities.
LS-D-D-2	Commission a Dieback interpreter to complete a Dieback survey post works and document results.	Site Environmental Coordinator	After rehabilitation.	Environment and Community relations Manager	After rehabilitation.

11.2.3 Weed management

Similar potential exists for the transportation and spread of weeds as exist for Dieback. Light vehicles, equipment and machinery will be frequently moving throughout the area during construction and the movement of vehicles could potentially transport weeds from other site areas and/or spread existing weed species within the project area.

Plant and equipment will be mobilised to site for the construction of the launch site area and then for the pre-works for the preparation of the ocean outfall pipe pull, with the potential for weed to be introduced to surrounding vegetation. The MhMs vegetation to the north of the launch site is currently vegetation which is in "Very Good" condition, and this will need to be maintained during the course of construction and operation of the launch site area. It is therefore important to put in place management measures prior to site entry to reduce the spread of weeds within the area.

Table 11.2.3 below specifically outlines the implementation schedule and responsibilities for weed management to ensure the objectives specified in Section 4.3.2 are met.

Table 11.2.3. Implementation schedule and responsibilities for weed management for the launch site

Action Item Ref	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
LS-W-PC-1	Undertake a survey of the weed invasion within and surrounding the site, document findings.	Site Environmental Coordinator	Prior to any works commencing.	Environment and Community Relations Manager	Following survey and prior to any works commencing.
LS-W-PC-2	Establish and map areas which currently have "Very Good" quality vegetation and low weed infestation. In particular the vegetation to the north of the launch site.	Site Environmental Coordinator	Prior to any works commencing.	Environment and Community Relations Manager	Following survey and prior to any works commencing.
Construction					
LS-W-C-1	Ensure all plant and equipment have been subject to the Plant and Equipment Hygiene procedure as outlined in Section 4.2.1.	Earthworks supervisor	At least 24 hours prior to site entry.	Site Environmental Coordinator	Upon plant/ equipment arrival.
LS-W-C-2	Review vehicle movements to ensure that vehicles remain on the road alignment and within the laydown area.	Earthworks Supervisor	Daily during launch site construction works.	Site Environmental Coordinator	Daily during construction works.
Operation					
LS-W-O-1	Review vehicle movements to ensure that vehicles remain on within approved areas.	Earthworks Supervisor	Daily during use of the launch site.	Site Environmental Coordinator	Weekly during use of the launch site.
LS-W-O-2	Monitor the vegetation condition of areas specified in LS-W-PC-2 and implement weed control measures if necessary as outlined in Section 4.3.	Site Environmental Coordinator	Weekly throughout the project duration.	Environment and Community relations Manager	Monthly throughout the project duration.
Decommissioning					
LS-W-D-2	Monitor the vegetation condition of areas specified in LC-W-PC-2 and implement weed control measures if necessary as outlined in Section 4.3.	Site Environmental Coordinator	Spring after completion of works.	Environment and Community relations Manager	Spring after completion of works.

11.2.4 Fire management

Fire management is particularly relevant to areas where works are taking place within or adjacent to vegetation and bushland areas.

Fire management measures will need to be implemented and monitored throughout the duration of the project, all staff will need to understand any evacuation procedures and site requirements specified in Section 4.4.3.2.

Table 11.2.4 below specifically outlines the implementation schedule and responsibilities for fire management which must be followed to ensure the objectives specified in Section 4.4.2 are met.

Table 11.2.4. Implementation schedule and responsibilities for fire management for the launch site

Action Item Ref	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
LS-PC-FM-1	Inductions of operational/management personnel, outline fire procedures as described in Section 4.4.	Environment and Community Relations Manager	Prior to commencement of works.	Construction Manager	Prior to commencement of works.
Construction					
LS-C-FM-1	Monitor to ensure that all vehicles in operation have a fire extinguisher on board	Earthworks Supervisor	During launch site construction.	Site Environmental Coordinator	Weekly during construction
LS-C-FM-3	Ensure that no smoking is occurring inside operational vehicles or outside designated smoking areas.	Site Supervisor	During launch site construction.	Site Environmental Coordinator	Daily during construction.
Operation					
LS-O-FM-2	If work occurs during summer months water cart is to be left full of water.	Earthworks Supervisor	Daily during summer months throughout the project duration.	Site Environmental Coordinator	Daily during summer months throughout the project duration.
LS-O-FM-3	Ensure that no smoking is occurring inside operational vehicles or outside designated smoking areas.	Site Supervisor	During launch site construction.	Site Environmental Coordinator	Daily during construction.

11.2.5 Hydrology management

The Alkimos area is made up of coastal calcareous sand dunes which are highly permeable. The launch site area will have a limestone hardstand surface which necessitates table drains to divert surface run-off away from the surface during heavy rainfall events, runoff will be managed to ensure that it does not impact the surrounding remnant vegetation.

Construction water for dust suppression and compaction will be sourced from ground water production bores at four locations within the project area, abstraction from these production bores will be monitored monthly.

Surface water generation will is unlikely to be an issue during the construction and operation of the launch site, due to the permeable nature of the underlying soils. Given that there are no existing surface water features on the site, the potential impacts are limited to disruptions to the existing water balance of the site, and impacts to groundwater quality from runoff contaminated by construction and support activities.

Table 11.2.5 below specifically outlines the implementation schedule and responsibilities for hydrology which must be followed to ensure the objectives specified in Section 4.5.2 are met.

Table 11.2.5. Implementation schedule and responsibilities for hydrology management for the launch site

Action Item Ref	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
LS-PC-H-1	Measure Department of Water monitoring bores as specified in the 'Licence to Take Water' and described in Section 4.5.3.3.	Site Environmental Coordinator	Prior to production bore construction.	Site Environmental Coordinator	Monthly.
LS-PC-H-2	Order and allocate spill kits to plant/equipment which will be working at the launch site during construction.	Earthworks Supervisor	Prior to construction activities.	Environment and Community Relations Manager	Prior to construction activities.
Construction					
LS-C-H-1	Construct hardstand with slope towards the beach and/or table drains.	Earthworks Supervisor	During construction of the launch site.	Site Environmental Coordinator	During construction of the launch site.
LS-C-H-2	Construct table drains (if required) along site the hardstand areas to direct water away from the road surface during heavy rainfall events.	Earthworks Supervisor	During construction of the launch site.	Site Environmental Coordinator	During construction of the launch site.
LS-C-H-3	Undertake refuelling offsite or with mobile refuelling vehicles on hard stand areas.	Earthworks Supervisor	During launch site construction.	Site Environmental Coordinator	Daily during construction
LS-C-H-4	Install spill response kits in allocated plant and equipment.	Earthworks Supervisor	During launch site construction.	Site Environmental Coordinator	Weekly during construction
Operation					
LS-O-H-1	Allow for surface runoff to infiltrate to groundwater within table drains.	Earthworks Supervisor	During operations at the launch site.	Site Environmental Coordinator	During operations at the launch site.
LS-O-H-2	Monitor and maintain table drains to ensure that they are free of debris and are providing adequately drainage for the launch site.	Earthworks Supervisor	Weekly after table drain construction.	Site Environmental Coordinator	Weekly during project duration
LS-O-H-3	Measure Department of Water monitoring bores as specified in the 'Licence to Take Water' and described in Section 4.5.3.3.	Site Environmental Coordinator	Monthly whilst ground water abstraction is taking place.	Site Environmental Coordinator	Monthly.
LS-O-H-4	Ensure spill kits as in close proximity to operations at all times.	Earthworks Supervisor	Weekly during operations.	Site Environmental Coordinator	Monthly during operations.
LS-O-H-5	If spill kits are used/damaged replace immediately.	Earthworks Supervisor	Immediately after a spill kit has been used.	Site Environmental Coordinator	Weekly during project duration
LS-O-H-6	Undertake refuelling offsite or with mobile refuelling vehicles on hard stand areas.	Earthworks Supervisor	During operations at the launch site.	Site Environmental Coordinator	During operations at the launch site.

11.2.6 Landform management

The launch site design has been carefully planned to minimise impacts to landform features and vegetation communities. The area of the launch site pad will not be re-contoured similar to the foredune area as specified in Section 12.2.6, however construction activities will need to be managed so that the integrity of the area and the fordune area maintained during both construction and operation activities. Monitoring will focus on surface stability of the area during works.

Table 11.2.6 below specifically outlines the implementation schedule and responsibilities for landform management for the launch site which must be followed to ensure the objectives specified in Section 4.6.2 are met.

Table 11.2.6. Implementation schedule and responsibilities for landform management for the launch site

Action Item Ref	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
LS-PC-L-1	Undertake survey of the launch site area and peg out alignment and boundaries.	Earthworks Supervisor	At least one month before ground disturbing activity	Environment and Community Relations Manager	Upon receiving the GDWP for the launch site area.
Construction					
LS-C-L-1	Review of vehicle movements to ensure that vehicles remain within areas authorised for disturbance only. If transgressions occur and landform in undermined notify the Site Environmental Coordinator who will direct restoration measures as appropriate.	Earthworks Supervisor	Daily during construction works for the launch site.	Site Environmental Coordinator	Daily during construction works
LS-C-L-2	Construct limestone area using materials from site, where practicable.	Earthworks Supervisor	During construction works for the launch site.	Environment and Community Relations Manager	During construction works for the launch site.
LS-C-L-3	Stabilise any construction batters using liquid stabilisers, matting and/or brush.	Earthworks Supervisor	At completion of construction of the launch site hardstand.	Environment and Community Relations Manager	At completion of launch site.
Operation					
LS-O-L-1	Review of vehicle movements to ensure that vehicles remain within areas authorised for disturbance only. If transgressions occur and landform is undermined notify the Site Environmental Coordinator who will direct restoration measures as appropriate.	Earthworks Supervisor	Daily during construction works.	Site Environmental Coordinator	Weekly during operations.
LS-O-L-2	Monitor and maintain batters to ensure the stability and deploy further stabilisation and management where required.	Earthworks Supervisor	Daily during construction works.	Site Environmental Coordinator	Weekly during project duration.

11.2.7 Rehabilitation management

An area reserved for "Public Purposes" covers the majority of the launch site (outside of the Bush Forever Site). This area is likely to be developed as a reserve in the future to coincide with urban development. Therefore, the rehabilitation for this area will involve revegetation for surface stability, however it is currently unclear whether this area will remain for the long term. In any event the area must remain level to allow for a future ocean outfall launch site if the demand requires. This means the original landform and soil profile will not be retained.

Rehabilitation of the outfall launch site will involve:

- Brushing (may or may not be used);
- Weed control;
- Direct seeding; and
- Monitoring and Maintenance.

Direct seeding will be applied at a 6 kg/Ha and the proportion of species required is listed in Table 6.7.6.2a.

Table 11.2.7a Seed and tubestock to be used in rehabilitation of the launch site

	Species	% seed mix
Shrubs	*Acacia lasiocarpa*	3
	Acacia rostellifera	2
	Acacia saligna	1
	Melaleuca systena	5
	Melaleuca huegelii	2
	Hibbertia subvaginata	2
	Leucopogon parviflorus	2
	Acanthocarpus preissii	3

Follow-up monitoring and maintenance is required to ensure that revegetation is successful and the launch site has been effectively stabilised. This will continue for two years after the completion of the rehabilitation and revegetation and would identify issues such as weed invasion, death of seedlings, predation, wind or water erosion, and be the basis for maintenance activities.

Table 11.2.7 below specifically outlines the implementation schedule and responsibilities for rehabilitation which must be followed to ensure the objectives specified in Section 4.7.2 are met.

Table 11.2.7. Implementation schedule and responsibilities for rehabilitation management for the launch site

Action Item Ref	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
LS-PC-R-1	Collection of provenance seed material from areas within Lot 101 and surrounding areas.	Site Environmental Coordinator	Annually depending on seeding times for target species .	Environment and Community Relations Manager	At least six months prior to revegetation commencing.
Construction					
LS-C-R-1	Undertake topsoil quality assessment and formulate topsoil segregation/management approach accordingly.	Site Environmental Coordinator	Prior to clearing commencing.	Environment and Community Relations Manager	After topsoil assessment has been undertaken and prior to clearing commencing.
LS-C-R-2	Clear existing vegetation and push into brush piles at the edge of the launch site. Aim to keep vegetation intact.	Earthworks Supervisor	Once topsoil assessment is completed.	Site Environmental Coordinator	During vegetation clearing.
LS-C-R-3	Strip topsoil and place into stockpiles at the edge of the launch site and within defined area of disturbance. Aim to keep stockpiles less than 1,500mm deep.	Earthworks Supervisor	Once vegetation has been cleared.	Site Environmental Coordinator	During topsoil stripping.
Decommissioning					
LS-D-R-1	Undertake deep ripping of any hardstand areas along the launch site surface .	Earthworks Supervisor	At completion of the construction of the WWTP.	Site Environmental Coordinator	At completion of the construction of the WWTP.
LS-D-R-3	Spread topsoil on launch site areas and provide other surface stabilisation measures where required.	Earthworks Supervisor	Following deep ripping.	Site Environmental Coordinator	Once topsoil has been spread.
LS-D-R-4	Spread brush on top-soiled landform and provide other surface stabilisation measures where required.	Earthworks Supervisor	Following spreading of topsoil.	Site Environmental Coordinator	Once brush has been place and other surface stability measures have been deployed.
Rehabilitation					
LS-R-R-1	Undertake direct seeding.	Site Environmental Coordinator	After the break of the season (first 300mm of soil profile is wet).	Environment and Community Relations Manager	After direct seeding has taken place.
LS-R-R-2	Undertake the first monitoring event to track seed germination and evidence of water and/or wind erosion.	Site Environmental Coordinator	Following end of Spring (November) after direct seeding.	Environment and Community Relations Manager	Following end of Spring (November) after direct seeding.
LS-R-R-3	Undertake post works maintenance as required (including weed control).	Site Environmental Coordinator	December following direct seeding.	Environment and Community Relations Manager	Following end of Spring (November) after direct seeding.

LS-R-R-4	Undertake second monitoring event to track seed germination, evidence of water and/or wind erosion and/or impacts from herbivores. If necessary schedule infill direct seeding for late autumn/early winter	Site Environmental Coordinator	Following end of Summer (February).	Environment and Community Relations Manager	Following end of Summer (February).
LS-R-R-5	Undertake maintenance as require.	Site Environmental Coordinator	February to March.	Environment and Community Relations Manager	February to March.
LS-R-R-6	Undertake any infill direct seeding as required.	Site Environmental Coordinator	Immediately following first autumn/winter rain event.	Environment and Community Relations Manager	Immediately following first autumn/winter rain event.

12 LAUNCH SITE DUNE CROSSING (THROUGH BUSH FOREVER SITE) AND BEACH ACCESS CORRIDOR

This section outlines the specific details and management measures for the site launch site beach crossing. The general management measures outlined in Section 4 have been referred to and incorporated in the environmental management framework for the launch site beach crossing.

A summary of the requirements for the specific management of the launch site beach crossing including timing and the designation of responsibility for ensuring that these requirements are implemented is provided within various tables in Section 12.1 to Section 12.7

12.1 DESIGN

The trenched section required for the pipeline will be excavated from the launch site down through Bush Forever Site 397 to the ultimate pipe invert level of the ocean outfall. The alignment of this dune corridor was adjusted from the alignment presented in the PER to an area 10 metres to the north, in order to locate the pipeline through an existing highly degraded blowout in the foredune as shown in Plate 1 and Plate 2. This also reduces the impact on limestone cliffs to the south of the excavation.

The profile of the launch site and the proposed dune crossing trench, and the extent of the trench batters are shown in Figure 15. The sidewall batter grade of the trench will be a maximum of 1:2 in order to ensure stability of the trench, but also to minimise the horizontal intrusion of batters into nearby vegetation and dunal landforms.

Material excavated from the launch site trench (through the primary dune) will be stockpiled within the launch site footprint (in areas previously cleared) and will be used for re-contouring and rehabilitation of the primary dune once the pipe launch is complete.

In association with the pipe launch activities, it will be necessary to excavate and access the excavated sub-ocean trench via a beach crossing. This beach crossing will comprise of a limestone-armoured groyne/cofferdam with internal sheet piling for the passage of the outfall pipe. This temporary beachhead structure connects to the outfall pipe trench excavated through the beach dunes providing passage for the pipe from the launching yard to the sub-ocean trench. Management of the beach crossing, groyne and coffer dam have been documented within the OOPCMP.

12.2 CONSTRUCTION

12.2.1 Disturbance management

The launch site area within the Bush Forever site 397 is to be managed in the longer term for conservation purposes, it is part of the Quindalup dune complex and it has vegetation which ranges from “Completely Degraded” where the existing blow out is located as seen in Plate 1 and Plate 2 to “Very Good” along the foredune area.

The area cleared will be re-contoured and re-instated to achieve pre-disturbance biodiversity values. It is therefore important to manage any ground disturbance during the construction and operation phase to ensure that this can be achieved and that all disturbances to the surrounding terrestrial vegetation is minimised.

Table 12.2.1 below specifically outlines the implementation schedule and responsibilities for disturbance management for the dune crossing to ensure the objectives specified in Section 4.1.2 are met.

Table 12.2.1 Implementation schedule and responsibilities for ground disturbance management for the launch site dune crossing

Action Item Reference	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
BF-GD-PC-1	Undertake survey of the launch site dune crossing and beach access corridor to mark out footprint areas.	Earthworks Supervisor	At least one month before ground disturbing activity.	Environment and Community Relations Manager	Prior to ground disturbing activities.
BF-GD-PC-2	Conduct inductions for operational/management personnel.	Environment and Community Relations Manager	Prior to commencement of works.	Construction Manager	Prior to commencement of works.
BF-GD-PC-3	Prepare a GDWP and submit it to the Environment and Community Relations Manager as outlined in Section 4.1.2.	Site Supervisor	At least a week prior to ground disturbing activity.	Environment and Community Relations Manager	Upon receiving the GDWP for the launch site dune crossing and beach access corridor.
Construction					
BF-GD-C-1	Clearly mark-out the extent of disturbance/clearing with fencing, and install signage.	Earthworks Supervisor	At least two weeks prior to commencement of vegetation clearing.	Earthworks Package Manager	At least one week prior to the intended commencement of vegetation clearing.
BF-GD-C-3	Review clearing is being completed as authorised within a GDWP.	Site Supervisor	During ground disturbing activities.	Site Environmental Coordinator	During ground disturbing activities and at the completion of ground disturbing activities.
BF-GD-C-4	Review GDWP to ensure that disturbance was within the approved boundary, mark up any variances with the permit and conduct rehabilitation of those areas as specified in Section 12.2.7. Follow up internally regarding the identified non-compliance with GDWP and report to the Alliance Manager.	Site Environmental Coordinator	At completion of construction of the launch site.	Environment and Community Relations Manager	At completion of the launch site.
Operation					
BF-GD-O-1	Review vehicle movements and, placement of materials to ensure that disturbance remains within fenced areas only. If transgressions occur and vegetation is damaged notify the Site Environmental Coordinator who will advise on restoration measures where appropriate.	Earthworks Supervisor	Daily during operations.	Site Environmental Coordinator	Daily during operations.
BF-GD-O-2	Monitor and maintain launch site dune crossing to ensure that the area is stable and deploy further stabilisation and	Earthworks Supervisor	Daily during operations.	Site Environmental Coordinator	Daily during operations.

	management where required.				
Decommissioning					
BF-GD-D-1	Remove any signs/fencing installed.	Earthworks Supervisor	At completion of construction of the WWTP.	Site Environmental Coordinator	At completion of earthworks program.

12.2.2 Dieback management

Plant and equipment will be mobilised to site for construction of the launch site area, the risk of transmission will be greatest during the excavation component of the launch site preparation. Without adequate management there is the potential for Dieback to be transmitted to areas within the site and from there to other areas within the project area.

Table 12.2.2 below specifically outlines the implementation schedule and responsibilities for dieback management for the dune crossing to ensure the objectives specified in Section 4.2.2 are met.

Table 12.2.2. Implementation schedule and responsibilities for Dieback management for the launch site dune crossing

Action Item Reference	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
BF-D-PC-1	Commission a Dieback interpreter to complete an initial Dieback survey across the project area.	Site Environmental Coordinator	Prior to any vehicle movements inside the WWTP buffer zone.	Environment and Community Relations Manager	Prior to the construction of the launch site.
BF-D-PC-2	Following advice from the Dieback interpreter develop management measures if not already specified within the management plan.	Site Environmental Coordinator	Prior to any vehicle movements inside the WWTP buffer zone.	Environment and Community Relations Manager	Following advice from Dieback interpreter.
BF-D-PC-3	Clearly delineate any areas infected with Dieback.	Site Environmental Coordinator	Prior to any vehicle movements inside the WWTP buffer zone.	Environment and Community Relations Manager	Weekly throughout project duration.
Construction					
BF-D-C-1	Ensure all plant and equipment have been subject to the Plant and Equipment Hygiene procedure as outlined in Section 4.2.1	Work Supervisor	At least 24 hours prior to site entry.	Site Environmental Coordinator	Upon plant/ equipment arrival.
BF-D-C-2	If Dieback exists ensure that appropriate wash down facilities are installed.	Earthworks Package Manager	Prior to vehicle movements within the dune crossing area.	Site Environmental Coordinator	Prior to vehicle movements within the launch site area.
BF-D-C-3	If Dieback exists ensure infected topsoil is stripped and kept separate from uninfected areas.	Earthworks Supervisor	During topsoil stripping.	Site Environmental Coordinator	Weekly during topsoil stripping.
BF-D-C-4	Construct table drains so that water is not diverted from infected areas into uninfected areas (if Dieback exists).	Earthworks Supervisor	During table drain construction.	Site Environmental Coordinator	At completion of road construction.
BF-D-C-5	Review of vehicle movements to ensure that vehicles remain within the dune crossing area and within areas authorised for disturbance.	Earthworks Supervisor	Daily during construction works.	Site Environmental Coordinator	Weekly during construction works.
Operation					
BF-D-O-1	Review of vehicle movements to ensure that vehicles remain within fenced areas.	Earthworks Supervisor	Daily during operations.	Site Environmental Coordinator	Daily during operations.
BF-D-O-2	Monitor the vegetation condition, especially surrounding infected areas and if Dieback is spreading review Dieback management framework.	Site Environmental Coordinator	Monthly throughout the project duration.	Environment and Community Relations Manager	Monthly throughout the project duration.
LS-D-O-3	Commission a Dieback interpreter to undertake an	Site Environmental	Annually throughout the	Environment and	Annually throughout the

	annual Dieback survey	Coordinator	project duration.	Community relations Manager	project duration.
Decommissioning					
LS-D-D-1	Topsoil from infected areas is to remain within infected areas (if any).	Earthworks Supervisor	At completion of construction activities.	Site Environmental Coordinator	At completion of construction activities.
LS-D-D-2	Commission a Dieback interpreter to complete a Dieback survey post works and document results.	Site Environmental Coordinator	After rehabilitation.	Environment and Community relations Manager	After rehabilitation.

12.2.3 Weed management

Similar potential exists for the transportation and spread of weeds as exist for Dieback. Plant and equipment will be mobilised to site for construction of the dune crossing area and then for the pre-works for the preparation of the ocean outfall pipe pull with the potential for weed to be introduced to surrounding vegetation. The surrounding vegetation of the Bush Forever site supports vegetation which ranges in quality from “Good” to “Very Good” and this will need to be maintained during the course of construction and operation of the dune crossing.

Table 12.2.3 below specifically outlines the implementation schedule and responsibilities for weed management for the dune crossing to ensure the objectives specified in Section 4.3.2 are met.

Table 12.2.3. Implementation schedule and responsibilities for weed management for the launch site dune crossing

Action Item Ref	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
BF-W-PC-1	Undertake a survey of the weed invasion within and surrounding the dune crossing , document findings.	Site Environmental Coordinator	Prior to any works commencing.	Environment and Community Relations Manager	Following survey and prior to any works commencing.
BF-W-PC-2	Establish and map areas which currently have "Very Good" quality vegetation and low weed infestation. In particular the vegetation to the north of the launch site.	Site Environmental Coordinator	Prior to any works commencing.	Environment and Community Relations Manager	Following survey and prior to any works commencing.
Construction					
BF-W-C-1	Ensure all plant and equipment have undertaken a Plant and Equipment Hygiene procedure as outlined in Section 4.2.1.	Earthworks supervisor	At least 24 hours prior to site entry.	Site Environmental Coordinator	Upon plant/ equipment arrival.
BF-W-C-2	Review vehicle movements to ensure that vehicles remain within the dune crossing.	Earthworks Supervisor	Daily during construction works.	Site Environmental Coordinator	Daily during construction works.
Operation					
BF-W-O-1	Review vehicle movements to ensure that vehicles remain on within footprint/fenced areas.	Earthworks Supervisor	Daily during use of the launch site.	Site Environmental Coordinator	Weekly during use of the launch site.
BF-W-O-2	Monitor the vegetation condition of areas specified in BF-W-PC-2 and implement weed control measures if necessary as outlined in Section 4.3.	Site Environmental Coordinator	Weekly throughout the project duration.	Environment and Community relations Manager	Monthly throughout the project duration.
Decommissioning					
BF-W-D-2	Monitor the vegetation condition of areas specified in LC-W-PC-2 and implement weed control measures if necessary as outlined in Section 4.3.	Site Environmental Coordinator	Spring after completion of works.	Environment and Community relations Manager	Spring after completion of works.

12.2.4 Fire management

Fire management is particularly relevant to areas where works are taking place within or adjacent to vegetation and bushland areas. The launch site dune crossing area is surrounded by vegetation and the site itself will be isolated from the main site office.

Fire management measures will need to be implemented and monitored throughout the duration of the project, all staff will need to understand any evacuation procedures and site requirements specified in Section 4.4.3.2.

Table 12.2.4 below specifically outlines the implementation schedule and responsibilities for fire management which must be followed to ensure the objectives specified in Section 4.4.2 are met.

Table 12.2.2. Implementation schedule and responsibilities for fire management for the launch site dune crossing

Action Item Ref	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
BF-PC-FM-1	Inductions of operational/management personnel, outline fire procedures as described in Section 4.4.	Environment and Community Relations Manager	Prior to commencement of works.	Construction Manager	Prior to commencement of works.
Construction					
BF-C-FM-1	Monitor to ensure that all vehicles in operation have a fire extinguisher on board	Earthworks Supervisor	During road construction.	Site Environmental Coordinator	Weekly during construction
BF-C-FM-2	Ensure that no smoking is occurring inside operational vehicles or outside designated smoking areas.	Site Supervisor	During road construction.	Site Environmental Coordinator	Daily during construction.
Operation					
BF-O-FM-1	If work occurs during summer months water cart is to be left full of water.	Earthworks Supervisor	Daily during summer months throughout the project duration.	Site Environmental Coordinator	Weekly during summer months throughout the project duration.
BF-O-FM-2	Ensure that no smoking is occurring inside operational vehicles or outside designated smoking areas.	Site Supervisor	During road construction.	Site Environmental Coordinator	Weekly during construction.

12.2.5 Hydrology management

The Alkimos area is made up of coastal calcareous sand dunes which are highly permeable. The launch site area will have a limestone hardstand surface which necessitates table drains to divert surface run-off away from the surface during heavy rainfall events.

Construction water for dust suppression and compaction will be sourced from ground water production bores at four locations within the project area, abstraction from these production bores will be monitored monthly.

Surface water generation will is unlikely to be an issue during the construction and operation of the launch site , due to the permeable nature of the underlying soils. Given that there are no existing surface water features on the site, the potential impacts are limited to disruptions to the existing water balance of the site, and impacts to groundwater quality from runoff contaminated by construction and support activities.

Table 12.2.5 below specifically outlines the implementation schedule and responsibilities for hydrology for the dune crossing which must be followed to ensure the objectives specified in Section 4.5.2 are met.

Table 12.2.5. Implementation schedule and responsibilities for hydrology management for the launch site dune crossing

Action Item Ref	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
BF-PC-H-1	Measure Department of Water monitoring bores as specified in the 'Licence to Take Water' and described in Section 4.5.3.3.	Site Environmental Coordinator	Prior to production bore construction.	Site Environmental Coordinator	Monthly.
BF-PC-H-2	Order and allocate spill kits to plant/equipment which will be working along the access roads during construction.	Earthworks Supervisor	Prior to construction activities.	Environment and Community Relations Manager	Prior to construction activities.
Construction					
BF-C-H-1	Construct hardstand with slope towards the beach and/or table drains.	Earthworks Supervisor	During construction of the launch site.	Site Environmental Coordinator	During construction of the launch site.
BF-C-H-3	Undertake refuelling offsite or with mobile refuelling vehicles on hard stand areas.	Earthworks Supervisor	During dune crossing construction.	Site Environmental Coordinator	Daily during construction
BF-C-H-4	Install spill response kits in allocated plant and equipment.	Earthworks Supervisor	During dune crossing construction.	Site Environmental Coordinator	Weekly during construction
Operation					
BF-O-H-1	Allow for surface runoff to infiltrate to groundwater within table drains or via flow into the beach zone.	Earthworks Supervisor	During operations at the dune crossing .	Site Environmental Coordinator	During operations at the launch site.
BF-O-H-2	Monitor and maintain table drains to ensure that they are free of debris and are providing adequately drainage for the launch site area.	Earthworks Supervisor	Weekly after table drain construction.	Site Environmental Coordinator	Weekly during project duration
BF-O-H-3	Measure Department of Water monitoring bores as specified in the 'Licence to Take Water' and described in Section 4.5.3.3.	Site Environmental Coordinator	Monthly whilst ground water abstraction is taking place.	Site Environmental Coordinator	Yearly whilst ground water abstraction is taking place.
BF-O-H-4	If spill kits are used/damaged replace immediately.	Earthworks Supervisor	Immediately after a spill kit has been used.	Site Environmental Coordinator	Weekly during project duration
BF-O-H-5	Undertake refuelling offsite or with mobile refuelling vehicles on hard stand areas.	Earthworks Supervisor	During operations at the dune crossing.	Site Environmental Coordinator	During operations at the launch site.

12.2.6 Landform management

Careful consideration has been given to the design and placement of the launch site to minimise impacts to significant geoheritage features. In order to locate the pipeline through an existing highly degraded blow-out area in the fore dune the ocean outfall alignment was adjusted from that presented in the PER to an area 10 metres to the north. This has the benefit of reducing the impact on limestone cliffs to the south of the excavation.

The side wall of the trench through the foredune of the launch site will have an average 1:2 grade, in order to ensure stability of the trench, thereby reducing the potential need for further restorative works to the trench during construction (that could potentially impact adjacent areas), but also minimising the extent of batter intrusion into adjacent areas. Landform management will focus on avoiding any further blow-outs occurring in the area and ensuring trench stability during construction.

The potential impacts to landform and geoheritage and beach profile are not anticipated to be long term, given that the foredune will be reconstructed and the site will be re-contoured as a part of the site rehabilitation measures. Therefore, landform monitoring is only relevant to the construction stage. Furthermore, given that the launch site and the beach access trench will be located predominantly within an existing blowout area and will avoid localised limestone cliff features, the potential short-term impacts are anticipated to be minimal and extremely localised.

The construction of a groyne and coffer dam to facilitate the excavation of the marine trench and pipe pull are not likely to have a permanent impact on the beach profile however the infrastructure may affect movement of sand up and down the beach causing accretion and erosion. A management measure will be to monitor for any significant accretion or erosion around the groyne and coffer dam to ensure that the integrity of the beach remains during the operation stage. Removal and relocation of sand can be facilitated if required and directed by the Environment and Community Relations Manager.

Table 12.2.6 below specifically outlines the implementation schedule and responsibilities for landform management for the dune crossing which must be followed to ensure the objectives specified in Section 4.6.2 are met.

Table 12.2.6. Implementation schedule and responsibilities for landform management for the launch site dune crossing

Action Item Ref	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
BF-PC-L-1	Undertake survey of the launch site area including beach profile and peg out alignment and boundaries.	Earthworks Supervisor	At least one month before ground disturbing activity	Environment and Community Relations Manager	Upon receiving the GDWP for the launch site area.
Construction					
BF-C-L-1	Review vehicle movements to ensure that vehicles remain within authorised areas of disturbance. If transgressions occur and landform is undermined notify the Site Environmental Coordinator who will advise on restoration measures where appropriate.	Earthworks Supervisor	Daily during construction works for the launch site.	Site Environmental Coordinator	Daily during construction works
BF-C-L-2	Construct trench with 1:2 sidewalls to ensure stability and low maintenance.	Earthworks Supervisor	After the limestone hardstand is constructed.	Environment and Community Relations Manager	After the beach access corridor is constructed.
BF-C-L-3	Construct limestone area using materials from site, where practicable.	Earthworks Supervisor	During construction works for the launch site.	Environment and Community Relations Manager	During construction works for the launch site.
BF-C-L-4	Stabilise any construction batters using liquid stabilisers, matting and/or brush.	Earthworks Supervisor	At completion of construction of the beach access structure.	Environment and Community Relations Manager	At completion of construction of the beach access structure
Operation					
BF-O-L-1	Review vehicle movements to ensure that vehicles remain within authorised areas of disturbance. If transgressions occur and landform is undermined notify the Site Environmental Coordinator who will advise on restoration measures where appropriate.	Earthworks Supervisor	Daily during operations.	Site Environmental Coordinator	Daily during operations.
BF-O-L-2	Monitor and maintain batters to ensure the stability and deploy further stabilisation and management where required.	Earthworks Supervisor	Daily during operations.	Site Environmental Coordinator	Weekly throughout project duration.
BF-O-L-3	Monitor the beach profile for any significant accretion or erosion, if observed report to the Environment and Community Relations Manager for implementation of remedial measures.	Earthworks Supervisor	Daily during operations.	Site Environmental Coordinator	Weekly throughout project duration.
Decommissioning					
BF-D-L-1	Backfill and re-contour the foredune to pre-disturbed levels.	Earthworks Supervisor	After the pipe pull is complete.	Environment and Community Relations Manager	After the pipe pull is complete.

12.2.7 Rehabilitation management

The primary dune crossing for rehabilitation purposes is the "cutting" for the launch site and access to the beach to facilitate outfall towing and laying processes. This dune is within a Bush Forever site and is also a very prominent and visually accessible location for the wider community. Given this and the degree of disturbance likely to occur during the outfall construction process a high degree of rehabilitation effort will be required. The primary dune will be removed and stockpiled in order to reinstate the landform following the completion of the construction works.

Rehabilitation of the site will involve:

- Brushing;
- Weed control;
- Direct seeding;
- Tubestock planting;
- Tree guards;
- Sand trap fencing;
- Infill planting; and
- Monitoring and Maintenance.

The approach for rehabilitation on the primary dune crossing area will be different to all other rehabilitation areas, given the area is a dune formation. Therefore dune restoration techniques will be adopted. These techniques are based around achieving stability in what are known to be instable landform features when vegetation is absent. This is due to the exposure of these areas to strong coastal winds and the tendency for the course dunal sands to be wind mobile.

Brushing will need to be undertaken in this area to achieve an intensive coverage, particularly on the ocean side of the dune formation. Brushing will cover approximately 50% of the rehabilitated dune area. In addition, 150 metres of sand trap fencing will need to be installed to slow prevailing wind velocities at the soil surface and to trap moving sand to prevent dune blowouts forming. Given well developed topsoil is not a common component of primary dune soil profiles, topsoil will not be reapplied to the disturbed area.

Direct seeding will be undertaken in the second year (after the above works have been completed and in place for 12 months) at 6 kg/Ha so that the soil surface is more stabilised and seed is not excessively lost through wind and sand movements. Tubestock will be planted at a density of 1 per square metre. Tree-guards should also be allowed to protect the tubestock from weather conditions and predation by kangaroos and rabbits.

The revegetation of the dune areas will attempt to reinstate the existing vegetation units, in their relative quantities along the dune (vegetation units is shown in Figure 10). The quantity of seeds and tubestock required is illustrated in Table 11.7.2b

Table 12.7.2b Seed and tubestock to be used in rehabilitation of the primary dune crossing and Bush Forever area

Melaleuca systena - Lomandra maritima herbland	**% seed mix + tubestock**

Conostylis pauciflora subsp. euryrhipis (P3)	5
Melaleuca systena	1
Acacia lasiocarpa	5
Gompholobium tomentosum	10
Acanthocarpus preissii	3
Desmocladus flexuosus	0.5
Hardenbergia comptoniana	3
Hibbertia subvaginata	1
Lepidosperma pubisquameum	0.5
Gastrolobium nervosum	1
Phyllanthus calycinus	5
Leucopogon parviflorus	1

Spyridium globulosum- Scaevola crassifolia shrubland	% seed mix + tubestock
Scaevola crassifolia	13
Spinifex hirsutus	22
Spinifex longifolius	22
Hemiandra pungens	5
Ficinia nodosa	1
Olearia axillaris	1
Rhagodia baccata	1
Threlkeldia diffusa	1
Hardenbergia comptoniana	1
Lepidosperma gladiatum	1
Acanthocarpus preissii	6
Exocarpos sparteus	1

Dryandra sessilis closed heath	% seed mix + tubestock
Dryandra sessilis	72
Gompholobium tomentosum	16
Hakea trifurcata	2
Hardenbergia comptoniana	1
Melaleuca systena	4
Melaleuca huegelii	2.5
Lepidosperma pubisquameum	0.5
Gastrolobium nervosum	0.5
Phyllanthus calycinus	0.5
Rhagodia baccata	0.5
Spyridium globulosum	0.5

Frankenia pauciflora shrubland (outfall site)	% seed mix + tubestock
Spinifex hirsutus	27
Spinifex longifolius	27
Olearia axillaris	3
Scaevola crassifolia	5

Rhagodia baccata	4
Threlkeldia diffusa	2
Cassytha racemosa	2
Frankenia pauciflora	2
Hardenbergia comptoniana	2
Lepidosperma gladiatum	2
Acanthocarpus preissii	2
Leucopogon sp.	2
Exocarpus sparteus	2
Hemiandra pungens	2
Acacia saligna	2

Melaueca hugelii - Melaleuca systena shrublands	% seed mix + tubestock
Acacia cyclops	1
Acacia truncata	4
Astroloma microcalyx	1
Conostephium pendulum	1
Conostylis pauciflora ssp eury	1
Dianella revoluta	1
Drosera sp.	1
Dryandra sessilis	9
Eremophila glabra	2
Gompholobium tomentosum	12
Hakea trifurcata	1
Hardenbergia comptoniana	2
Leucopogon pauciflora	1
Melaleuca huegelii	20
Melaleuca systena	9
Phyllanthus calycinus	2
Pimelea calcicola	3
Pimelea ferruginea	1
Rhagodia baccata subsp. dioica	1
Sarcozona bicarinata	16
Scaevola nitida	8
Spyridium globulosum	1
Thomasia cognata	1
Trymalium ledifolium	1

Follow-up monitoring and maintenance will be required to ensure that revegetation is successful and the primary dune area has been effectively stabilised and revegetation is stable and self-sustaining. This will continue for two years after the completion of tubestock planting and will identify issues such as weed invasion, death of seedlings, predation, wind or water erosion, and be the basis for maintenance activities.

Infill planting and seeding will be conducted in the third year, after tubestock planting in the first year and direct seeding in the second year. The infill will be applied at 20% of the initial application rate (1 plant every 5 m^2 for tubestock and 1.2 kg/Ha for direct seeding).

Table 12.2.7 below specifically outlines the implementation schedule and responsibilities for rehabilitation for the dune crossing which must be followed to ensure the objectives specified in Section 4.7.2 are met.

Table 12.2.7 Implementation schedule and responsibilities for rehabilitation management for the launch site dune crossing

Action Item Ref	Details of Management Actions	Responsibility for Implementation	Timing for Implementation	Responsibility for Audit and Review	Timing for Review/Audit
Pre-Construction					
BF-PC-R-1	Collection of provenance seed material from areas within Lot 101 and surrounding areas.	Site Environmental Coordinator	Annually depending on seeding times for target species.	Environment and Community Relations Manager	At least six months prior to revegetation commencing.
BF-PC-R-2	Salvage plants/cuttings of species which cannot be propagated from seed for rehabilitation.	Site Environmental Coordinator	Prior to clearing activities.	Environment and Community Relations Manager	Prior to clearing activities.
Construction					
BF-C-R-1	Undertake topsoil quality assessment and formulate topsoil segregation/management approach accordingly.	Site Environmental Coordinator	Prior to clearing commencing.	Environment and Community Relations Manager	After topsoil assessment has been undertaken and prior to clearing commencing.
BF-C-R-2	Clear existing vegetation and push into brush piles at the edge of the road alignment. Aim to keep vegetation intact.	Earthworks Supervisor	Once topsoil assessment is completed.	Site Environmental Coordinator	During vegetation clearing.
BF-C-R-3	Bury weed contaminated vegetation and topsoil separately within the soil column at least 200mm below the surface.	Earthworks Supervisor	Once topsoil has been stripped.	Site Environmental Coordinator	Once topsoil has been stripped.
Decommissioning					
BF-D-R-1	Undertake deep ripping of any hardstand areas along the road surface.	Earthworks Supervisor	At completion of the construction of the ocean outfall pipe pull.	Site Environmental Coordinator	At completion of the construction of the ocean outfall pipe pull.
BF-D-R-2	Re-contour foredune area to resemble natural profile using stockpiled spoil and limestone.	Earthworks Supervisor	At completion of the construction of the ocean outfall pipe pull.	Environment and Community Relations Manager	At completion of the construction of the ocean outfall pipe pull.
BF-D-R-3	Spread brush and track roll on top-soiled landform and provide other surface stabilisation measures where required.	Earthworks Supervisor	Following recontouring.	Site Environmental Coordinator	Once brush has been place and other surface stability measures have been deployed.

Rehabilitation					
BF-R-R-1	Install sand trap fencing.	Earthworks Supervisor	Following brushing.	Environment and Community Relations Manager	Once sand trap fencing and other surface stability measures have been deployed.
BF-R-R-2	Plant tubestock and undertake direct seeding at specified rates as seen in Table 12.2.7a.	Site Environmental Coordinator	After the break of the season (first 300mm of soil profile is wet).	Environment and Community Relations Manager	After tubestock planting and direct seeding has taken place.
BF-R-R-3	Undertake the first monitoring event to track seed germination and evidence of water and/or wind erosion.	Site Environmental Coordinator	Following end of Spring (November) after direct seeding.	Environment and Community Relations Manager	Following end of Spring (November) after direct seeding.
BF-R-R-4	Undertake post works maintenance as required (including weed control).	Site Environmental Coordinator	December following direct seeding.	Environment and Community Relations Manager	Following end of Spring (November) after direct seeding.
BF-R-R-5	Prepare a progress report for following the first year of monitoring and maintenance.	Site Environmental Coordinator	December of the first calendar year following the completion of rehabilitation and revegetation works.	Environment and Community Relations Manager	December of the first calendar year following the completion of rehabilitation and revegetation works.
BF-R-R-6	Undertake second monitoring event to track seed germination, evidence of water and/or wind erosion and/or impacts from herbivores. If necessary schedule infill direct seeding for late autumn/early winter and any maintenance required including weed control.	Site Environmental Coordinator	December of the first calendar year following the completion of rehabilitation and revegetation works.	Environment and Community Relations Manager	December of the first calendar year following the completion of rehabilitation and revegetation works.
BF-R-R-7	Prepare a progress report for following the second year of monitoring and maintenance.	Site Environmental Coordinator	December of the second calendar year following the completion of rehabilitation and revegetation works.	Environment and Community Relations Manager	December of the second calendar year following the completion of rehabilitation and revegetation works.

13 OPERATIONAL MONITORING

Weekly progress meetings covering environmental performance will be held between the Environment and Community Relations Manager and the Site Environmental Coordinator, with findings from these meetings being directly reported to the Alliance Manager.

13.1 ENVIRONMENTAL AND COMPLIANCE MONITORING

During the course of the project, monthly Environmental Audits will be undertaken internally by the Environment and Community Relations Manager and the Site Environmental Coordinator. The audit will ensure compliance with the TCMP is being achieved with a view to immediately rectifying any shortcomings that are identified. All audit findings will be reported directly to the Alliance Manager.

Quarterly Environmental Audits by Water Corporation Environment Branch will be conducted to ensure compliance with the TCMP, with findings being reported directly to the Environment and Community Relations Manager and the Alliance Manager.

The AWA in conjunction with the Water Corporation will need to undertake annual Compliance Audits to ensure compliance with all the conditions outlined in the Ministerial Statement 755. These reports will be provided annually to the DEC Audit and Compliance Branch.

14 REPORTING

14.1 INTERNAL REPORTING

Weekly reports will be available following weekly meetings between the Site Environmental Coordinator and the Environmental and Community Relations Manager.

Reporting will include;

- Induction procedures review and records of inducted personnel;
- Area of clearing completed to date; and
- Issues/incidents with operations and actions/resolutions for these.

All findings will be reported back to the Alliance Manager and will be made available to the Water Corporation.

The TCMP is a live document and as such will be reviewed annually, all revisions will be incorporated where necessary so it maintains an accurate and up to date tool to be used throughout the projects duration.

14.2 EXTERNAL REPORTING

The Water Corporation will be provided with quarterly environmental update reports. Included in the report will be information pertaining to the TCMP, which will outline:

- Induction procedures and records of inducted personnel;
- Area of clearing completed to date; and
- Issues/incidents with operations and actions/resolutions for these;

An Environmental Compliance Report will be submitted to the DEC annually on behalf of the Water Corporation as the proponent for the project. The report will document the process of compliance with all the environmental conditions outlined in the Ministerial Statement 755.

14.3 ROLES AND RESPONSIBILITIES

To ensure the AWA adequately resources and complies with the TCMP throughout the life of the Alliance, various responsibilities have been delegated to personnel within the Alliance. The table attached in Appendix D outlines the roles and responsibilities for the AWA personnel.

15 SUMMARY

This TCMP details how the AWA will manage the terrestrial environment during construction activities for the Alkimos Wastewater Scheme. The design and construction of the Alkimos Wastewater Scheme was undertaken by the AWA on behalf of the Water Corporation will be in accordance with the guiding principle of minimising impacts to the existing environment.

The management measures detailed in this TCMP are considered to be the most appropriate to achieve the objectives stated throughout the document, given the environment in which construction is to occur. Furthermore, the TCMP has been prepared in a manner to comply with Condition 6 associated with Ministerial Statement 755, which was issued in accordance with the provisions of Part IV of the *Environmental Protection Act 1986*. This TCMP is a live document, which may require revision and modification throughout the life of the project.

16 REFERENCES

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PLATES

Plate 1: The proposed location of the Launch Site primary dune crossing through an existing dune blow out, looking directly west towards the ocean.

Plate 2: The proposed location of the Launch Site primary dune crossing, looking directly east.

Plate 3: Photograph of the WWTP area looking north from the southern end

Plate 4: Photograph of the Launch Site looking south indicating the generally degraded nature of the vegetation

Plate 5: Photograph of the Launch Site looking northeast showing the clear delineation between the degraded vegetation and the limestone ridge vegetation community

Plate 6: An indicative Launch Site layout on another project in the United Kingdom

Figures

DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD	DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

WATER CORPORATION | ALKIMOS Water Alliance

Scale: 1:24,000

0 300 600 1,200 1,800 2,400 Meters

PROJECT: ALKIMOS WASTEWATER SCHEME
TERRESTRIAL CONSTRUCTION MANAGEMENT PLAN

DRAWING TITLE: FIGURE 1 :Alkimos WWTP locality plan

Project Number 12769
Original A4
Drawing Number SK01
Revision 00
Designed ND
Checked
Drawn MGW
Approved
Local Authority City of Wanneroo
Sheet 1 of 1
Date 4/01/08

DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD	DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD	DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

PROJECT **ALKIMOS WASTEWATER SCHEME**
TERRESTRIAL CONSTRUCTION MANAGEMENT PLAN

DRAWING TITLE **FIGURE 2 : WWTP and launch site footprint as proposed in the public environmental review**

Scale: **1:14,000** 0 100 200 400 600 800 1,000 1,200 1,400 Metres

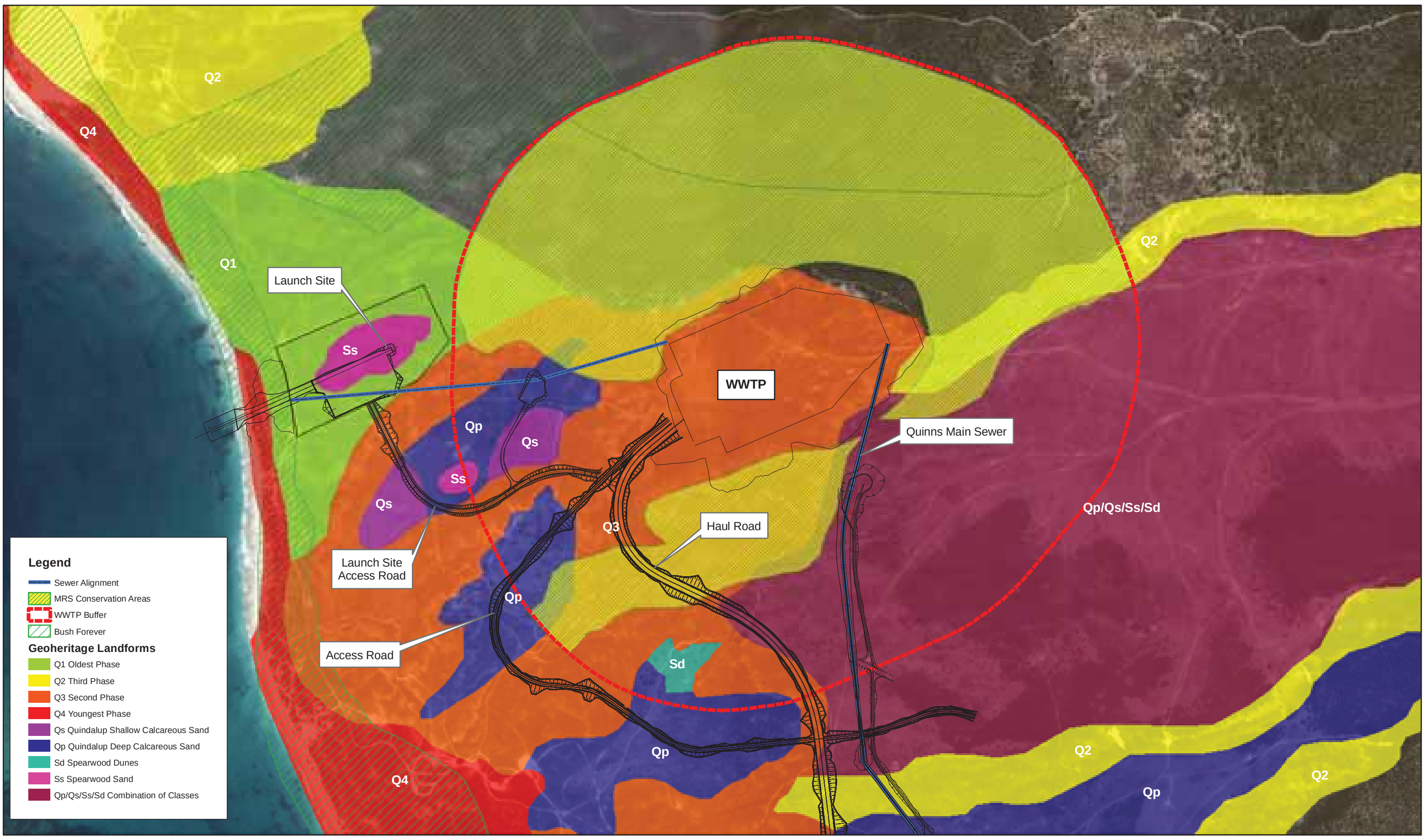
WATER CORPORATION | ALKIMOS

Project Number **12769** | Drawing Number **SK02** | Revision **00** | Original **A4**

Designed KM | Checked | Date 4/01/08
Drawn MGW | Approved | Sheet 1 of 1
Local Authority City of Wanneroo

WATER

ALKIMOS



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PROJECT **ALKIMOS WASTEWATER SCHEME**
TERRESTRIAL CONSTRUCTION MANAGEMENT PLAN

DRAWING TITLE **FIGURE 4: Alkimos landforms and geoheritage features**

Scale: **1:9,000**

0 100 200 400 600 800 1,000 1,200 Metres

WATER ALKIMOS

Project Number	Drawing Number	Revision	Original
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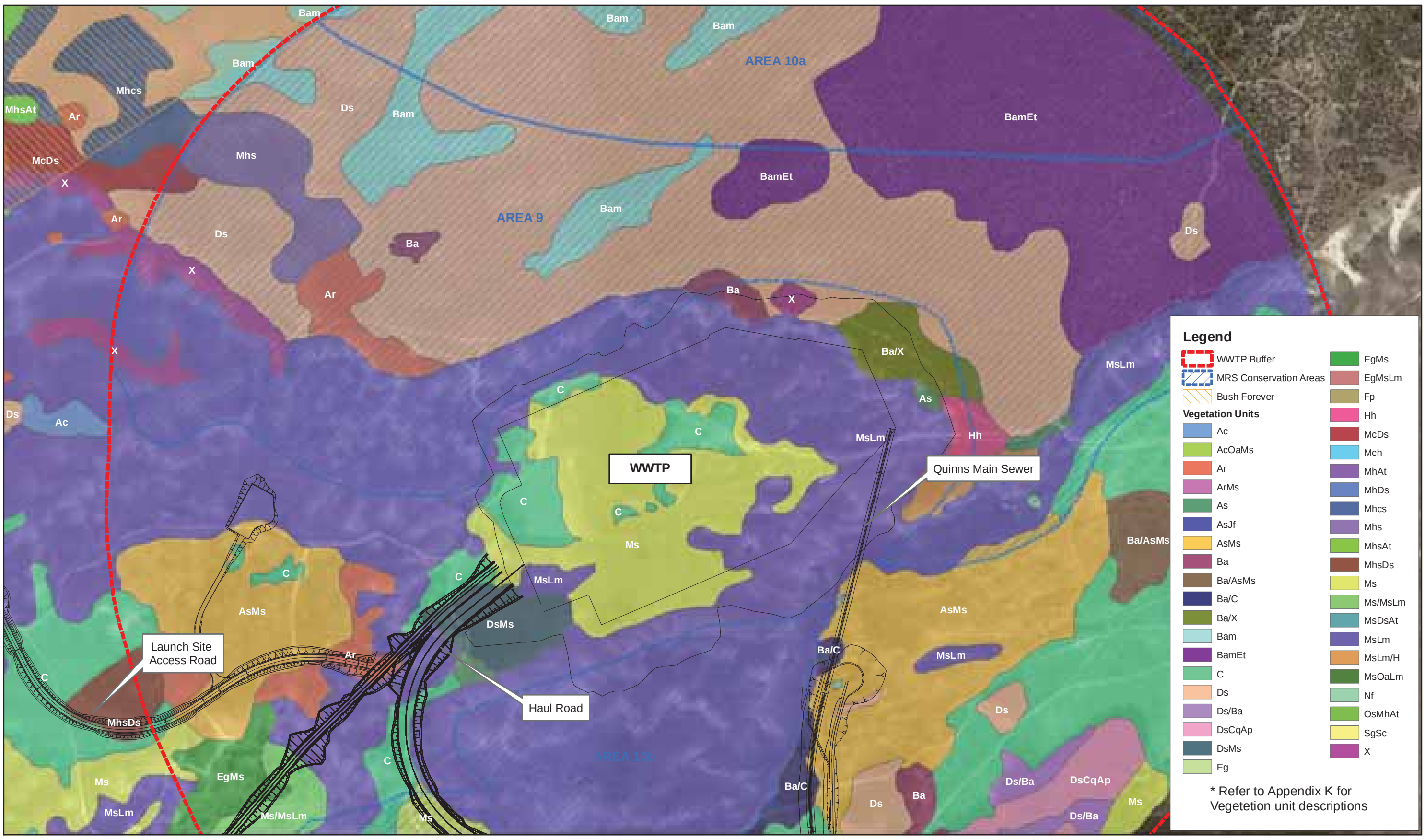
Designed KM Checked Date 4/01/08
Drawn MGW Approved Sheet 1 of 1
Local Authority City of Wanneroo



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PROJECT **ALKIMOS WASTEWATER SCHEME**
TERRESTRIAL CONSTRUCTION MANAGEMENT PLAN

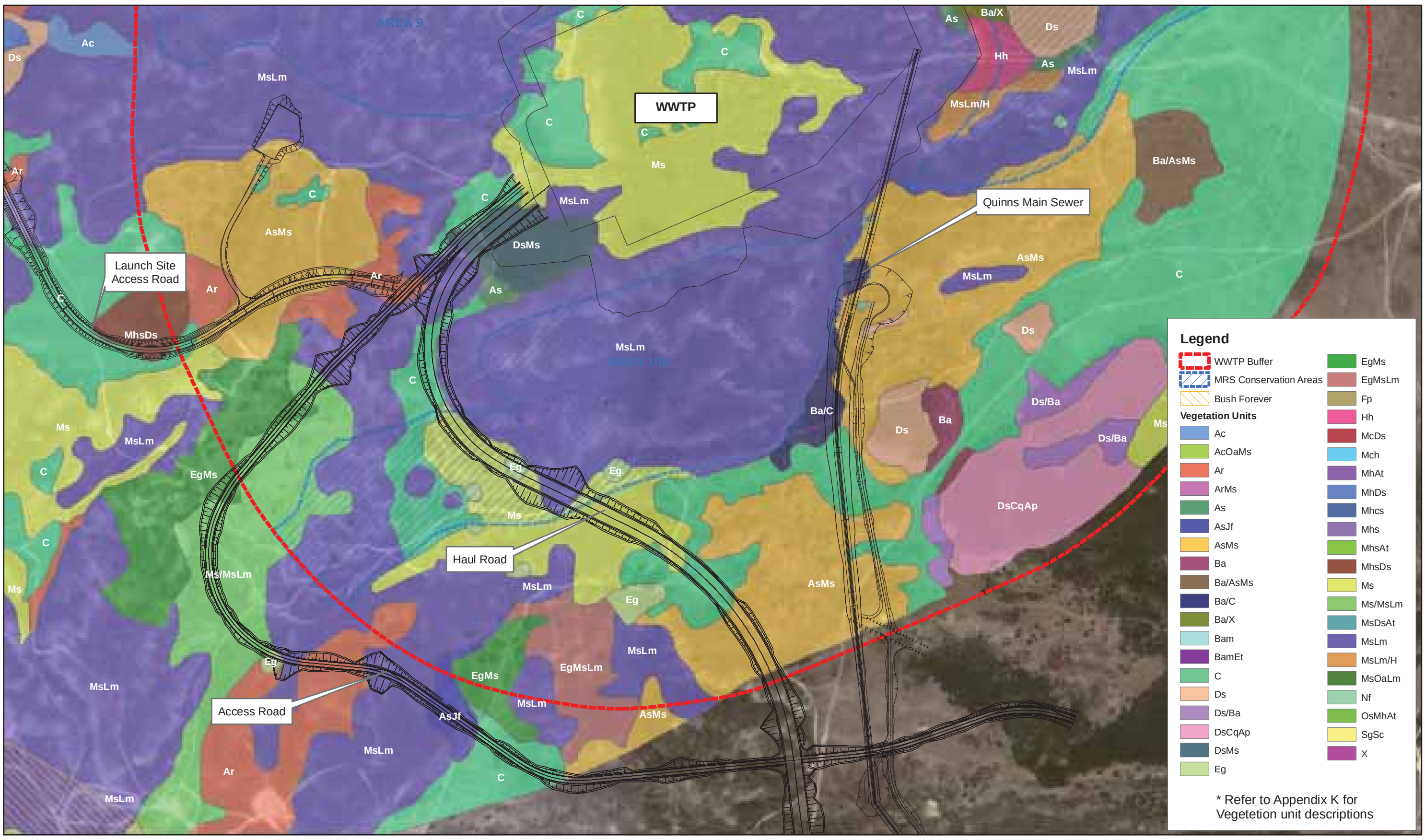
DRAWING TITLE **FIGURE 5: Vegetation units of WWTP site**

Scale: **1:5,000**

0 50 100 200 300 400 500 600 Metres

Project Number	Drawing Number	Revision	Original
12769	SK05	00	A3

Designed KM Checked Date 4/01/08
Drawn MGW Approved Sheet 1 of 1
Local Authority City of Wanneroo



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PROJECT **ALKIMOS WASTEWATER SCHEME**
TERRESTRIAL CONSTRUCTION MANAGEMENT PLAN

DRAWING TITLE **FIGURE 6: Vegetation units of haul and access roads and surrounding areas**

Scale: **1:5,000**

0 60 120 240 360 480 600 Metres

Project Number	Drawing Number	Revision	Original
12769	SK06	00	A3

Designed KM Checked Date 4/01/08
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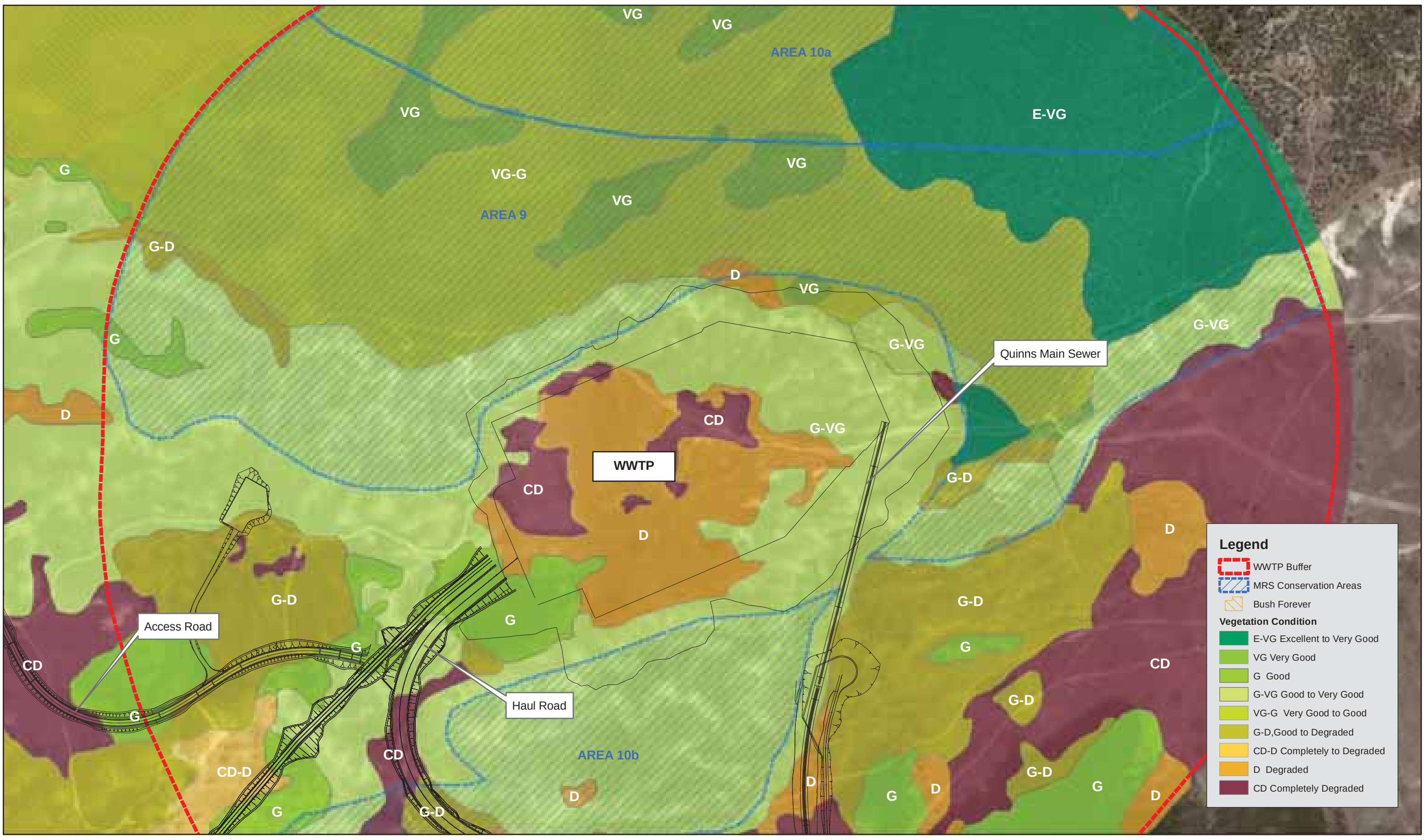

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PROJECT **ALKIMOS WASTEWATER SCHEME**
TERRESTRIAL CONSTRUCTION MANAGEMENT PLAN

DRAWING TITLE **FIGURE 7 : Vegetation condition of WWTP and surrounding areas**

Scale: **1:5,000**

0 75 150 300 450 600 Metres

WATER CORPORATION | ALKIMOS

Project Number	Drawing Number	Revision	Original
12769	SK07	00	A3

Designed KM Checked Date 4/01/08
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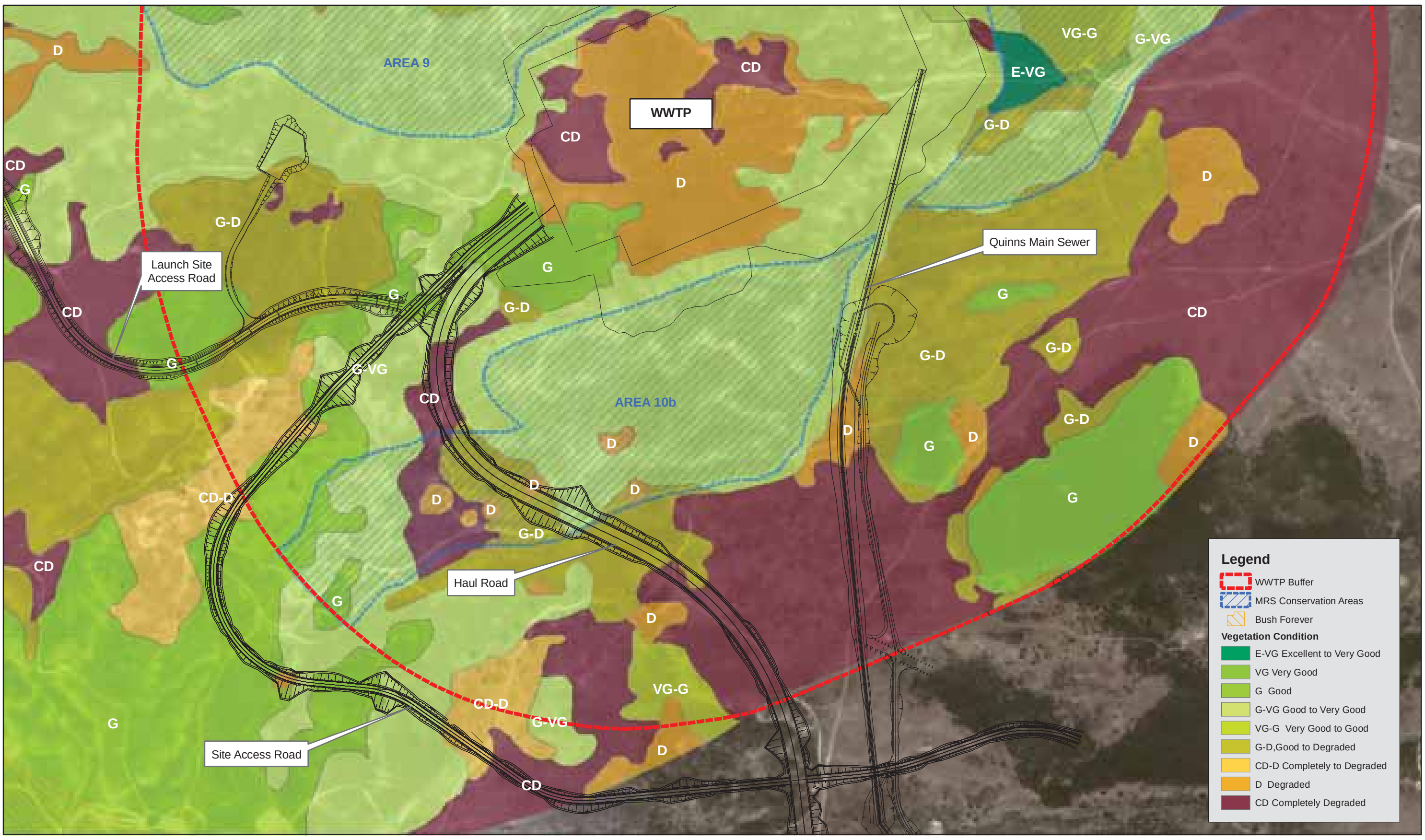
Local Authority City of Wanneroo



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PROJECT **ALKIMOS WASTEWATER SCHEME**
TERRESTRIAL CONSTRUCTION MANAGEMENT PLAN

DRAWING TITLE **FIGURE 8: Vegetation condition of haul and access roads and surrounding areas**

Scale: **1:5,000**

0 70 140 280 420 560 700 Metres

WATER CORPORATION | ALKIMOS

Project Number	Drawing Number	Revision	Original
12769	SK08	00	A3

Designed KM Checked Date 4/01/08
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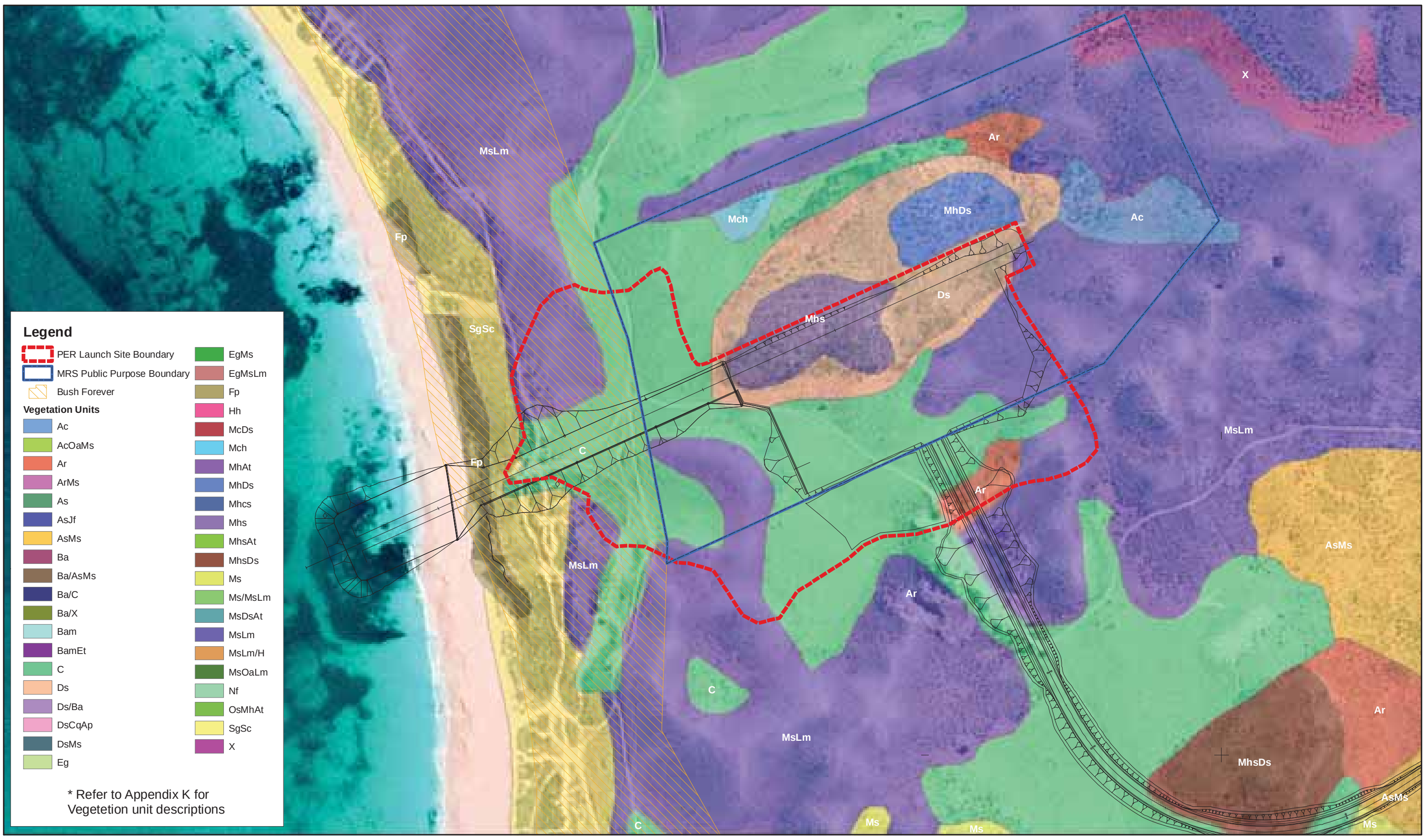
Local Authority City of Wanneroo



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PROJECT **ALKIMOS WASTEWATER SCHEME**
TERRESTRIAL CONSTRUCTION MANAGEMENT PLAN

DRAWING TITLE **FIGURE 9: Vegetation units of launch site and surrounding areas**

Scale: **1:2,500**

0 30 60 120 180 240 300 Metres

WATER CORPORATION | ALKIMOS

Project Number	Drawing Number	Revision	Original
12769	**SK09**	**00**	**A3**

Designed KM Checked Date 22/01/08
Drawn MGW Approved Sheet 1 of 1
Local Authority City of Wanneroo

DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD	DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD	DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

PROJECT **ALKIMOS WASTEWATER SCHEME**
TERRESTRIAL CONSTRUCTION MANAGEMENT PLAN

DRAWING TITLE **FIGURE 10: Vegetation condition of launch site and surrounding areas**

Scale: **1:2,500**

0 30 60 120 180 240 300 Metres

WATER CORPORATION | ALKIMOS

Project Number	Drawing Number	Revision	Original
12769	**SK10**	**00**	**A3**

Designed KM Checked Date 4/01/08
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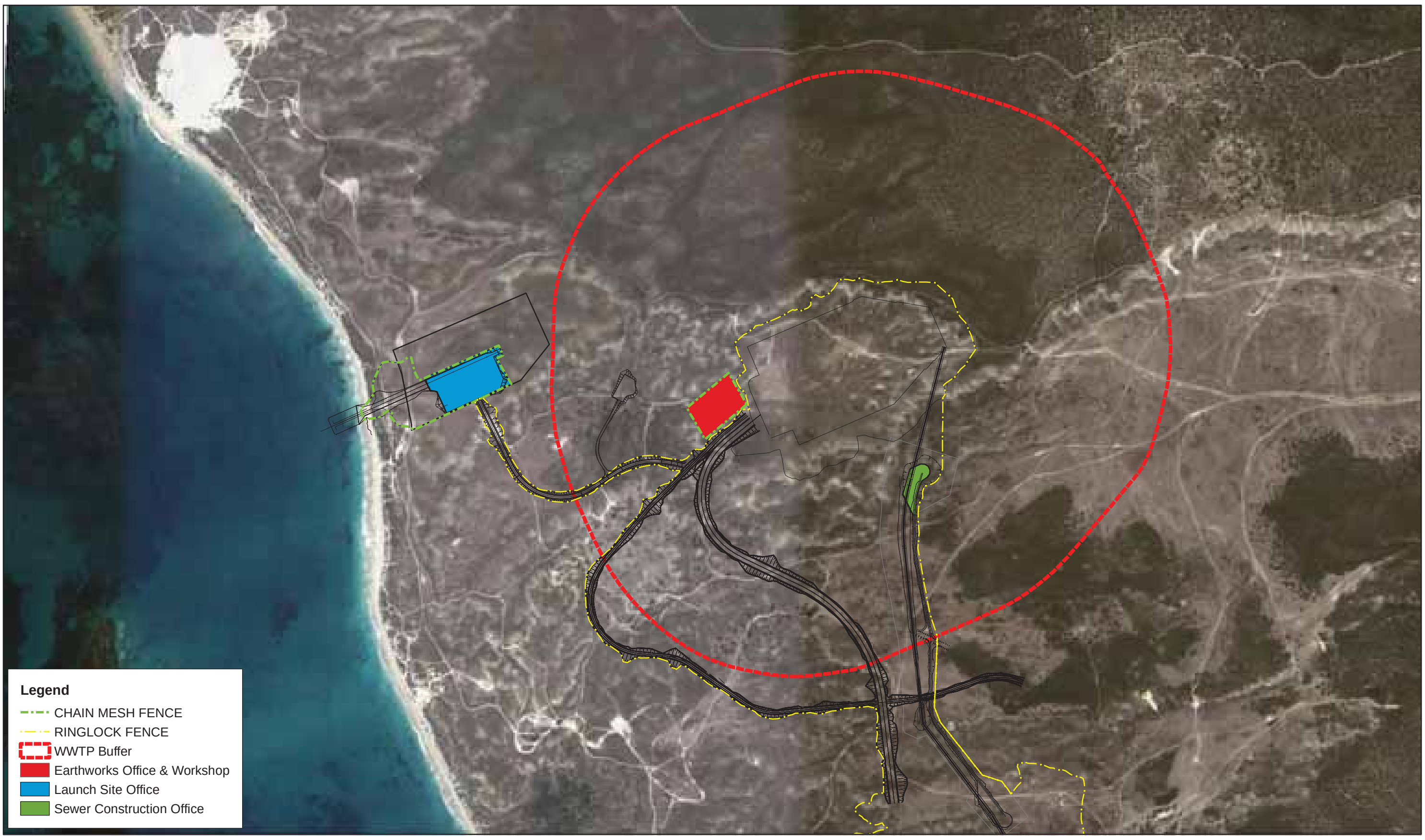
Local Authority City of Wanneroo



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PROJECT: ALKIMOS WASTEWATER SCHEME
TERRESTRIAL CONSTRUCTION MANAGEMENT PLAN

DRAWING TITLE: FIGURE 11 :Fencing Plan

Scale: 1:10,000 — 0 125 250 500 750 1,000 1,250 1,500 Metres

WATER CORPORATION | ALKIMOS

Project Number	Drawing Number	Revision	Original
12769	SK11	00	A3

Designed KM Checked Date 22/01/08
Drawn MGW Approved Sheet 1 of 1
Local Authority City of Wanneroo

Coordinate System: Map Grid of Australia MGA Zone 50
GEOCENTRIC DATUM of AUSTRALIA 1994 (GDA94)

Point Numbers	Easting mE	Northing mN
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3	374654.0	6500751.0
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5	374621.5	6500745.2
6	374613.7	6500752.2
7	374609.1	6500760.5
8	374606.4	6500769.8
9	374598.4	6500783.6
10	374588.6	6500798.1
11	374574.5	6500817.3
12	374566.8	6500830.9
13	374560.5	6500842.8
14	374543.1	6500862.3
15	374525.4	6500878.2
16	374510.5	6500890.9
17	374492.0	6500904.4
18	374468.2	6500919.4
19	374456.6	6500927.5
20	374448.4	6500930.2
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24	374391.7	6500954.7
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43	374171.3	6501116.7
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45	374158.2	6501140.3
46	374150.6	6501163.8
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48	374151.5	6501211.2
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50	374156.3	6501243.3
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53	374134.4	6501254.1
54	374124.9	6501248.4
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56	374100.6	6501232.6
57	374090.3	6501218.7
58	374081.5	6501209.6
59	374069.5	6501199.8
60	374062.6	6501192.5
61	374061.1	6501179.8
62	374055.4	6501171.3
63	374056.0	6501156.5
64	374051.2	6501149.3
65	374041.7	6501148.8
66	374029.4	6501146.7
67	374017.7	6501142.4
68	374007.4	6501136.0
69	374004.1	6501125.7
70	374000.3	6501117.5
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72	373982.9	6501094.4
73	373975.5	6501084.4
74	373963.9	6501074.0
75	373952.3	6501064.7
76	373938.9	6501052.2
77	373925.4	6501038.9
78	373910.0	6501021.8
79	373900.1	6501040.7
80	373908.7	6501049.1
81	373917.5	6501054.8
82	373930.1	6501071.9
83	373948.5	6501099.2
84	373966.2	6501119.7
85	373986.3	6501140.7
86	373993.8	6501147.4
87	374001.4	6501167.2
88	374007.1	6501190.2
89	374019.4	6501193.7
90	374031.4	6501195.7
91	374040.8	6501200.5

92	374045.2	6501213.7
93	374047.4	6501222.2
94	374055.2	6501228.5
95	374065.3	6501232.6
96	374076.6	6501235.3
97	374082.0	6501244.1
98	374092.5	6501247.7
99	374097.1	6501257.2
100	374109.9	6501270.8
101	374120.8	6501281.5
102	374130.8	6501291.4
103	374147.9	6501305.3
104	374142.1	6501325.1
105	374151.8	6501329.5
106	374157.0	6501328.6
107	374176.4	6501333.3
108	374179.6	6501344.2
109	374187.2	6501354.5
110	374194.6	6501363.7
111	374218.3	6501378.7
112	374234.3	6501389.4
113	374245.5	6501396.9
114	374255.5	6501406.2
115	374261.7	6501414.4
116	374267.6	6501424.9
117	374272.5	6501432.9
118	374279.1	6501440.5
119	374292.3	6501424.3
120	374307.2	6501406.4
121	374315.6	6501395.6
122	374327.1	6501381.5
123	374326.4	6501378.8
124	374309.1	6501368.9
125	374292.9	6501360.1
126	374271.7	6501347.2
127	374249.1	6501335.7
128	374240.3	6501331.3
129	374233.3	6501324.9
130	374229.7	6501303.9
131	374225.0	6501296.7
132	374215.7	6501286.6
133	374206.8	6501277.4
134	374200.1	6501270.7
135	374194.9	6501263.1
136	374196.8	6501243.8
137	374192.0	6501227.0
138	374190.1	6501212.1
139	374188.8	6501195.6
140	374188.8	6501180.3
141	374190.1	6501165.2
142	374195.6	6501145.4
143	374202.4	6501129.7
144	374206.0	6501124.3
145	374210.2	6501115.3
146	374212.4	6501105.9
147	374227.3	6501090.8
148	374236.3	6501081.8
149	374245.4	6501074.6
150	374250.1	6501065.7
151	374261.1	6501060.1
152	374275.7	6501053.8
153	374286.9	6501049.0
154	374293.0	6501045.6
155	374299.9	6501037.5
156	374311.0	6501037.6
157	374321.1	6501035.7
158	374334.3	6501034.1
159	374350.4	6501035.0
160	374366.6	6501037.9
161	374373.3	6501028.8
162	374378.1	6501017.7
163	374384.8	6501006.5
164	374393.4	6501001.3
165	374412.5	6500994.8
166	374437.6	6500980.7
167	374447.9	6500975.5
168	374466.0	6500965.4
169	374475.4	6500960.9
170	374489.5	6500943.6
171	374520.5	6500920.7
172	374549.0	6500897.8
173	374574.2	6500871.6
174	374588.3	6500853.8
175	374599.7	6500848.8
176	374610.3	6500835.1
177	374620.1	6500818.9
178	374632.8	6500795.5
179	374637.4	6500786.1
180	374639.4	6500775.5
181	374645.8	6500764.6

DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

PROJECT **ALKIMOS WASTEWATER SCHEME**
TERRESTRIAL CONSTRUCTION MANAGEMENT PLAN

DRAWING TITLE **FIGURE 12 : Access road and haul road extent of disturbance**

Scale: **1:1,200** 0 30 60 120 180 240 300 Metres

CONSULTING ENGINEERS
TOWN PLANNERS
PROJECT MANAGERS
ENVIRONMENTAL CONSULTANTS

Cardno BSD Centre 2 Bagot Road
P.O. Box 155 Subiaco
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Telephone (08) 9273 3888
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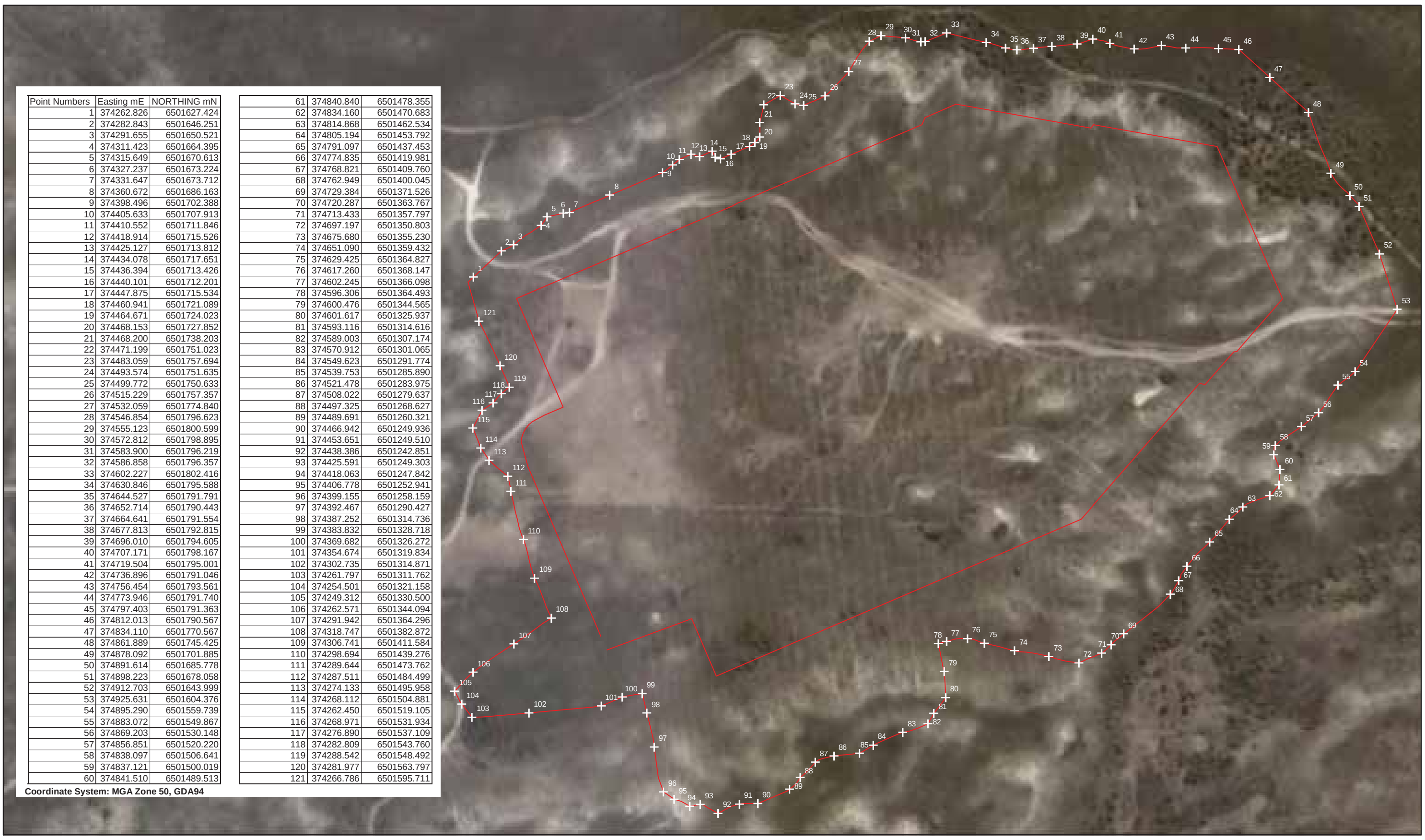
Project Number **V7012** Drawing Number **SK12** Revision **00** Original **A0**
Designed JGH Checked
Drawn MGW Approved
Local Authority City of Joonalup
Date 4/01/08
Sheet 1 of 1



Point Numbers	Easting mE	NORTHING mN
1	374262.826	6501627.424
2	374282.843	6501646.251
3	374291.655	6501650.521
4	374311.423	6501664.395
5	374315.649	6501670.613
6	374327.237	6501673.224
7	374331.647	6501673.712
8	374360.672	6501686.163
9	374398.496	6501702.388
10	374405.633	6501707.913
11	374410.552	6501711.846
12	374418.914	6501715.526
13	374425.127	6501713.812
14	374434.078	6501717.651
15	374436.394	6501713.426
16	374440.101	6501712.201
17	374447.875	6501715.534
18	374460.941	6501721.089
19	374464.671	6501724.023
20	374468.153	6501727.852
21	374468.200	6501738.203
22	374471.199	6501751.023
23	374483.059	6501757.694
24	374493.574	6501751.635
25	374499.772	6501750.633
26	374515.229	6501757.357
27	374532.059	6501774.840
28	374546.854	6501796.623
29	374555.123	6501800.599
30	374572.812	6501798.895
31	374583.900	6501796.219
32	374586.858	6501796.357
33	374602.227	6501802.416
34	374630.846	6501795.588
35	374644.527	6501791.791
36	374652.714	6501790.443
37	374664.641	6501791.554
38	374677.813	6501792.815
39	374696.010	6501794.605
40	374707.171	6501798.167
41	374719.504	6501795.001
42	374736.896	6501791.046
43	374756.454	6501793.561
44	374773.946	6501791.740
45	374797.403	6501791.363
46	374812.013	6501790.567
47	374834.110	6501770.567
48	374861.889	6501745.425
49	374878.092	6501701.885
50	374891.614	6501685.778
51	374898.223	6501678.058
52	374912.703	6501643.999
53	374925.631	6501604.376
54	374895.290	6501559.739
55	374883.072	6501549.867
56	374869.203	6501530.148
57	374856.851	6501520.220
58	374838.097	6501506.641
59	374837.121	6501500.019
60	374841.510	6501489.513
61	374840.840	6501478.355
62	374834.160	6501470.683
63	374814.868	6501462.534
64	374805.194	6501453.792
65	374791.097	6501437.453
66	374774.835	6501419.981
67	374768.821	6501409.760
68	374762.949	6501400.045
69	374729.384	6501371.526
70	374720.287	6501363.767
71	374713.433	6501357.797
72	374697.197	6501350.803
73	374675.680	6501355.230
74	374651.090	6501359.432
75	374629.425	6501364.827
76	374617.260	6501368.147
77	374602.245	6501366.098
78	374596.306	6501364.493
79	374600.476	6501344.565
80	374601.617	6501325.937
81	374593.116	6501314.616
82	374589.003	6501307.174
83	374570.912	6501301.065
84	374549.623	6501291.774
85	374539.753	6501285.890
86	374521.478	6501283.975
87	374508.022	6501279.637
88	374497.325	6501268.627
89	374489.691	6501260.321
90	374466.942	6501249.936
91	374453.651	6501249.510
92	374438.386	6501242.851
93	374425.591	6501249.303
94	374418.063	6501247.842
95	374406.778	6501252.941
96	374399.155	6501258.159
97	374392.467	6501290.427
98	374387.252	6501314.736
99	374383.832	6501328.718
100	374369.682	6501326.272
101	374354.674	6501319.834
102	374302.735	6501314.871
103	374261.797	6501311.762
104	374254.501	6501321.158
105	374249.312	6501330.500
106	374262.571	6501344.094
107	374291.942	6501364.296
108	374318.747	6501382.872
109	374306.741	6501411.584
110	374298.694	6501439.276
111	374289.644	6501473.762
112	374287.511	6501484.499
113	374274.133	6501495.958
114	374268.112	6501504.881
115	374262.450	6501519.105
116	374268.971	6501531.934
117	374276.890	6501537.109
118	374282.809	6501543.760
119	374288.542	6501548.492
120	374281.977	6501563.797
121	374266.786	6501595.711

Coordinate System: MGA Zone 50, GDA94

DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD	DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD	DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

PROJECT **ALKIMOS WASTEWATER SCHEME**
TERRESTRIAL CONSTRUCTION MANAGEMENT PLAN

DRAWING TITLE **FIGURE 13 : WWTP footprint and extent of disturbance**

Scale: **1:2,600**

0 25 50 100 150 200 250 300 Metres

Project Number	Drawing Number	Revision	Original
12769	SK13	00	A3

Designed JGH Checked Date 4/01/08
Drawn MGW Approved Sheet 1 of 1
Local Authority City of Wanneroo

Point No.	Easting mE	Northing mN
1	373214.656	6501449.865
2	373222.824	6501398.489
3	373234.749	6501453.467
4	373238.884	6501412.536
5	373245.348	6501413.004
6	373251.957	6501409.127
7	373258.889	6501405.059
8	373282.955	6501402.203
9	373292.706	6501407.476
10	373301.512	6501412.239
11	373313.565	6501429.225
12	373313.295	6501417.214
13	373324.692	6501399.958
14	373332.882	6501394.287
15	373344.676	6501394.762
16	373352.35	6501394.373
17	373374.202	6501382.598
18	373382.4	6501382.242
19	373399.51	6501377.252
20	373419.827	6501346.241
21	373429.807	6501340.894
22	373445.135	6501344.459
23	373457.254	6501362.638
24	373491.829	6501384.737
25	373503.948	6501395.074
26	373516.78	6501400.777
27	373539.593	6501402.203
28	373577.081	6501418.492
29	373606.337	6501435.308
30	373630.397	6501440.12
31	373664.349	6501460.705
32	373651.228	6501496.685
33	373626.551	6501535.953
34	373614.006	6501555.702
35	373601.793	6501579.668
36	373620.773	6501588.223
37	373607.941	6501617.095
38	373537.995	6501585.326
39	373470.905	6501554.853
40	373429.489	6501536.042
41	373397.816	6501521.657
42	373388.46	6501519.518
43	373383.235	6501527.929
44	373374.151	6501553.256
45	373369.746	6501574.322
46	373364.839	6501584.278
47	373358.912	6501584.088
48	373350.578	6501578.059
49	373341.142	6501570.579
50	373326.628	6501569.095
51	373307.956	6501572.352
52	373292.598	6501570.291
53	373280.52	6501560.165
54	373269.203	6501535.322
55	373260.562	6501512.059
56	373261.711	6501501.891
57	373255.119	6501491.228
58	373246.672	6501477.301
59	373239.751	6501461.939
60	373218.898	6501424.128
61	373229.875	6501448.815

DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD	DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD	DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

PROJECT **ALKIMOS WASTEWATER SCHEME**
TERRESTRIAL CONSTRUCTION MANAGEMENT PLAN

DRAWING TITLE **FIGURE 14 : Launch site footprint and extent of disturbance**

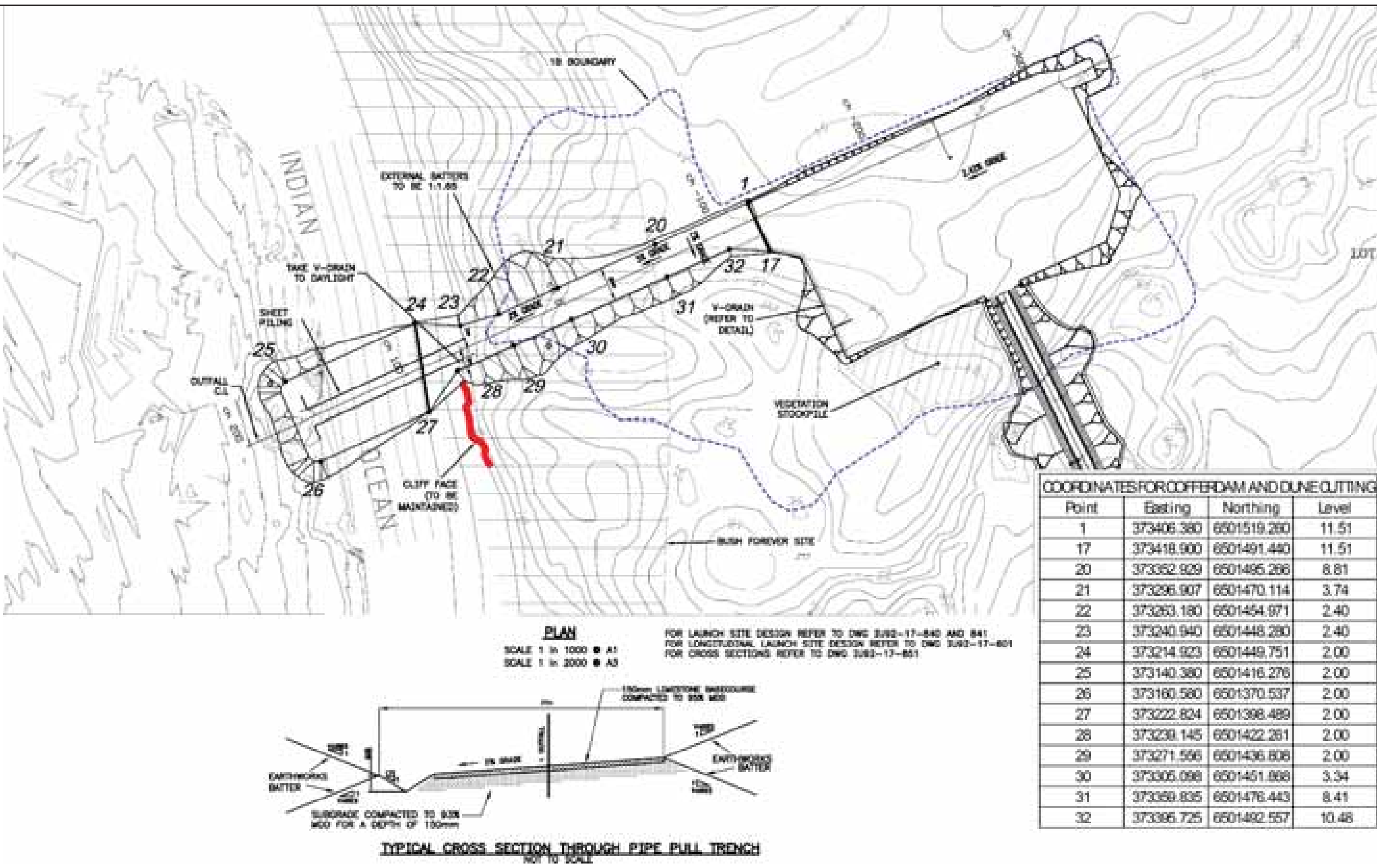
Scale: **1:1,500**

0 20 40 80 120 160 200 Metres

WATER CORPORATION | ALKIMOS

Project Number	Drawing Number	Revision	Original
12769	SK14	00	A3

Designed JGH Checked Date 4/01/08
Drawn MGW Approved Sheet 1 of 1
Local Authority City of Wanneroo



COORDINATES FOR COFFERDAM AND DUNE CUTTING			
Point	Easting	Northing	Level
1	373406.380	6501519.260	11.51
17	373418.900	6501491.440	11.51
20	373352.929	6501495.266	8.81
21	373296.907	6501470.114	3.74
22	373263.180	6501454.971	2.40
23	373240.940	6501448.280	2.40
24	373214.923	6501449.751	2.00
25	373140.380	6501416.276	2.00
26	373160.580	6501370.537	2.00
27	373222.824	6501398.489	2.00
28	373239.145	6501422.261	2.00
29	373271.566	6501436.806	2.00
30	373305.098	6501451.868	3.34
31	373359.835	6501476.443	8.41
32	373395.725	6501492.557	10.46

DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD	DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD	DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

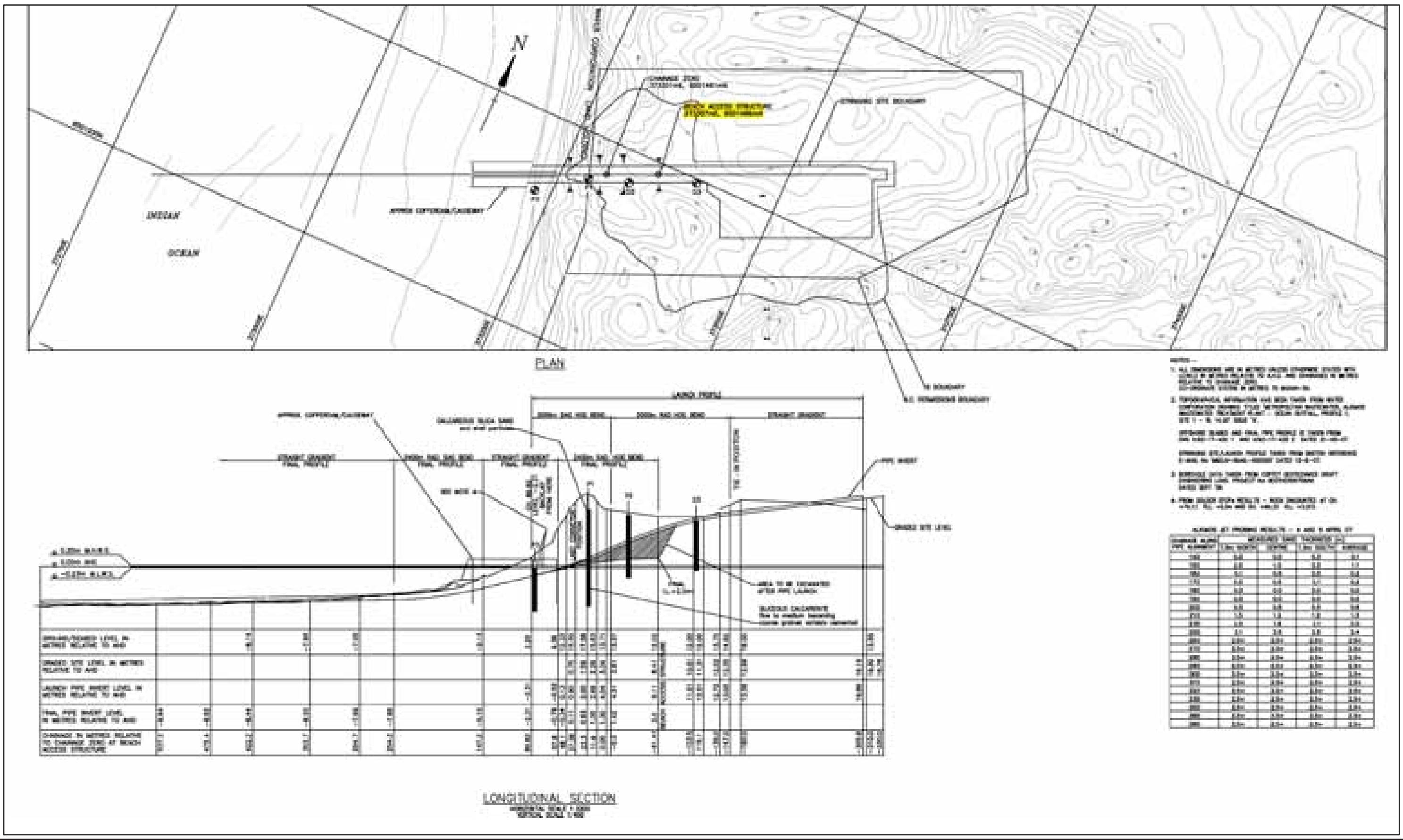
Scale: **NTS: Not to Scale**

PROJECT **ALKIMOS WASTEWATER SCHEME**
TERRESTRIAL CONSTRUCTION MANAGEMENT PLAN

DRAWING TITLE **FIGURE 15: Proposed launch site footprint, groyne and coffer dam structures**

Project Number	Drawing Number	Revision	Original
12769	SK15	00	A3

Designed KM Checked Date 4/01/08
Drawn MGW Approved Sheet 1 of 1
Local Authority City of Wanneroo



DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

PROJECT **ALKIMOS WASTEWATER SCHEME**
TERRESTRIAL CONSTRUCTION MANAGEMENT PLAN

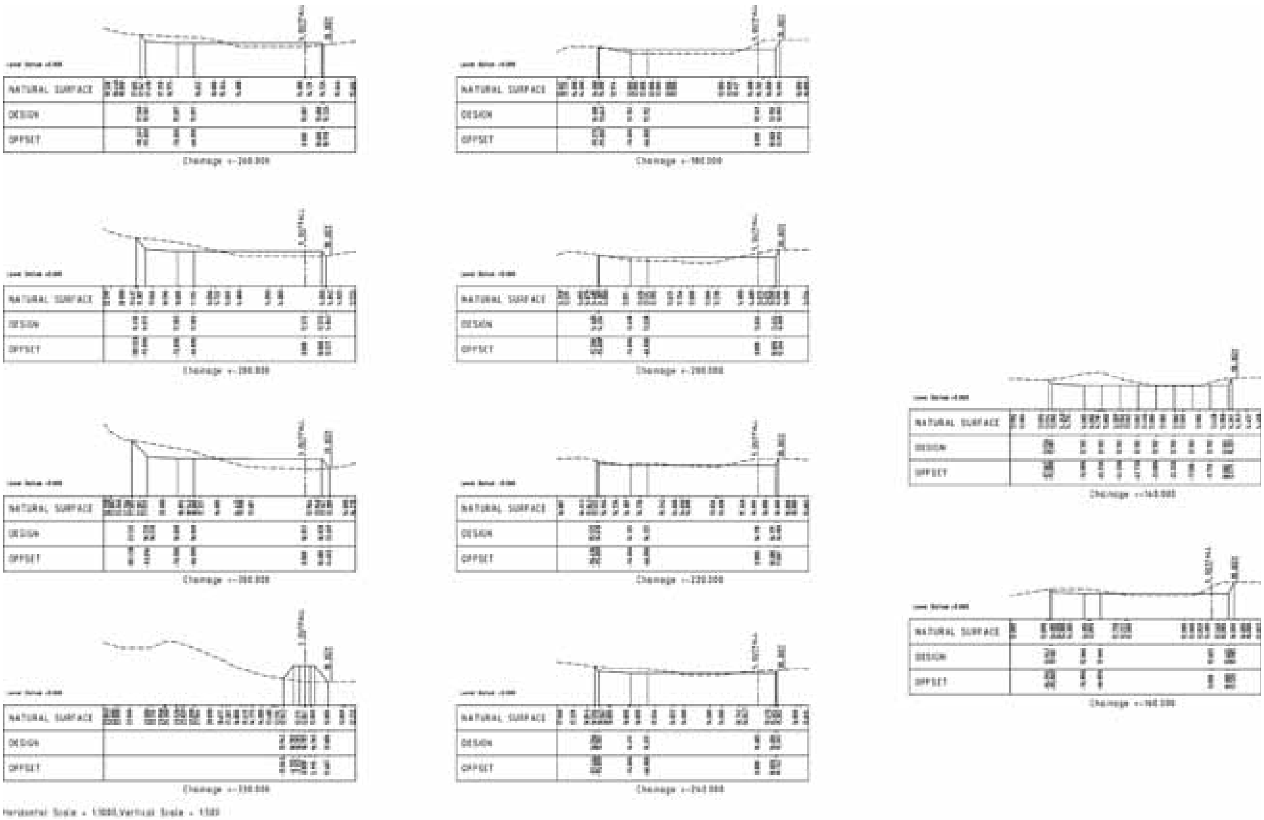
DRAWING TITLE **FIGURE 16: Launch site longitudinal section**

Scale: **NTS: Not to Scale**

WATER CORPORATION | ALKIMOS

Project Number	Drawing Number	Revision	Original
12769	**SK16**	**00**	**A3**

Designed KM Checked Date 4/01/08
Drawn MGW Approved Sheet 1 of 1
Local Authority City of Wanneroo



DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD	DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD	DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

PROJECT **ALKIMOS WASTEWATER SCHEME**
TERRESTRIAL CONSTRUCTION MANAGEMENT PLAN

DRAWING TITLE **FIGURE 17: Launch site cross sections**

Scale: **NTS: Not to Scale**

WATER CORPORATION ALKIMOS

Project Number	Drawing Number	Revision	Original
12769	SK17	00	A3

Designed KM Checked Date 4/01/08
Drawn MGW Approved Sheet 1 of 1
Local Authority City of Wanneroo

Appendix A: Ministerial Statement 755

Published on 12 November 2007 Statement No. 755

STATEMENT THAT A PROPOSAL MAY BE IMPLEMENTED
(PURSUANT TO THE PROVISIONS OF THE
ENVIRONMENTAL PROTECTION ACT 1986)

ALKIMOS WASTEWATER TREATMENT PLANT – SITE B
CITY OF WANNEROO

Proposal: The construction and operation of a wastewater treatment plant, and associated ocean outfall, on the Alkimos-Eglinton Dunal System with an ultimate processing capacity of 160 megalitres per day, as documented in schedule 1 of this statement.

Proponent: Water Corporation

Proponent Address: 629 Newcastle Street, LEEDERVILLE WA 60072

Assessment Number: 1529

Report of the Environmental Protection Authority: Bulletin 1239

The proposal referred to in the above report of the Environmental Protection Authority may be implemented. The implementation of that proposal is subject to the following conditions and procedures (See note 1 at foot of this statement):

1 Proposal Implementation

1-1 The proponent shall implement the proposal as documented and described in schedules 1, 2 and 3 of this statement subject to the conditions and procedures of this statement.

2 Proponent Nomination and Contact Details

2-1 The proponent for the time being nominated by the Minister for the Environment under sections 38(6) or 38(7) of the Environmental Protection Act 1986 is responsible for the implementation of the proposal.

2-2 The proponent shall notify the Chief Executive Officer of the Department of Environment and Conservation (CEO) of any change of the name and address of the proponent for the serving of a notice or other correspondence within 30 days of such change.

3 Time Limit of Authorisation

3-1 The authorisation to implement the proposal provided for in this statement shall lapse and be void within five years after the date of this statement if the proposal to which this statement relates is not substantially commenced.

3-2 The proponent shall provide the CEO with written evidence which demonstrates that the proposal has substantially commenced on or before the expiration of five years from the date of this statement.

4 Compliance Reporting

4-1 The proponent shall submit to the CEO environmental compliance reports annually reporting on the previous twelve-month period, unless required by the CEO to report more frequently.

4-2 The environmental compliance reports shall address each element of an audit program approved by the CEO and shall be prepared and submitted in a format acceptable to the CEO.

4-3 The environmental compliance reports shall:

1. be endorsed by signature of the proponent's Chief Executive Officer or a person, approved in writing by the CEO, delegated to sign on behalf of the proponent's Chief Executive Officer;
2. state whether the proponent has complied with each condition and procedure contained in this statement;
3. provide verifiable evidence of compliance with each condition and procedure contained in this statement;
4. state whether the proponent has complied with each key action contained in any environmental management plan or program required by this statement;
5. provide verifiable evidence of conformance with each key action contained in any environmental management plan or program required by this statement;
6. identify all non-compliances and non-conformances and describe the corrective and preventative actions taken in relation to each non-compliance or non-conformance;
7. provide an assessment of the effectiveness of all corrective and preventative actions taken; and
8. describe the state of implementation of the proposal.

4-4 The proponent shall make the environmental compliance reports required by condition 4-1 publicly available in a manner approved by the CEO.

5 Performance Review

5-1 The proponent shall submit a Performance Review report every five years after the start of construction to the Environmental Protection Authority, which addresses:

1. the major environmental issues associated with implementing the project; the environmental objectives for those issues; the methodologies used to achieve

these; and the key indicators of environmental performance measured against those objectives;

2. the level of progress in the achievement of sound environmental performance, including industry benchmarking, and the use of best available technology where practicable;
3. investigations undertaken in relation to developing alternative options to ocean disposal of treated wastewater, including wastewater re-use;
4. significant improvements gained in environmental management, including the use of external peer reviews;
5. stakeholder and community consultation about environmental performance and the outcomes of that consultation, including a report of any on-going concerns being expressed; and
6. the proposed environmental objectives over the next five years, including improvements in technology and management processes.

6 Terrestrial Construction Management Plan

6.1 Up to three launch/recovery chambers may be used for tunneling of the overland pipeline. These chambers are to be located within the footprint of the WWTP and the footprint of the launch site. Any intermediate chamber is to be located outside a Bush Forever site or Conservation Area as identified by the Water Corporation, to be rehabilitated upon completion of the tunneling.

6-2 Prior to commencement of clearing for the installation of the pipeline, the proponent shall prepare and submit, a Terrestrial Construction Management Plan (the Plan) that meets the objective of Condition 6-3 and the requirements of Condition 6-4 as determined by the Minister for the Environment.

In preparing the Plan the Proponent shall consult with Department of Environment and Conservation.

6-3 The objective of the Plan is to protect native vegetation and landforms on the site outside the area of disturbance as defined in Figure 3 in Schedule 2 and Figure 4 in Schedule 3.

6-4 The Plan shall address the following:

1. modification and configuration (dimension, shape and gradient) of the launch site as far as practicable to minimise the impact of the on terrestrial vegetation and formations launch site dimensions;
2. access roads;
3. sheds, amenities, and other facilities to be installed;
4. management of activities in areas outside the area of disturbance as defined in Figure 3 in Schedule 2 and Figure 4 in Schedule 3;
5. depth of burial of pipe sufficient to withstand a one-in-one hundred year storm;
6. impacts on the beach profile;
7. Bush Forever site, including *Frankenia pauciflora*;
8. Threatened Ecological Communities; and

9. rehabilitation of the launch site/s.

6-5 The proponent shall implement the Plan.

6-6 The proponent shall make the Plan available in a manner approved by the CEO.

6-7 Prior to ground-disturbing activities and in consultation with the Department of Environment and Conservation, the proponent shall put in place measures (which may include fencing and/or signposting) to delineate and protect the locations of plants, vegetation, or other areas of particular conservation significance.

In carrying out rehabilitation activities, the proponent shall only use native plant species of local provenance, defined as plant material or seeds collected within ten kilometres of the project site, except with permission in writing from the CEO.

7. Stability of dunes

7-1 The proponent shall construct the WWTP and associated works to ensure the ongoing stability of the dunal system outside the area of disturbance as defined in Figure 3 in Schedule 2 and Figure 4 in Schedule 3.

8. Ocean Outlet Pipeline Construction Management Plan (Marine)

8-1 Prior to commencement of installation of the pipeline, the proponent shall prepare and submit an Ocean Outlet Pipeline Construction Management Plan (the Plan) that meets the objectives set out in Condition 8.2 that meets the requirements of 8.3 as determined by the Minister for the Environment.

In preparing the Plan the Proponent shall consult with the Environmental Protection Authority.

8-2 The objectives of the Plan is to

(a) ensure the maintenance of the ecological integrity of the marine waters surrounding the Alkimos site; and

(b) ensure the final area of disturbance from Ocean Outlet Pipeline (and diffuser) taking into account rehabilitation works and the ongoing impacts from the presence of the pipeline will be within the area defined in Figure 5 and Table 4 in Schedule 4

8-3 The Plan shall address the following:

1 route design;

2. define the spatial definition of the extent of the disturbance footprint

(a) direct loss of habitat due to construction,

(b) indirect loss of habitat due to construction (sediment plume impacts – loss of light and burial) ;

3. prediction and spatially definition of the long-term stable' state of the marine environment following construction and taking into account indirect effects of construction and on-going impacts from the presence of infrastructure – i.e. predicted impacts (the extent and severity) on the marine environment of indirect

impacts (construction and ongoing impact (see Note 9).

4 amount and type of material to be excavated;

5 rehabilitation of excavated trenches;

6 blasting techniques and areas where blasting occurs;

7 identify where drilling and open-cut techniques (minimising open-cut technique) are to be used for the entire pipe installation;

8 positioning of pipe-laying vessels, mooring pattern design and dredge support vessels;

9 management of benthic community in construction areas;

10 monitoring and establishment of impact from anchoring, wire and chain sweep techniques, marine dredging and supra-tidal excavation techniques used;

11 identification of areas to be dredged, excavated and the timing and duration of dredging/excavation;

12 water quality targets for criteria that will trigger management of sedimentation and protection of benthic community;

13 monitoring reporting, and mitigating impacts on natural littoral drift processes from construction activities and beach profiles during construction; and

14 the management actions and contingencies that will be implemented in the event that criteria for water quality targets required by point 12 above are not being met.

8-4 To ensure that the diffuser is located in a position to reduce the likelihood of plume impacts on high relief algal reefs immediately to the east of the outlet, the proponent shall extend the pipe length by 200 metres from the end of the pipe shown in Figure 4.17 of the proponent’s Public Environmental Review document, Version 3, 8 November 2005. This will give a total pipe length of 3.7 kilometres from the high water mark.

8-5 The proponent is to ensure that the extent of the disturbance footprint (direct and indirect loss of habitat) is no greater than that defined in Condition 8-3 (2).

8-6 The proponent is to ensure that the extent of the disturbance footprint (direct impacts) shall be within the area defined in Figure 5 and Table 4 in Schedule 4.

8-7 The proponent is required to minimise indirect impacts as far as practicable within this boundary during construction.

8-8 The pipeline will be laid within the area defined in Figure 5 and Table 4 in Schedule 4, and the ‘line’ of direct disturbance footprint will also be within the area. (see note 9).

8-9 The proponent shall implement the Plan.

8-10 The proponent shall make Plan publicly available in a manner approved by the CEO.

9 Seabed and Benthic Habitat Monitoring and Management Plan

9-1 Prior to commencement of construction of the Alkimos ocean outlet in the marine environment, the proponent shall prepare and submit a Seabed and Benthic Habitat Monitoring and Management Plan (the Plan) that meets the objectives of condition 9-

2 and the requirements of 9-3 as determined by the Minister for the Environment.

In preparing the Plan the Proponent shall consult with Department of Environment and Conservation.

9-2 The objective of this Plan is to ensure that seabed and benthic habitat loss outside the area of direct loss defined in the Plan required by Condition 8-3 (2) is avoided during construction and re-instated following construction.

9-3 This Plan shall address:

1. Procedures for obtaining and providing to the CEO, within six months following the completion of pipeline installation, an accurate total area and geographically referenced location map of areas of seabed (subtidal, intertidal and beaches) modification and benthic primary producer habitats lost or damaged during pipeline construction, including specific identification of any areas of loss or damage that are in excess or outside of those areas defined and predicted in the Plan required by Condition 8
2. Prediction and spatial definition of long-term stable' state of the marine environment following construction and taking into account on-going impacts from the presence of infrastructure – i.e. predicted impacts (the extent and severity) on the marine environment of indirect impacts (construction and ongoing impacts) (see also Condition 8-3 (3));
3. The establishment of a quantitative annual monitoring program of the seabed and benthic habitat condition in, and adjacent to, areas of seabed and benthic primary producer habitats damaged during pipeline installation and the ongoing presence of the infrastructure; and
4. The indicator(s) and criteria to be used to trigger cessation or reduction in the frequency of monitoring after three years following construction or, in the event of the trigger level referred to in item 3 above being exceeded, after the proponent has demonstrated the success of contingency actions in reducing the rate of annual seagrass loss or damage to less than the contingency trigger level referred to in item 3 above, for three successive years; and
5. Reporting procedures.

9-4 If within six months of completion of construction the marine habitat outside the area of direct impact has not returned to the state predicted in Condition 9-3 (3) the proponent is to commence contingency actions to ensure that the rate of post-construction seabed and/or benthic primary producer habitat loss or damage, is restricted and reduced.

9-5 The proponent shall implement the Plan.

9-6 The proponent shall make Plan publicly available in a manner approved by the CEO.

10 Fauna Management

10-1 Prior to ground-disturbing activity, the proponent shall prepare and submit a Fauna Management Plan (the Plan) that meets the requirements of Condition 10-2 as determined by the Minister for the Environment.

In preparing the Plan the Proponent shall consult with the Environmental Protection Authority.

10-2 The Plan shall address:

1 clearing of the construction area in a step-wise fashion as the plant expands, to reduce impacts on fauna;

2 avoidance of clearing land when Carnaby Cockatoos are actively breeding or foraging in the area; and

3 presence of terrestrial fauna and their translocation.

10-3 The proponent shall implement Plan.

10-4 The proponent shall make Plan publicly available in a manner approved by the CEO.

11 Marine Treated Wastewater Discharge Monitoring and Management Plan

11-1 Prior to commissioning of the wastewater treatment plant, the proponent shall prepare and submit a Marine Treated Wastewater Discharge Management Plan (the Plan) that meets the objective and Environmental Quality Objectives described in 11-2 and the requirements set out in 11-3 as determined by of the Minister for the Environment

In preparing the Plan the Proponent shall consult with the Environmental Protection Authority and the Department of Environment and Conservation

11-2 The objective of the Plan is to ensure that the discharge of Alkimos treated wastewater is managed to achieve simultaneously the following Environmental Quality Objectives as described in the document, Perth's Coastal Waters: Environmental Values and Objectives (Environmental Protection Authority, February 2000).

- Environmental Quality Objective 1 (Maintenance of ecosystem integrity), with spatially-assigned levels of protection as shown in figure 2 of schedule 1;
- Environmental Quality Objective 2 (Maintenance of aquatic life for human consumption) assigned to all parts of the marine environment surrounding the Alkimos ocean outlet with the exception of zones shown in figure 2 of schedule 1; and
- Environmental Quality Objectives 3 and 4 (Maintenance of primary contact recreation values, and Maintenance of secondary contact recreation values) assigned to all parts of the marine environment surrounding the Alkimos ocean outlet with the exception of zones shown in figure 2 of schedule 1.

11-3 The Plan shall address:

1. within the Zone of Low Ecological Protection (i.e. within a 100 metres from the diffuser as shown in figure 1, schedule 2), the proponent shall seek to achieve the ANZECC & ARMCANZ1 80% species protection guideline "trigger" levels (as published from time to time) for bio-accumulating toxicants;
2. within the Zone of High Ecological Protection (i.e. beyond a 100 metres from the diffuser as shown in figure 1, schedule 2), the proponent shall seek to achieve the ANZECC & ARMCANZ 99% species protection guideline "trigger" levels (as published from time to time) for toxicants (with the exception of cobalt, where the 95% guideline shall apply),

3. the establishment of indicators and associated “trigger” levels for further investigations (environmental quality guidelines) for nutrients and social quality objectives;
4. the establishment of “trigger” levels for the implementation of remedial and/or preventative actions to protect the water quality and the environment off Alkimos (environmental quality standards) for toxicants, nutrients and social quality objectives;
5. the monitoring and evaluation, including remodelling, of the social and environmental effects of discharging treated wastewater into the marine environment off Alkimos to assess performance in the protection and maintenance of environmental values and objectives;
6. the specific management actions that will be implemented in the event that environmental quality standards levels are not met, including the option of modifying the diffuser to increase dilution;
7. a program to undertake whole-of-effluent toxicity testing of treated wastewater;
8. the monitoring and reporting of diffuser performance in terms of achieving required number of initial dilutions within the area of low level of ecosystem protection compared to the initial dilutions in schedule 1 under low energy/calm meteorological and sea-state conditions; and
9. the protocols and schedules for reporting performance against the Environmental Quality Objectives.

11-4 The proponent shall implement the Plan.

11-5 The proponent shall make the Plan publicly available in a manner approved by the CEO.

11-6 In the event that a guideline “trigger” level referred to in condition 11-3 is exceeded, the proponent shall report the matter to the Department of Environment and Conservation within one working day of determining that this has occurred, and shall initiate an investigation against the environmental quality standards and into the cause of the exceedance in accordance with the framework developed in the Revised Environmental Quality Criteria Reference Document (Cockburn Sound)2, to the requirements of the Minister for the Environment on advice of the Department of Environment and Conservation.

11-7 In the event that an environmental quality standard referred to in condition 11-3 is exceeded, the proponent shall initiate a management response to determine the source and remedy the exceedance in accordance with the implementation framework for the National Water Quality Management Strategy, to the requirements of the Minister for the Environment on advice of the Department of Environment and Conservation

Note:

1 ANZECC & ARMCANZ guidelines are published in Australian and New Zealand Guidelines for Fresh and Marine Water Quality.

2 Revised Environmental Quality Criteria Reference Document (Cockburn Sound), A supporting document to the draft Environmental Protection (Cockburn Sound) Policy 2002, Environmental Protection Authority Report 20, November 2002.

3 Implementation framework for Western Australia for the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (Guidelines Nos 4 & 7: National Water Quality Management Strategy), Report of the Environmental Protection Authority, Bulletin 1078, November 2002.

11-8 Prior to submitting a Works Approval application for the plant, the proponent shall:

1 estimate the expected typical physico-chemical composition and flow rates of all wastewater streams discharging into the environment from the site;

2 estimate, for all non-negligible contaminants and nutrients, the total annual loads of contaminants and nutrients in the wastewater discharge exiting the site;

3 estimate, for normal and worst-case conditions, the concentrations of contaminants and nutrients (for agreed averaging periods) in the wastewater discharge exiting the site; and

4. Establish a reporting process that is an inventory of toxicants that enter and leave the plant.

11-9 Prior to submitting a Works Approval application for the plant, the proponent shall provide information to show how "best practicable technology" and waste minimisation principles for contaminants and nutrients have been adopted for the wastewater discharge.

11-10 Within three months following commissioning and stabilizing of plant operations, the proponent shall conduct an analysis demonstrating that effluent properties are substantially consistent with predictions. Similar analyses shall also be conducted within three months following every major increase in the volume of treated wastewater discharged from the plant or any significant change in effluent characteristics.

11-11 The proponent shall develop a Contingency Wastewater Management Plan which will consider alternate options for wastewater treatment and/or disposal in the event that the Water Quality Objectives are not met.

11-12 In the event that effluent properties are not substantially consistent with predictions (refer to condition 11-9), the proponent shall conduct toxicological studies on the actual effluent, or provide acceptable alternative information such as risk assessment, to the timing and other requirements of the Minister for the Environment.

These studies and/or information shall be consistent with ANZECC requirements

11-13 In the event that the findings resulting from condition 11-12 indicate that the effluent poses a significant risk to the diversity of the species and biological communities and abundance/biomass of marine life, the proponent shall implement the Contingency Wastewater Management Plan required by condition 11-11.

11-14 The proponent shall review and revise the Contingency Wastewater Management Plan required by condition 11-11.

11-15 The proponent shall make any revisions of the Contingency Wastewater Management Plan, as required by condition 11-11, publicly available in a manner approved by the CEO

12 Odour Management Plan

12-1 Prior to commencement of operation, the proponent shall prepare and submit an Odour Management Plan (the Plan) to meet the objective set out in Condition 12-2 and the requirement in Condition 12-3 as determined by the Minister for the Environment.

In preparing the Plan the Proponent shall consult with the Environmental Protection Authority.

12-2 The Objective of the Plan is to manage the impacts of odour on health and amenity.

12-3 The Plan shall address

1. an initial dynamic olfactometry determination;
2. the biofilter acclimation period;
3. procedures for the replacement of the biofilter media;
4. regular checks of biofilter loading to ensure that the biofilter is balanced and to identify any short circuits (e.g. surface flow rate measurements and smoke tests);
5. the size of the stack;
6. compliance with the odour criteria, and trigger mechanisms for remedial actions when appropriate;
7. regular qualitative determination of odour from the facility;
8. odour surveys every five years;
9. contingency plans during upset or maintenance conditions;
10. contingency plans in the event of exceedances; and
11. complaint registration, investigation and response.

12-4 The proponent shall implement the Plan.

12-5 The proponent shall make the Plan publicly available in a manner approved by the CEO

12-6 The proponent shall operate the plant at all times to ensure that odour at all adjacent odour sensitive premises meets criterion for odours set out in condition 12-7 .

12-7 The odour criterion referred to in Condition 12-6 shall be 5 odour units (OU) (based on the 99.9 percentile 1 hour averaging Australia Standard OU) or as specified by the CEO from time to time through amendment of the operating licence issued under Part V of the *Environment Protection Act 1986*.

13 Decommissioning and Closure Plan

13-1 At least two years prior to the anticipated date of decommissioning and closure, or at a time agreed by the Environmental Protection Authority, the proponent shall prepare and submit a Decommissioning and Closure Plan (the Plan) that meets the requirements of Condition 13-2 as determined by the Minister for the Environment

In preparing the Plan the Proponent shall consult with the Environmental Protection Authority.

13-2 The Plan shall address:

1. removal or, if appropriate, retention of plant and infrastructure in consultation with relevant stakeholders;
2. rehabilitation to a standard suitable for the agreed new land use(s); and
3. identification of contaminated areas, including provision of evidence of notification and proposed management measures to relevant statutory authorities.

13-3 The proponent shall implement the Plan until such time as the Minister for the Environment determines, on advice of the Environmental Protection Authority, that the proponent's decommissioning and closure responsibilities have been fulfilled.

13-4 The proponent shall make the Plan publicly available in a manner approved by the CEO.

Notes

1. In the event that implementation of this proposal at Site B (Assessment No. 1529) is approved, implementation of the similar proposal at Site A (Assessment No. 1582), will not be approved.
2. The CEO may seek the advice of the Environmental Protection Authority, government agencies and relevant parties, as necessary, for the preparation of written notice to the proponent
3. The proponent should consult with relevant stakeholders, including but not necessarily limited to, the Department of Fisheries (regarding potential impacts on a rock lobster puerulis monitoring site) and the City of Wanneroo in the preparation of the management plans required by these conditions as and where appropriate.
4. The proponent is required to apply for a Works Approval and Licence for this project under the provisions of Part V of the *Environmental Protection Act 1986.*
5. The CEO will review the licence when the wastewater flow reaches 40 Megalitres per day, and periodically thereafter.
6. The proponent has committed to undertake best engineering design and construction practices to ensure the stability of the dune systems affected by the excavation for the WWTP and associated works.
7. It is expected that the proponent would address the use of additional odour Reduction Technology as required through the licensing process under Part V of the *Environment Protection Act 1986.*
8. These conditions do not in any way remove the proponent's obligation to comply with all relevant conditions contained in the Ministerial Statement 722, particularly in respect of the proponent's responsibility to develop and implement management plans for the installation of minor infrastructure on the land known as Areas 9a, 10a and 10b.

9. It is expected that the final area of disturbance from Ocean Outlet Pipeline (and diffuser) taking into account rehabilitation works and the ongoing impacts from the presence of the pipeline will be within the area defined in Figure 5 and Table 4 in Schedule 4.

David Templeman MLA
MINISTER FOR THE ENVIRONMENT; CLIMATE CHANGE; PEEL

Schedule 1

Alkimos Wastewater Treatment Plant – Site B, City of Wanneroo (Assessment No. 1529)

General Description

The construction and operation of a wastewater treatment plant, and associated ocean outfall, on the Alkimos-Eglinton Dunal System with an ultimate processing capacity of 160 megalitres per day.

The main characteristics of the proposal are summarised in Table 1 below.

Table 1: Summary of Key Proposal Characteristics

Characteristic	Site B
Indicative life of project	Staged capacity to be implemented as follows: **Indicative Timing** — **Installed Capacity (ML/d) of inflow** 2009/10 — 10 2020 — 40 2030 — 60 2040 — 80 2050 — 120 Beyond 2050 — 160
Treatment process	Wastewater will be treated to an advanced secondary standard based upon the activated sludge process similar to that recently constructed at Woodman Point wastewater treatment plant. Additional treatment processes will be utilised to make the treated wastewater "fit for purpose" for disposal and re-use opportunities as and when they become available/viable. Odours will be vented via an approximately 50 metre tall stack.
Toxicant concentrations	Projected loads and flows will result in toxicant concentrations meeting the ANZECC & ARMCANZ 80% species protection guideline values for bio-accumulating toxicants within 100 metres of the ocean outlet diffuser, and meeting the ANZECC & ARMCANZ 99% species protection guideline values for bio-accumulating toxicants beyond 100 metres from the ocean outlet diffuser.
Connecting Pipeline Length Diameter Construction method	 750 metres approximately 1000 to 1200mm inner diameter and 1400 to 1500mm outer diameter Drilling/boring method of pipe installation
Outlet pipeline Description Length Diameter Construction method	 Discharge up to 40ML/d advanced secondary treated wastewater beyond 2009. Duplication of the outlet may be required in the future, dependent upon availability of other disposal/reuse options at that time. 3.7 kilometres 1000 to 1200mm inner diameter and 1400 to 1500mm outer diameter Open-cut pipe installation

Characteristic	Site B
Outlet diffuser Length Diameter Number of ports Port spacing Port diameter Dilution	 300 metres 1200mm inner diameter and 1400 to 1500mm outer diameter 100 3 metres 100mm The average dilution of the wastewater stream in the ocean will be at least 1:300 with the dilution being above 1:200 99% of the time within 100 metres of the ocean outlet diffuser.
Marine habitat loss arising from the construction of the pipeline	Not more than 7ha of seagrass (cumulative benthic primary producer habitat losses less than 1%)
Power requirements	3 Megawatts (ultimate)
Power source	Western Power grid
Volume of excavation	Not more than 3,000,000 cubic metres
Clearing of vegetation required Treatment plant site (including batters) Ocean outlet launch Site 1B Access roads within buffer Haul roads within buffer Quinns sewer route-within buffer to treatment plant **Total**	 19ha 6.6ha 0.7ha 1.3ha 0.6ha **Not more than 29 ha**
Odour buffer	A 600 metre Public Purpose Reserve Buffer as gazetted (Western Australian Planning Commission, 2006) on 7 July 2006.

Abbreviations
ha = hectares
ML/d = Megalitres per day
mg/L = milligrams per litre

Figures (attached)

Figure 1: Alkimos Location Map
Figure 2: Areas where Environmental Quality Objectives are to apply

Figure 1: Alkimos Location Map

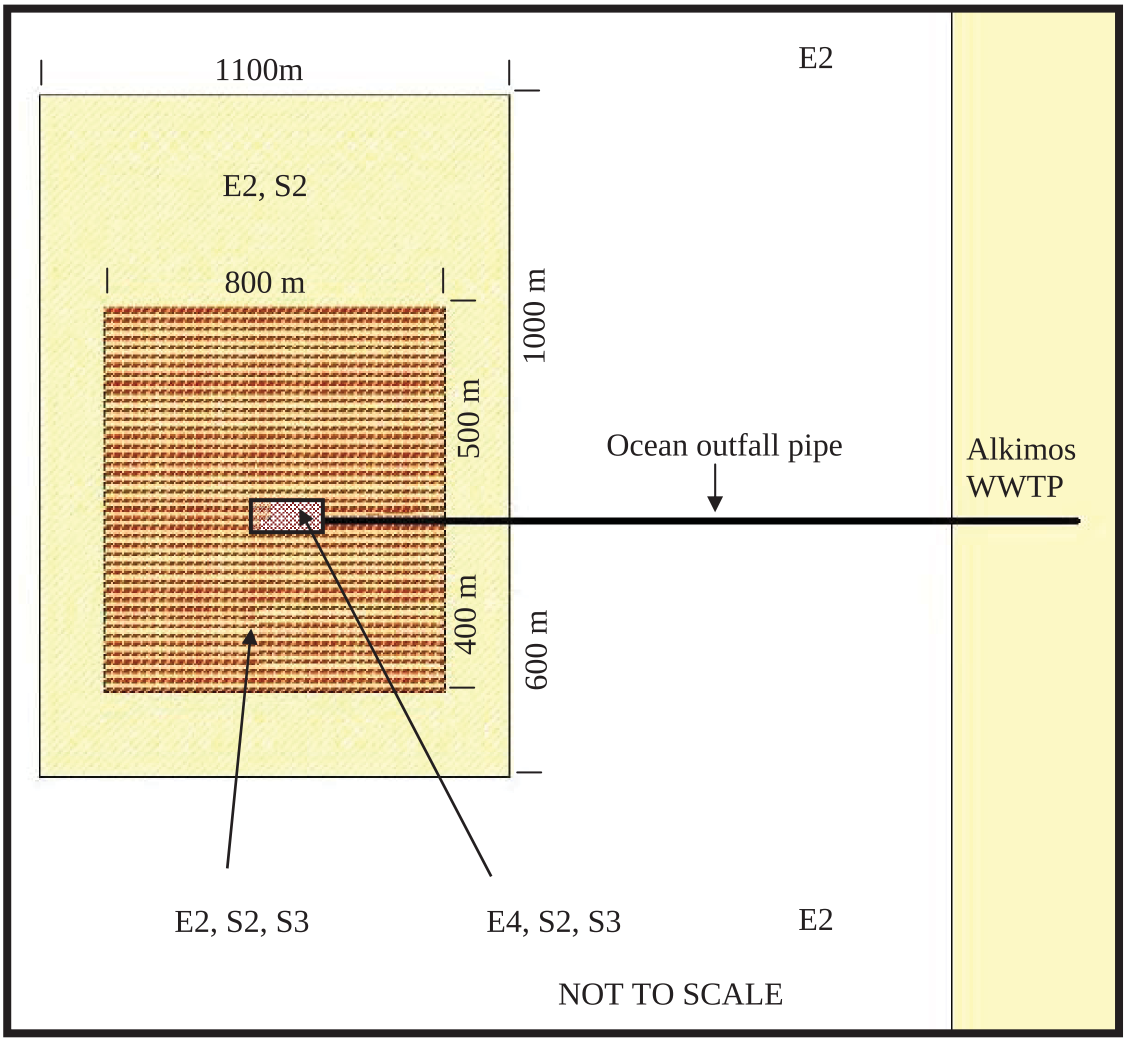


Figure 2: ***Areas where Environmental Quality Objectives are to apply***

Key

E2: High level of ecosystem protection (everywhere more than 100 metres from the diffuser)
E4: Low level of ecosystem protection (within 100 metres of the diffuser)
S2: Not safe to harvest seafood
S3: Not safe for primary contact recreation

Note

Outlet diffuser length not exceeding 300 metres.

Schedule 2

Disturbance footprint for the wastewater treatment plant

The construction and operation of the wastewater treatment plant shall not extend beyond the limits defined in Figure 3 and Table 2 below.

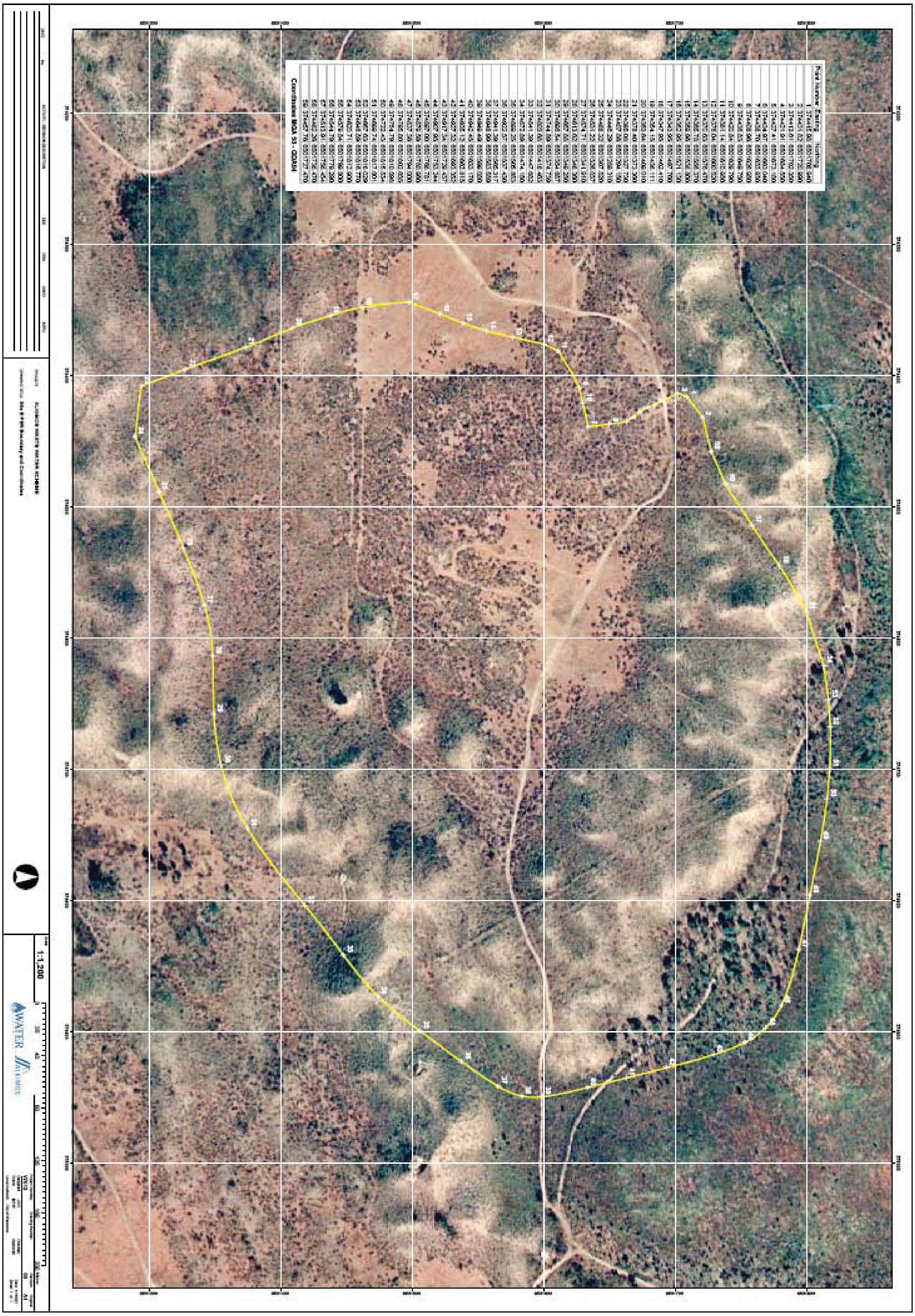


Figure 3: Disturbance footprint for the wastewater treatment plant

Table 2: Coordinates of disturbance footprint for wastewater treatment plant

Point Number	Easting	Northing
1	374415.98	6501708.940
2	374431.82	6501720.990
3	374413.61	6501702.350
4	374421.91	6501684.550
5	374427.41	6501673.180
6	374434.97	6501663.040
7	374438.70	6501633.930
8	374408.96	6501626.980
9	374436.83	6501649.750
10	374420.84	6501629.790
11	374381.14	6501610.980
12	374376.04	6501600.520
13	374370.63	6501576.470
14	374365.78	6501556.370
15	374359.96	6501538.800
16	374352.95	6501521.130
17	374343.95	6501497.760
18	374347.95	6501462.410
19	374354.15	6501438.111
20	374363.64	6501409.010
21	374378.40	6501373.360
22	374395.08	6501327.730
23	374407.86	6501294.150
24	374446.29	6501289.310
25	374488.32	6501307.520
26	374531.22	6501326.037
27	374574.71	6501341.910
28	374613.62	6501348.360
29	374657.88	6501349.250
30	374696.54	6501354.687
31	374744.89	6501374.739
32	374803.68	6501418.463
33	374841.39	6501447.682
34	374872.89	6501474.150
35	374899.25	6501505.883
36	374922.57	6501537.430
37	374941.39	6501565.317
38	374948.99	6501583.589
39	374949.49	6501599.080
40	374942.45	6501633.170
41	374935.12	6501662.815
42	374927.32	6501693.352

43	374917.34	6501729.437
44	374907.95	6501753.244
45	374897.00	6501768.781
46	374879.59	6501780.960
47	374837.36	6501794.000
48	374795.80	6501802.655
49	374754.79	6501810.598
50	374722.43	6501815.534
51	374699.74	6501817.601
52	374667.63	6501818.029
53	374646.89	6501816.770
54	374620.71	6501812.900
55	374579.84	6501799.800
56	374544.79	6501779.290
57	374513.91	6501758.454
58	374482.26	6501738.470
59	374457.76	6501727.470

Schedule 3

Disturbance footprint for the launching site

The construction and operation of the launching site shall not extend beyond the limits defined in Figure 4 and Table 3 below.

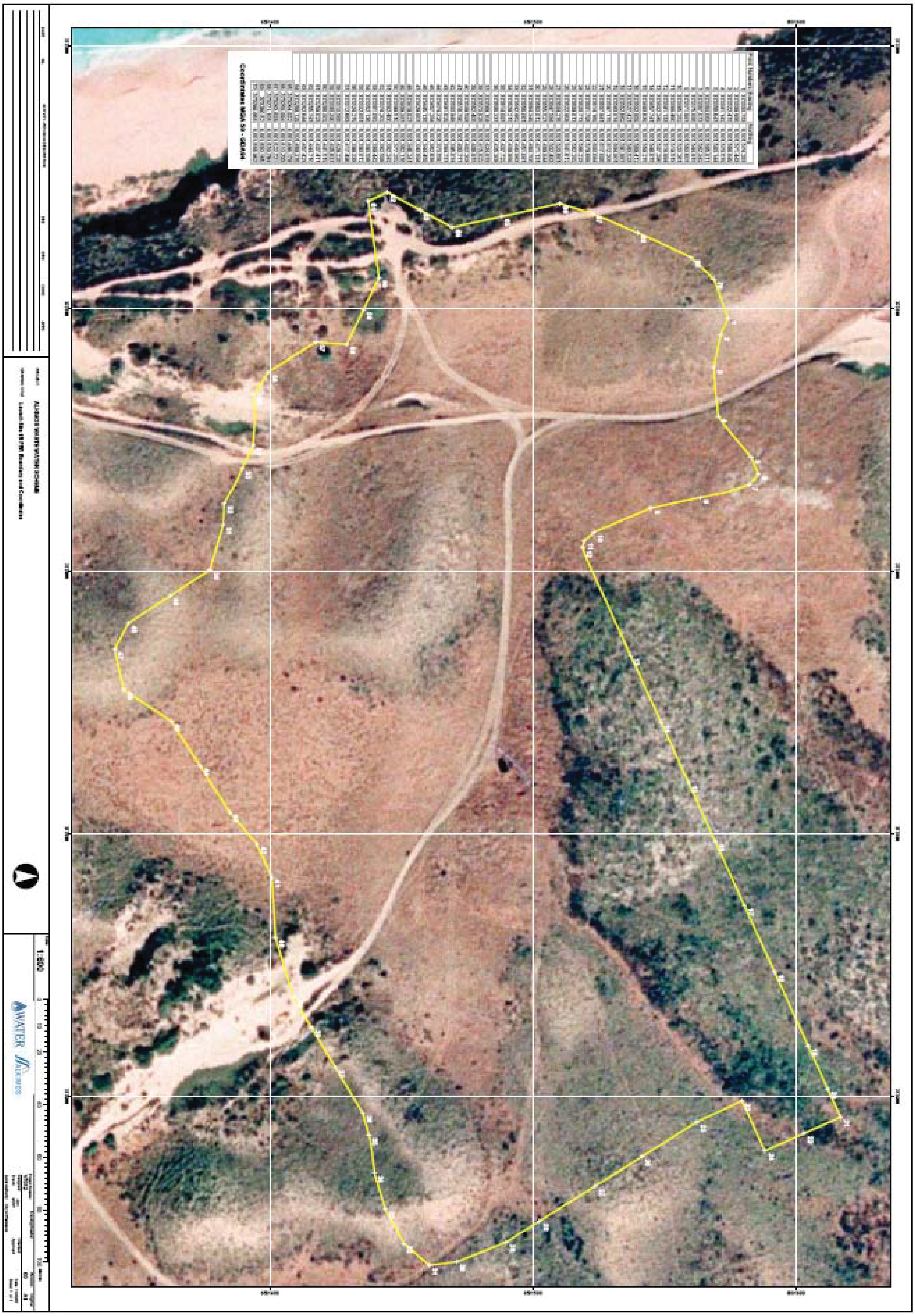


Figure 4: Disturbance footprint for the launching site

Table 3: Coordinates of disturbance footprint for launching site

Point Numbers	Easting mE	Northing mE
1	373303.753	6501574.263
2	373309.956	6501571.443
3	373322.475	6501568.849
4	373341.142	6501570.579
5	373356.647	6501583.144
6	373363.063	6501585.817
7	373367.073	6501582.342
8	373375.895	6501544.915
9	373371.987	6501563.607
10	373385.252	6501523.261
11	373388.460	6501519.518
12	373391.133	6501518.984
13	373432.249	6501537.296
14	373457.741	6501548.875
15	373480.639	6501559.275
16	373502.959	6501569.412
17	373527.421	6501580.523
18	373552.662	6501591.987
19	373580.874	6501604.801
20	373597.175	6501612.205
21	373607.941	6501617.095
22	373614.169	6501603.084
23	373601.793	6501579.668
24	373620.773	6501588.223
25	373609.813	6501562.292
26	373622.908	6501541.612
27	373634.276	6501523.661
28	373647.584	6501502.483
29	373655.527	6501489.844
30	373663.012	6501471.131
31	373664.349	6501460.705
32	373656.061	6501451.081
33	373642.962	6501443.863
34	373629.215	6501439.958
35	373614.897	6501437.722
36	373606.337	6501435.308
37	373589.104	6501424.978
38	373573.828	6501415.822
39	373562.405	6501408.975
40	373539.593	6501402.203
41	373516.780	6501400.777
42	373503.948	6501395.074
43	373491.829	6501384.737
44	373474.326	6501373.550
45	373457.254	6501362.638
46	373445.135	6501344.459
47	373429.807	6501340.894
48	373419.827	6501346.241
49	373409.387	6501362.176

50	373399.510	6501377.252
51	373382.400	6501382.242
52	373374.202	6501382.598
53	373361.082	6501389.442
54	373352.136	6501393.586
55	373332.851	6501393.812
56	373324.279	6501399.338
57	373312.663	6501417.496
58	373313.565	6501429.225
59	373300.390	6501435.637
60	373288.302	6501441.519
61	373259.023	6501437.411
62	373255.747	6501444.710
63	373262.644	6501457.423
64	373269.129	6501469.376
65	373264.922	6501488.179
66	373259.994	6501510.203
67	373263.828	6501522.721
68	373271.106	6501539.784
69	373280.520	6501560.165
70	373288.866	6501568.962

Schedule 4

Ocean Outlet Pipeline (and diffuser) ‘containment’ zone

Figure 5: Ocean Outlet Pipeline (and diffuser) ‘containment’ zone

Table 4: Coordinates of the Ocean Outlet Pipeline (and diffuser) 'containment' zone

Point Number	Easting mE	Northing mN	Point Number	Easting mE	Northing mN	Point Number	Easting mE	Northing mN	Point Number	Easting mE	Northing mN	Point Number	Easting mE	Northing mN
1	373116.063	6501411.317	47	372234.770	6501009.350	93	371257.979	6500562.156	139	370261.039	6500105.993	185	370624.436	6500256.744
2	373095.786	6501397.697	48	372220.458	6501002.620	94	371244.778	6500555.084	140	370213.995	6500084.650	186	370642.673	6500264.954
3	373078.120	6501388.638	49	372205.318	6500997.874	95	371232.132	6500547.012	141	370178.390	6500073.435	187	370661.366	6500272.150
4	373071.365	6501385.482	50	372175.115	6500990.389	96	371208.910	6500536.606	142	370165.338	6500067.684	188	370676.344	6500277.853
5	373056.569	6501369.599	51	372158.296	6500982.003	97	371186.770	6500526.686	143	370141.920	6500055.061	189	370686.340	6500282.444
6	373040.458	6501361.980	52	372145.559	6500968.264	98	371164.071	6500515.918	144	370127.212	6500048.430	190	370698.092	6500288.008
7	373024.214	6501352.260	53	372142.185	6500964.335	99	371147.517	6500504.560	145	370103.796	6500036.566	191	370709.097	6500292.795
8	373000.458	6501338.448	54	372127.439	6500955.323	100	371134.712	6500498.066	146	370083.334	6500025.669	192	370720.646	6500298.810
9	372988.624	6501332.975	55	372110.458	6500948.048	101	371123.888	6500493.907	147	370042.338	6500007.438	193	370729.926	6500302.558
10	372973.669	6501328.909	56	372106.906	6500946.615	102	371101.151	6500489.519	148	370000.536	6499988.498	194	370743.593	6500308.739
11	372966.597	6501327.218	57	372082.353	6500933.731	103	371084.250	6500486.608	149	369953.639	6499967.653	195	370766.968	6500320.153
12	372932.851	6501310.635	58	372060.458	6500923.036	104	371058.693	6500475.665	150	369914.175	6499949.761	196	370793.217	6500332.493
13	372902.144	6501296.737	59	372033.540	6500911.077	105	371039.260	6500466.758	151	369873.116	6499931.323	197	370815.119	6500342.306
14	372890.458	6501290.821	60	372013.971	6500903.169	106	371028.035	6500461.692	152	369844.256	6499918.671	198	370836.860	6500352.479
15	372880.458	6501284.831	61	371972.920	6500884.842	107	371012.877	6500451.994	153	369851.820	6499909.651	199	370853.337	6500359.726
16	372870.458	6501279.939	62	371950.458	6500875.067	108	370996.425	6500439.912	154	369880.932	6499922.936	200	370868.923	6500366.516
17	372852.791	6501272.153	63	371920.458	6500864.890	109	370979.601	6500430.392	155	369916.467	6499939.008	201	370880.754	6500371.905
18	372820.458	6501257.283	64	371900.458	6500858.761	110	370959.575	6500426.363	156	369941.078	6499950.113	202	370890.736	6500376.528
19	372785.649	6501241.645	65	371886.749	6500853.440	111	370930.471	6500413.083	157	369954.785	6499956.204	203	370906.122	6500381.322
20	372762.968	6501231.573	66	371858.929	6500866.899	112	370904.597	6500401.564	158	369974.929	6499965.050	204	370914.708	6500384.172
21	372736.648	6501220.489	67	371850.214	6500864.310	113	370887.010	6500391.383	159	370007.662	6499980.037	205	370926.953	6500391.080
22	372714.660	6501210.367	68	371828.271	6500854.456	114	370870.439	6500379.210	160	370047.890	6499997.864	206	370937.427	6500397.048
23	372712.578	6501209.393	69	371796.847	6500840.345	115	370829.313	6500360.754	161	370086.997	6500015.744	207	370945.080	6500399.536
24	372690.458	6501203.156	70	371749.109	6500818.907	116	370799.335	6500347.214	162	370107.292	6500024.254	208	370951.905	6500403.865
25	372674.485	6501196.970	71	371723.410	6500807.367	117	370778.860	6500340.367	163	370125.700	6500032.084	209	370963.944	6500408.792
26	372654.345	6501193.539	72	371714.380	6500793.839	118	370754.438	6500330.450	164	370140.196	6500038.861	210	370976.547	6500414.900
27	372633.487	6501190.597	73	371696.060	6500786.072	119	370722.777	6500318.603	165	370166.616	6500050.818	211	370993.238	6500421.672
28	372618.805	6501184.221	74	371683.161	6500765.840	120	370704.638	6500310.458	166	370187.743	6500059.917	212	371006.798	6500425.651
29	372603.784	6501178.650	75	371665.415	6500757.016	121	370684.978	6500305.350	167	370207.640	6500069.312	213	371016.122	6500429.298
30	372588.858	6501172.707	76	371635.386	6500726.381	122	370666.586	6500296.463	168	370231.195	6500080.327	214	371025.153	6500433.598
31	372566.810	6501163.903	77	371620.458	6500719.184	123	370650.925	6500284.034	169	370247.928	6500087.590	215	371037.906	6500439.374
32	372545.073	6501155.577	78	371600.458	6500704.739	124	370631.585	6500272.223	170	370270.506	6500097.753	216	371050.436	6500445.647
33	372518.678	6501144.634	79	371595.186	6500697.218	125	370624.624	6500261.206	171	370322.536	6500121.032	217	371066.175	6500452.098
34	372486.605	6501130.736	80	371561.549	6500681.801	126	370607.918	6500254.469	172	370351.751	6500134.090	218	371075.389	6500455.990
35	372463.627	6501123.487	81	371537.760	6500671.308	127	370592.733	6500246.784	173	370376.407	6500145.093	219	371088.942	6500462.425
36	372444.595	6501118.193	82	371511.214	6500666.955	128	370577.500	6500240.700	174	370388.260	6500150.432	220	371104.500	6500471.721
37	372430.458	6501111.852	83	371491.219	6500657.995	129	370562.572	6500240.734	175	370429.261	6500168.978	221	371117.131	6500477.767
38	372406.792	6501098.601	84	371459.435	6500646.871	130	370541.578	6500234.082	176	370455.918	6500180.409	222	371126.997	6500482.648
39	372384.436	6501088.439	85	371435.329	6500637.508	131	370523.331	6500226.214	177	370482.612	6500191.757	223	371137.965	6500487.519
40	372363.842	6501080.565	86	371413.056	6500640.295	132	370503.465	6500221.381	178	370503.140	6500199.747	224	371153.452	6500494.529
41	372350.458	6501074.799	87	371391.203	6500629.594	133	370477.717	6500208.375	179	370521.717	6500209.642	225	371167.995	6500501.201
42	372337.102	6501067.523	88	371362.866	6500600.917	134	370444.576	6500190.023	180	370539.892	6500217.990	226	371181.202	6500505.967
43	372322.544	6501051.273	89	371345.478	6500592.563	135	370401.202	6500169.195	181	370554.971	6500225.909	227	371190.332	6500510.045
44	372300.458	6501041.385	90	371324.272	6500591.143	136	370377.652	6500159.488	182	370575.162	6500234.651	228	371200.199	6500514.926
45	372280.458	6501033.589	91	371300.837	6500581.947	137	370335.740	6500140.122	183	370591.550	6500242.096	229	371214.751	6500521.577
46	372250.458	6501020.962	92	371275.035	6500570.162	138	370307.914	6500126.650	184	370606.204	6500248.522	230	371237.469	6500532.016

Point Number	Easting mE	Northing mN	Point Number	Easting mE	Northing mN	Point Number	Easting mE	Northing mN
231	371253.471	6500537.879	278	372403.146	6501052.277	325	373242.126	6501456.491
232	371267.447	6500543.373	279	372358.363	6501032.166	326	373233.816	6501453.297
233	371282.679	6500550.952	280	372458.421	6501077.099	327	373219.613	6501451.004
234	371293.913	6500555.228	281	372509.920	6501100.225	328	373213.811	6501449.859
235	371304.413	6500561.138	282	372554.660	6501120.316	329	373203.641	6501447.425
236	371322.569	6500569.529	283	372606.044	6501143.390	330	373187.162	6501442.817
237	371339.497	6500578.214	284	372656.243	6501166.052	331	373167.851	6501437.471
238	371348.170	6500580.871	285	372671.197	6501174.252	332	373162.576	6501435.013
239	371358.655	6500586.816	286	372687.450	6501181.998	333	373160.326	6501435.778
240	371370.513	6500592.144	287	372708.271	6501191.778	334	373152.720	6501433.094
241	371384.477	6500595.223	288	372730.208	6501201.512	335	373139.717	6501429.133
242	371430.015	6500615.870	289	372748.388	6501209.849	336	373135.146	6501428.374
243	371443.543	6500624.804	290	372771.007	6501220.507	337	373133.289	6501428.347
244	371475.638	6500638.769	291	372798.287	6501232.992	338	373130.901	6501425.703
245	371490.036	6500645.765	292	372824.716	6501244.930	339	373128.197	6501422.377
246	371521.158	6500659.456	293	372851.251	6501256.631	340	373125.852	6501418.594
247	371545.703	6500670.709	294	372879.554	6501269.278			
248	371573.945	6500683.490	295	372905.180	6501280.563			
249	371597.680	6500694.104	296	372931.740	6501292.208			
250	371610.473	6500699.793	297	372968.231	6501308.592			
251	371618.037	6500702.477	298	372996.690	6501320.891			
252	371630.053	6500707.453	299	373033.412	6501336.761			
253	371648.681	6500714.792	300	373065.667	6501350.372			
254	371666.422	6500721.665	301	373100.803	6501364.890			
255	371676.845	6500726.247	302	373128.438	6501376.583			
256	371706.873	6500739.723	303	373137.644	6501380.494			
257	371781.862	6500773.378	304	373140.136	6501371.157			
258	371826.878	6500793.581	305	373147.282	6501361.799			
259	371880.541	6500817.665	306	373156.996	6501358.611			
260	371910.848	6500831.574	307	373169.384	6501363.487			
261	371930.628	6500841.231	308	373186.386	6501374.716			
262	371956.793	6500853.758	309	373209.968	6501389.578			
263	371986.000	6500866.832	310	373227.847	6501402.327			
264	372022.424	6500883.365	311	373239.697	6501413.317			
265	372052.343	6500897.295	312	373247.788	6501415.289			
266	372083.547	6500910.804	313	373243.560	6501416.901			
267	372106.576	6500920.551	314	373251.998	6501414.234			
268	372122.624	6500926.312	315	373261.323	6501416.150			
269	372140.232	6500933.481	316	373269.418	6501417.296			
270	372152.113	6500938.758	317	373276.423	6501417.499			
271	372173.210	6500947.924	318	373283.361	6501418.843			
272	372196.282	6500957.573	319	373290.473	6501421.860			
273	372216.932	6500967.734	320	373268.857	6501486.965			
274	372235.201	6500978.313	321	373264.885	6501482.828			
275	372257.203	6500987.903	322	373258.539	6501474.608			
276	372283.948	6500999.139	323	373254.717	6501470.122			
277	372313.430	6501011.989	324	373247.834	6501463.198			

Appendix B: Clearing Permit CPS 1064/2

Department of
Environment and Conservation

Your ref:
Our ref: CPS 1064/2
Enquiries: Pennie Ginn
Phone: 9334 0102
Fax:
Email:

Mr A Baker
Water Corporation
629 Newcastle St
LEEDERVILLE WA 6007

Dear Mr Baker

AMENDED CLEARING PERMIT CPS 1064/2

Thank you for your letter dated 7 August 2007 regarding the amendment of Clearing Permit 1064/1 as a result of your application dated 22 June 2007 to alter the proposed area of clearing.

Please find enclosed your amended permit to clear native vegetation granted under s.51E of the *Environmental Protection Act 1986*. This authorisation gives you approval to clear, subject to certain terms, conditions or restrictions. A copy of your permit is now available for the public to view, as required by the regulations.

Please read your permit carefully. If you do not understand your permit, contact the Department of Environment and Conservation (DEC) immediately. Be aware that there are penalties for failing to comply with the requirements of your permit.

Be aware that compliance with the terms, conditions or restrictions of this permit does not absolve the Permit Holder from responsibility for compliance with the requirements of all Commonwealth and State legislation.

If you have any queries regarding this decision, please do not hesitate to contact Native Vegetation Conservation Branch on 9334 0333.

Yours sincerely

G Wyre
DIRECTOR, NATURE CONSERVATION DIVISION

9 August 2007

Attached: Clearing Permit CPS 1064/2

GOVERNMENT OF
WESTERN AUSTRALIA

CLEARING PERMIT

Granted under section 51E of the Environmental Protection Act 1986

Purpose permit number:	CPS 1064/2
Permit holder:	Water Corporation
Purpose of clearing:	Pipeline construction
Shire:	City of Wanneroo
Duration of permit:	24 December 2006 – 24 December 2011

TABLE OF CONTENTS

Purpose permit number:	CPS 1064/2
Permit holder:	Water Corporation
Purpose of clearing:	Pipeline Construction
Shire:	City of Wanneroo
Duration of permit:	24 December 2006 – 24 December 2011

The permit holder is authorised to clear native vegetation for the above stated purposes, subject to the conditions of this Permit.

PART I –CLEARING AUTHORISED

1. Land on which clearing is to be done

The area hatched yellow within:-

- Plan 1064/2a

2. Area of clearing

Clearing of up to 23.51 hectares of native vegetation.

3. Application

This Permit allows the permit holder to authorise persons, including employees, contractors and agents of the permit holder, to clear *native vegetation* for the purposes of this Permit subject to compliance with the conditions of this Permit and approval from the Permit Holder.

4. Compliance with Assessment Sequence and Management Procedures

Prior to clearing any native vegetation under conditions 1 and 2 of this Permit, the permit holder must comply with the Assessment Sequence and the Management Procedures set out in Part II of this Permit.

PART II – ASSESSMENT SEQUENCE AND MANAGEMENT PROCEDURES

5. Avoid, minimise etc clearing

(a) In determining the amount of native vegetation to be cleared for the purposes of pipeline construction the Permit Holder must have regard to the following principles, set out in order of preference:
   (i) avoid the clearing of native vegetation;
   (ii) minimise the amount of native vegetation to be cleared; and
   (iii) reduce the impact of clearing on any environmental value.

6. Fauna Management

(a) The Permit Holder must undertake construction of the pipeline to avoid leaving trenches open over night.

(b) Should a trench be required to stay open the following activities shall occur:
   (i) Ramps must be placed within trenches to allow fauna movement out of trenches.

(ii) Prior to commencing activities within the trench, the trench shall be inspected to determine the presence of fauna and;

(c) Where fauna is identified within trenches, the fauna shall only be removed and relocated by a *fauna clearing person*, in accordance with a licence issued by the Department of Environment and Conservation.

PART III – RECORD KEEPING AND REPORTING

7. Records must be kept

The Permit Holder must maintain the following records for activities done pursuant to this Permit, as relevant:

a) In relation to the *clearing* of *native vegetation* undertaken pursuant to the purpose of clearing:

(i) The species composition, structure and density of the cleared area;
(ii) The location where the clearing occurred, recorded using Geocentric Datum Australia 1994;
(iii) The date that the area was cleared; and
(iv) The size of the area cleared (in hectares).

b) In relation to Fauna Management pursuant to condition 6:

(i) The species and number of each species relocated; and
(ii) The location and date where relocated fauna was released, using Geocentric Datum Australia 1994.

8. Reporting

The Permit Holder must provide to the *CEO* on or before the 30th of June of each year, for the term of this permit, a written report of records requested under condition 7 and activities done by the Permit Holder under this Permit between 1 January and 31 December of the preceding year.

9. Definitions

The following meanings are given to terms used in this Permit:

CEO means the Chief Executive Officer of the Department of Environment and Conservation;

Environmental Specialist means a person who is engaged by the permit holder for the purpose of providing environmental advice, who holds a tertiary qualification in environmental science or equivalent, and has experience relevant to the type of environmental advice that an environmental specialist is required to provide under this Permit;

fauna clearing person means a person who has obtained a licence from the DEC, issued pursuant to the *Wildlife Conservation Regulations 1970* (as amended) authorising them to take fauna in order to carry out the approved clearing associated with this permit.

fauna specialist means a person with training and specific work experience in fauna identification or faunal assemblage surveys of Western Australian fauna;

fill means material used to increase the ground level, or fill a hollow;

mulch means the use of organic matter, wood chips or rocks to slow the movement of water across the soil surface and to reduce evaporation;

native vegetation has the meaning given to it in sections 3 and 51A of the *Environmental Protection Act 1986* and regulation 4 of the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004*;

revegetation means the re-establishment of a cover of *native vegetation* in an area such that the species composition, structure and density is similar to pre-*clearing* vegetation types in that area, and can involve regeneration, direct seeding and/or planting;

road building materials means rock, gravel, soil, stone, timber, boulders and water;

term means the duration of this Permit, including as amended or renewed;

weed means a species listed in Appendix 3 of the "Environmental Weed Strategy" published by the Department of Conservation and Land Management (1999), and plants declared under section 37 of the Agricultural and Related Resources Protection Act 1976.

G Wyre
Director, Nature Conservation Division
Department of Environment and Conservation.
Officer delegated under Section 20
of the Environmental Protection Act 1986

09 August 2007

Draft Plan 1064/2

LEGEND

Clearing Instruments

Areas Approved to Clear

Road Centrelines - DLI 1/5/04

N

0 — 500 m

Scale 1:19857

(Approximate when reproduced at A4)

Geocentric Datum Australia 1994

Note: the data in this map have not been projected. This may result in geometric distortion or measurement inaccuracies.

G Wyre Date 9/8/07

Information derived from this map should be confirmed with the data custodian acknowledged by the agency acronym in the legend

Department of Environment

* Project Data. This data has not been quality assured. Please contact map author for details.

Appendix C: Department of Environment and Heritage

Statement 2007/3259

Australian Government

Department of the Environment and Water Resources

Notification of
DECISION ON REFERRAL – NOT CONTROLLED ACTION
Construction and Operation of Alkimos Wastewater Treatment Plant, WA
EPBC 2007/3259

This decision is made under Section 75 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

Proposed action

person named in the referral	Water Corporation of Western Australia
proposed action	To construct and operate the Alkimos Wastewater Treatment Plant, located 40km north of Perth, and as described in the referral received on 24 January 2007 (EPBC 2007/3259).

Person authorised to make decision

Name and position	Ms Alex Rankin Assistant Secretary Environment Assessment Branch
signature	
date of decision	26 February 2007

Appendix D: Roles and Responsibilities Table

ROLE	RESPONSIBILITY
Alliance Manager	The Alliance Manager is responsible for the internal approval and implementation of this TCMP. The Alliance Manager shall: - Actively promote sound environmental management and ensure that all project personnel are fully conversant with this TCMP and any incumbent responsibilities. - Be aware of meetings, audits and reviews pertaining to environmental matters resulting from the TCMP. - Ensure that the FMP is adopted into the construction management system and procedures. - Review marked out clearing areas and sign a Ground Disturbing Activity Permit Form prior to any ground disturbing activities being undertaken.
Environment and Community Relations Manager	The Environment and Community Relations Manager is accountable to the Alliance Manager and is responsible for ensuring the AWA is adequately resourced to comply with and implement the TCMP. The Environment and Community Relations Manager shall: - Advise on environmental requirements and ensure compliance with all current statutory obligations - Ensure potential subcontractors have suitable experience and knowledge to conduct any potential work in compliance with the TCMP. - Ensure performance is monitored, documented and reported to senior management. - Review marked out clearing areas and sign a Ground Disturbing Activity Permit Form prior to any clearing. In conjunction with the Environmental Coordinator, review the document every 3 months and implement system improvements
Construction Manager	The Construction Manager is accountable to the Alliance Manager. The Construction Manager has the authority to assess the environmental implications of installation Methodology/design on fauna habitat and make changes as appropriate in consultation with the Manager of Environment and Community Relations. The Construction Manger shall: - Develop a construction methodology compliant with the TCMP. - Liaise with the Environment and Communications Manager and the Site Environmental Coordinator with respect to terrestrial issues which may occur on site. - Ensure that a Ground Disturbing Activity Permit Form has been signed off by the Alliance Manager and the Environment and Community Relations Manager prior to any ground disturbing activities being undertaken.
Site Environmental Coordinator	The Site Environmental Coordinator reports to the Environment and Community Relations Manager. This position provides daily site environmental management, advice of the environment issues to site construction personnel and assists them in managing environmental issues. The Site Environmental Coordinator shall: - Coordinate site reconnaissance survey for significant fauna prior to construction. - Monitor environmental performance of construction activities on a daily basis. - Distribute information in relation to the TCMP readily available. - Be available to consult with subcontractors should there be any queries in relation to the TCMP. - Facilitate training of personnel on site. - Report back to the Environment and Communications Manager on a weekly basis regarding any issues associated with the TCMP.
Supervisors & Site Engineers	Supervisors shall be responsible for determining the course of actions to be taken, Supervisors shall: - Be aware of the TCMP and have a copy of it on site at all times. - Provide leadership which encourages a consultative interaction with team members. - Be responsible for ensuring that sufficient resources are available for the implementation of the TCMP. - Comply with and adhere to the requirements of the TCMP, instruction and procedures - Ensure that the personnel under their supervision have an understanding of the TCMP and are provided with the necessary instructions and support to perform their tasks in a manner which minimises impacts on the environment. - Ensure compliance with any conditions within Ground Disturbing Activity Permit Forms lodged.

ROLE	RESPONSIBILITY
Personnel and Subcontractors	All personnel, including subcontractors, are responsible for the environment, in so far as they have some control, either direct of indirectly. Each person shall: - Participate in environmental meetings and awareness training though an induction process prior to entering site. - Be responsible for keeping the workplace in a clean and tidy condition. - Immediately report all incidents/accidents to the Site Supervisor. - Comply with and adhere to the requirements of the TCMP, instruction and procedures.

Appendix E: Ground Disturbing Works Permit

A signed copy of this permit is to be retained by Package Leader/Contractor responsible for works during full duration of ground disturbing works approved to be undertaken

WORKS PACKAGE (SEWER, OUTFALL, EARTHWORKS, OTHER – please describe)	
Works Details	
Commencement date	
Commencement time (am/pm)	
Works duration (working days)	
Works completion date (dd/mm/yy)	
Approximate area of works (ha)	
Approximate area of vegetation clearing (ha)	
Details of services located in area	
Responsible supervisor	
Responsible supervisor’s signature	
Contracting company (if relevant)	
Contracting company contact details	
Landowner details	
Have you notified the Landowner of clearing commencing?	

DESCRIPTION OF WORKS (ATTACH SKETCH OR DRAWING – SHOW LOCATED SERVICES)

MANAGER ENVIRONMENT AND SUSTAINABILITY REVIEW			
☐	Is vegetation clearing required?	☐	Has the area been clearly identified on ground?
☐	Do works comply with management plans?	☐	Has the works area been inspected?
☐	Are works consistent with statutory approvals?	☐	Are conditions on works required?

Recommended environmental management conditions for works	
Approved by	
Signature	
Date	
ALLIANCE MANAGER REVIEW	
Additional comments and conditions	
Approved by	
Signature	
Date	
Approved permit number	

Appendix F: AWA Environmental Incident Form

Environmental Incident No: EI___________

WORKS PACKAGE (SEWER, OUTFALL, EARTHWORKS, OTHER – please describe)

Incident Details	
Incident date	
Incident time (am/pm)	
Operating company	
Operating company contact details	
Responsible supervisor	
Ground Disturbing Works Permit No. (if relevant)	
Name and position of person lodging this incident report	

DESCRIPTION OF INCIDENT (ATTACH SKETCH OR DRAWING IF RELEVANT)

MANAGER ENVIRONMENT AND COMMUNITY RELATIONS REVIEW			
☐	Do works need to cease until remedial or correction actions are deployed?	☐	Does the incident result in a breech of statutory conditions/approvals?
☐	Has the Incident resulted in unauthorized clearing?	☐	Has the incident also resulted in and injury or raised safety concerns?
☐	Has the Incident arisen without an approved GDWP?	☐	Does the ALT need to be notified of this incident?
☐	Has the Incident involved chemical spills that could result in contamination?	☐	Does the Water Corporation need to be notified of this Incident?
☐	Is there a need to review existing controls and procedures?	☐	Do other parties need to be notified of the incident? (e.g. DEC, DOW, CoW)

Recommended remedial and/or corrective actions (detail below)	
Incident registered by	
Signature	
Date	
ALLIANCE MANAGER REVIEW	
Additional comments and recommended remedial/corrective actions	
Incident cleared by	
Signature	
Date	

Copies to be distributed to: Records (original hardcopy and electronic)
Environmental Manager/Site Coordinator
Alliance Manager
Construction Manager
Others (based on nature of incident)

Appendix G: Contact Details for Site Based Staff

Contact details for site based staff

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Site Environmental Coordinator	Kate McManus	Phone: (08) 9561 4016 Mobile: 0448 978 752 Email: Kate.McManus@alkimoswa.com
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Sewer Works Superintendent	Barrie Evans	Phone: (08) 9561 4024 Mobile: 0439 450 242 Email: Barrie.Evans@alkimoswa.com
Earthworks Superintendent	John Hitchen	Phone: (08) 9561 4028 Mobile: 0417 090 201 Email: John.Hitchen@alkimoswa.com

Appendix H: Vehicle Hygiene Declaration Form

Form: REP 000069	# Weed / Dieback Hygiene Certificate	ALKIMOS Water Alliance
Revision: 0		
Date: 14/5/07		

Project No: ____________ **Site Location:** Alkimos WWTP Date: ____________

Unit (Asset) No.	Plant Description	Location of last works undertaken	Date Cleaned & Inspected	Inspected by	Date due on site

Approved for access to site by ____________

Signature ____________

Position ____________

Date ____________

Appendix I: Dieback Management Plan

ALKIMOS WASTEWATER TREATMENT SCHEME

Dieback Management Plan

April 2008
Job No. V7012

Alkimos Alliance

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ABN 77 009 119 000

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Document Control

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1	April 2008	Ian Miscamble		Ian Gale	

EXECUTIVE SUMMARY

The Alkimos Wastewater Treatment Scheme (AWTS) is to be constructed and operated approximately 40km north-west of Perth’s CBD, within the future suburb of Alkimos on the Western Australian coast. The project has been proposed since the 1970s to provide for the planned continued residential growth in the Perth metropolitan north-west corridor. The proponent, Water Corporation has engaged the Alkimos Water Alliance (AWA) to undertake the design, construction works and environmental approvals associated with the project.

A Terrestrial Construction Management Plan (TCMP) was developed by the AWA to address environmental aspects associated with the Scheme’s construction, primarily addressing potential impact to flora/vegetation and landforms. The survey and management protocols of Dieback (*Phytophthora cinnamomi*) are one of the environmental considerations to be addressed prior to any ground disturbing activities commencing.

In February 2008 a field survey was conducted over the clearing and construction footprint for the AWTS site to investigate the presence of the Dieback pathogen *Phytophthora cinnamomi* (Pc) by Cardno BSD (CBSD) for the purpose of identifying any areas in which disease may be present. This “interpretation” focused upon those areas within the AWTS that were to be disturbed and earth moving operations were proposed. These areas included the haul road, the launch site, the proposed wastewater treatment plant and its buffer zone, the workshop and office site, temporary access chamber, the Quinns main sewer and the access roads.

Pc is an introduced soil-borne pathogen that kills a wide range of plant species in Western Australia by attacking their root systems. It is spread via root to root contact, through infested soil and plant material, and via surface and sub-surface water flows. Native animals, feral animals and humans act as vectors aiding in the wide and rapid spread of Pc, thereby enabling it to establish new centres of infestation in previously uninfected areas.

No obvious disease symptoms were encountered within the area of interpretation at Alkimos, although some drought and fire deaths were observed. Samples of recently dead plant material and soil were collected for laboratory analysis by the Vegetation Health Service of the Department of Environment and Conservation (DEC). This is a necessary process for establishing conclusive evidence as to the pathogenic status of the area under survey, particularly in an area with limited indicator species such as Alkimos.

This Alkimos area has historically been accessed by motorcycle and four wheel drive vehicles for many years. As such there are numerous tracks traversing the area providing an ideal vector for the introduction of dieback, especially as these activities have been uncontrolled from a dieback hygiene perspective. However, the deep calcareous sands that cover the area are not prone for collecting water in any appreciable amounts, or retaining available water in the soil for uptake by plants for any useful length of time. Any infested material e.g. mud, deposited by car or motorcycle tyres, is unlikely to find a suitable environment to establish a new infestation in this type of habitat. The rapid drying nature and free draining properties of the sand gives rise to an inhospitable medium for harbouring the pathogen. The passage of water through this sandy matrix is swift and without a nonporous sub-surface layer to allow water to "pond" below the surface there is little chance of the pathogen establishing here.

Dieback zoospores require moisture to survive, and although this can be supplied by roots of susceptible plants, continual dry soil conditions will lead to the pathogens death. Thus it follows that the areas most likely to be infested are those with the greatest likelihood of retaining moisture. These areas include swamps, riparian zones, wetlands etc, or places in which water can "pond" below the surface e.g. lateritic cap-rock in the Jarrah forest. The paucity of such environments within the area of interpretation decreases the risk of such infestations persisting in this area. Soil and root tissue samples were taken from the dampest areas to determine wether the pathogen was present or not. These sites were the most likely to yield positive laboratory results for Pc. The samples that were taken all returned negative results for *Phytophthora cinnamomi*, though returned a positive result to *Phytophthora citrocola* and a yet to be described pathogen (currently not displaying morphology to that usually illustrated by *Phytophthora* spp. in subculture). The lack of death and expression in the field and the difficulty in plating these specimen samples further in the laboratory supports the low risk approach that has been taken in regards to managing these results in relation to the Alkimos project.

Due to the problems associated with the control of Pc once it has been introduced into an area, the priority for management of the pathogen rests on the exclusion and protection of uninfected and susceptible vegetation. The formation of this management plan has addressed the specific environmental factors that may influence the survival of Pc within the Alkimos development and the management of clearing and construction in regards to the risk of introducing the pathogen to the site in the future. From the extensive field assessment and sampling undertaken at the site it is concluded that the risk of environmental degradation from Pc to the remaining conservation estate surrounding the Waste Water Treatment Scheme Development is minimal to non existent if hygiene recommendations provided in this report are followed.

ALKIMOS WASTE WATER TREATMENT SCHEME

DIEBACK MANAGEMENT PLAN

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1. INTRODUCTION

1.1 Alkimos Water Treatment Scheme

The Alkimos Wastewater Treatment Scheme (AWTS) is to be constructed and operated approximately 40km north-west of Perth's CBD, within the future suburb of Alkimos on the Western Australian coast. The project has been proposed since the 1970s to provide for the planned continued residential growth in the Perth metropolitan north-west corridor (see **Figure 1**). The proponent, Water Corporation, has engaged the Alkimos Water Alliance (AWA) to undertake the design, construction works and environmental approvals associated with the project.

To meet the requirements of approvals, a Terrestrial Construction Management Plan (TCMP) was developed by the AWA to address environmental aspects associated with the Schemes construction, primarily addressing potential impact to flora/vegetation and landforms. The survey and management protocols of Dieback (*Phytophthora cinnamomi*) are one of the environmental considerations to be addressed prior to any ground disturbing activities commencing.

Outside of the proposed development footprints the proposed Alkimos buffer zone will be made up of over 43 hectares of conservation estate including remnant Banksia woodland which is susceptible to dieback (AWA 2007). The priority for the management of dieback in this area will focus on the identification of potential disease sources within the construction areas so as to limit the risk of dieback disease being introduced to these areas of conservation estate.

1.2 Background – *Phytophthora cinnamomi*

The colourless microbe known to science as *Phytophthora cinnamomi* (Pc) is infamous across the world for its capacity to invade and destroy the function of the root systems of an extraordinary range of plants. The slow moving epidemic of destructive root disease the pathogen causes in native vegetation in Australia is known as *Phytophthora* dieback. The impact of this now widespread pathogen, believed to have been originally introduced to Western Australia (WA) at or soon after European settlement in 1827, varies greatly across the landscape.

Pc has created major problems for road construction, timber harvesting, mining and other industries since land managers realised that the movement of soil is the most important method of spreading the pathogen. There are several other species of *Phytophthora* present in native vegetation in the south-west of WA, including *P. citricola* and *P. megasperma*, but their extent and impact on native vegetation is slight in comparison to that of *P. cinnamomi*. For the purpose of this report unless otherwise stated the use of Dieback and Pc within this report will refer to discussion focussing on the management and control of *Phytophthora cinnamomi* only.

In Western Australia Pc will continue its autonomous spread from all its established disease fronts with control very difficult, if not impossible, within natural surroundings due to the nature of its soil borne properties. The rate of uphill spread via root to root contact amongst host plants has been reported as approximately one metre per annum under ideal environmental conditions (CALM 2003). The cross slope and down-slope rate of spread occurs much faster due to the influence of surface and sub-surface water-flows on the dispersal of zoospores. Native animals, feral animals and people act as vectors aiding the wide and rapid spread of dieback, thereby enabling it to establish new centres of infestation in previously un-infested areas.

This autonomous spread of Pc can be limited by chemical application of phosphite (also referred to as phosphonate), the anionic form of phosphonic acid. It has been demonstrated through trials in WA and Victoria to kill Pc within a plant and boost immunity by as much as 90 – 95% within susceptible vegetation (CALM 2003). Phosphite increases plant health in similar ways to fertiliser and works best when utilised as a preventative rather than a curative (G. Tuffnel, personal communication April 9 2008). Phosphite is currently used in WA to protect areas of high conservation value and critically endangered species from the threat of Pc, e.g. the Stirling Range National Park. While there is a limited capacity to reduce the impact of Pc by manipulating fire and applying phosphite, these methods are not practical to apply except on a small scale. The most practical solution to managing the impact of Pc is to be found through addressing the protection of the values at risk rather than managing Pc per se (Rudmen 2007)

2. BIOLOGY

2.1 Description of *Phytophthora cinnamomi*

Pc and other members of the genus *Phytophthora* are not part of the Fungi kingdom but instead belong to the water moulds or Oomycota (class Oomycetes) which are placed in the Kingdom Chromista (or Stramenopila).

Pc is an introduced soil-borne pathogen that kills as many as 2000 of the estimated 9000 native plant species in the South West by attacking their root systems. Pc can also survive and reproduce on a wide range of native plants without killing them. In general, Pc is restricted to areas in the south-west of the State receiving at least 400mm of average annual rainfall although in water-gaining sites it is possible for the pathogen to exist in slightly drier areas. Between the 400mm and 700mm isohyets the pathogen is restricted to stream zones and water-gaining sites.

There are over 50 species of *Phytophthora* which occur around the world and all of them cause plant diseases. Pc is the *Phytophthora* species most frequently isolated from areas of dead vegetation in the South West (CALM 2003). The pathogen grows as microscopic sized filaments (mycelia) on the surface of plant roots and invades the cells of susceptible host plants. Their food source is root and basal stem tissue of living plants. The pathogen consumes the host plants causing lesions (areas that appear rotten). This weakens or kills the plants by reducing or stopping the movement of water and nutrients within the plant.

Once attacked susceptible hosts rarely recover. Most succumb to a "sudden death" syndrome, rather than a "dying back" or "dieback" syndrome.

2.2 History of Introduction and Spread

Since 1921 it has become evident that an increasing number of patches of formerly healthy Jarrah forest had become afflicted with a disease referred to as "Jarrah dieback". Until 1964 the cause of this problem had been the subject of contending speculation. In that year, proof of the role of the plant pathogen Pc as the cause of "Jarrah Dieback" was established. At the same time, it was recognised that this exotic microbe was also intimately associated with similar damage in other plant communities of sclerophyllous natives, whether Jarrah was dominant, a minor component only, or not present at all. The period of intensive research that followed is ongoing and has resulted in revised perceptions of the pathogen and of the diseases that result from its interactions with the enormously diverse native vegetation of South Western Australia.

Pc is a soil-borne micro-organism of foreign origins. It almost certainly entered WA for the first time in soil around the roots of cultivated plants shortly after European settlement in 1827. Until the effective implementation by Australia of quarantine of the import of exotic soil and plant products, there must have been innumerable introductions at many points of entry around the continent and its redistribution within the country over a period of some 150 years. Pc has now extended its colonisation of the South West by human and animal (native and feral) movement of infested soils and autonomous spread (the latter largely by growth of the pathogen in the root systems of highly susceptible native plants, but also assisted by sub-surface and overland flow of water-carrying zoospores). This epidemic of colonisation, which has produced a complex mosaic of infested and un-infested areas, is now well on its way toward the middle stages of its ultimate potential to occupy all of those sites which are environmentally suited to its establishment, survival and multiplication. Such sites are very widely distributed over some 20% or more of the natural vegetation in areas throughout that part of the South West Land Division that receives mean annual rainfall in excess of 800mm and occurs sporadically at lower rainfall (CALM 2003).

Within the 600 – 800mm rainfall zone the occurrence of Pc is also widespread but much less extensive. In this zone, severe damage to native vegetation is largely confined to water-gaining sites or to years with abnormally high summer rains. In these circumstances localised patches of the vegetation may periodically suffer severe damage with intervals of recovery during drier periods.

2.3 Life cycle

The life cycle of Pc depends on moist conditions that favour survival, sporulation and dispersal. The pathogen is not capable of photosynthesis and so it needs to extract food from living plant tissue. It does this via a mass of microscopic thread-like mycelia that forms the body of the organism that grows through host tissue. Mycelia continue to grow within the host tissue when it is above 80% moisture ambient. Moisture levels and elevated soil temperatures are important in the reproduction of Pc and spore production increases dramatically when these factors reach optimum levels. Mycelia may be transported in soil and host tissue and deposited where it may infect new hosts. The mycelia, given warm, moist conditions are capable of producing millions of tiny spores that reproduce the pathogen. Two kinds of spores (zoospores and chlamydospores) are produced by Pc and are likely to be found within soil and water mediums.

2.3.1 Zoospores

Zoospores are very small spores that can actively swim very short distances towards new hosts and initiate new infections. They can also be carried along in moving water over large distances. As they move through the soil, zoospores lodge on plant roots, infect them and in susceptible plants produce mycelia. The mycelium then grows feeding on the host, rotting the roots and cutting off the plant's water supply. The mycelia may grow from plant to plant via root to root contact points and/or root grafts.

2.3.2 Chlamydospores

Chlamydospores are larger spores that are tough and long-lived (within dead plants and the soil). They are produced under favourable conditions and are the resistant resting phase of the pathogen. They may be transported in soil or roots and then germinate to cause a new infection when they encounter favourable conditions. The chlamydospores produce mycelia and zoospores. When conditions are warm and moist, microscopic spore sacks called sporangia and thick-walled chlamydospores are produced vegetatively from mycelia strands that form the body of the pathogen in the soil or host tissue. The sporangia release motile zoospores in the free water to infect host roots. Mycelia of different mating types may grow together inducing the production of thick walled sexual spores called oospores. The mating types are called A1 or A2. Only the A1 type occurs in WA. Currently the pathogen cannot reproduce sexually in WA and relies on vegetative reproduction for survival and dispersal (CALM 2003).

After infection the pathogen invades root, bark and forms lesions that may extend into the plant's stem collar. In susceptible species the infection of roots and collar results in death of the host. Once dispersed the spores may infect a wide range of resistant and susceptible hosts.

2.4 Interaction of the pathogen with the host

Pc has a very wide range of hosts. At least 1000 species from taxonomically diverse families have been reported as hosts for Pc of which nearly half have been recorded from research in Australia. Indigenous species most affected belong to four families:

- Proteaceae;
- Epacridaceae;
- Papilionaceae/Fabaceae; and
- Myrtaceae.

Not all genera within a family or all species within a genus are necessarily susceptible, eg: some species of *Eucalypts* are highly resistant (including Karri, Marri and Wandoo), while some, such as Jarrah, are affected but have the ability to resist the invasion of the pathogen under certain conditions (tissue moisture content < 80%).

Broad estimates are that perhaps 2000 species of the estimated 9000 species of vascular plants in the South West of WA may be susceptible to the degree that successful infections result in the death of the host (CALM 2003). The interaction between pathogen and host starts with infection, with zoospores and mycelium growth via root to root contact initiating most infections. Zoospores are attracted to the growing tips of the roots chemotacticly, they encyst and germinate to produce germ tubes which penetrate roots. Hyphae proliferate within roots, macerating tissues and causing roots to rot. The mycelium feeds on sugars within the plants cells (CALM 2003).

Once the pathogen has established within the roots of a prospective host, it establishes within unlignified cortical tissue and the phloem. This blocks the conductive tissue and prevents the uptake of water and nutrients. Host plants can resist the attack with the formation of blocking lesions or resist entry by having tough epidermal cells on roots hairs.

3. THE NATURE OF THE THREAT

3.1 Disease Syndromes

The effect of Pc upon the health of plant communities and upon the species in them varies greatly. In numerous places lethal root disease destroys the structure of many native communities, reduces their floristic diversity, decimates their primary productivity and destroys habitat for much dependant native fauna, and its value as protection against feral predators. In some places the pathogen causes little damage at all. Unfortunately the extent of susceptible communities in vulnerable environments is much greater than that of communities which occur in environments which are inherently unfavourable to the pathogen. No simple or single relationships exist between the presence of Pc and the development of disease because of:

- The considerable variability which exists within and between native plant species in their responses to the presence of Pc; and
- The differential influence of temporal and spatial variation in environmental forces.

However, within the spectrum of variable disease response of numerous hosts to particular environmental circumstance, at least four specific nodes can be recognised. These are due to either distinct processes or to different stages in the development of the disease, which occur upon and after the arrival of the pathogen and its persistence in previously un-infested areas (CALM 2003). Each of these circumstances presents a different problem that requires a separate management response. It is now evident that among the variety of plant communities which occur within that part of the South West Land Division that receive more than 800mm mean annual rainfall, the four sets of distinctive consequences are:

3.1.1 No apparent disease at all

This applies inter alia to those areas of Karri and Wandoo forest which contain no floristic elements of the dry sclerophyll (Jarrah) forest type and to plant communities on the calcareous soils of the Spearwood and Quindalup Dune Systems and of the Swan Coastal Plain and pedogenically related landscapes.

3.1.2 An extremely destructive epidemic of root rot

This applies within the highly susceptible understorey elements of the dry sclerophyll forest, in Banksia woodland and in heath on podsols, podsolic and lateritic landforms. It is characterised by:

- devastation soon after the first arrival of the wave front of infestation;
- steady extension of epidemic disease soon after arrival of the pathogen;
- complete or near complete elimination of important structural elements of plant community; and
- a relative insensitivity of the degree of damage to variation in soil characteristics.

3.1.3 A variable epidemic within the dominant Jarrah tree component of the forest

This is characterised by:

- a much more erratic and often protracted onset of mortality ranging from early localised onset of mass collapse (similar to type above) through delayed and patchy mortality to no apparent effect at all on health of the Jarrah over storey; and
- a high sensitivity to subtle differences in soil characteristics, particularly those effecting drainage.

All variants in the response of Jarrah are coincident with, or preceded by, mass deaths in susceptible elements of the understorey. In Jarrah, their behaviour varies from that characteristic of epidemics of disease due to invasion by an exotic organism to which the vegetation has not been previously exposed to that typical of long established endemic disease.

3.1.4 An endemic pathogen

Where Pc has been long established (some 50 years or more) in sites formerly dominated by Jarrah/Banksia forest and has been very heavily impacted, Pc behaves in a manner characteristic of an endemic pathogen. The forest is often replaced by open woodland of Marri/Parrot Bush. Periodic outbreaks of mortality in Parrot Bush (*Banksia sessilis*) follow, with subsequent regeneration by seed. At this late stage, Pc causes more muted disease than at the wave front.

3.2 Other *Phytophthora* species

As listed within **Section 5**, one of the samples returned a positive identification of *Phytophthora citrocola* (*P. citrocola*) a *Phytophthora* species that currently is regarded as the most geographically widespread within the state (Bunny 1996). *P. citrocola* can withstand drier and hotter conditions than that of Pc due to the formation of oospores which are able to resist soil moisture and temperature extremes and can survive up to 18 months in desiccated soils. Disease impact from *P. citrocola* is often low and confined to a single or few species, with pathogen activity episodic (Bunny 1996). This disease is not considered currently by DEC to be a major threat to ecosystems and is not mapped or included on current logging, roading or mining operation plans. The impact of this species has not been proven to be of the same significance of Pc and the lack of expression within vegetation can make it very difficult to even locate. This leads to difficulties in sampling the disease and identification of the disease can take extended periods of plating and culturing to finally reach a result to species level.

Conservation losses from *P. citrocola* are poorly documented due to symptom expression being chronic and sub-lethal, leading to the perception that significant losses are not occurring. Since its original description in Sawada in 1927, *P. citrocola* has been recorded extensively on all continents (Bunny 1996). This has generated a great deal of interest in the scientific community and it has been suggested that *P. citrocola* may even be a native component of soil mycoflora in the region (Bunny 1996). The comparison with Pc and *P. citrocola* in terms of impact on plant communities also leads further to supporting this indigenous claim due to the relative susceptibility of vegetation and its possible evolution with the pathogen. Due to the low impact and expression of *P. citrocola,* it currently does not receive the same level of management attention as Pc and has not been seen as a major threat to currently known conservation values.

4. METHODS

In February 2008 a field survey was conducted over the Alkimos Water Treatment site to investigate the presence of the Dieback pathogen by Cardno BSD (CBSD) for the purpose of identifying any areas in which the disease may be present. This “interpretation” focused upon those areas within the AWTS that were to be disturbed and earthmoving operations were proposed. These areas included the haul road, the launch site, the proposed wastewater treatment plant and its buffer zone, the workshop and office site, temporary access chamber, the Quinns main sewer and the access roads. This report has been prepared to present these field observations and compliment existing guidance documents such as the Water Corporation’s Dieback Management Guidelines.

The field investigations were carried out on foot and involved ground reconnaissance of all proposed clearing and construction areas and the recording of field observations on non-differential Global Positioning Systems (GPS). Floristic surveys conducted in the past over the area where assessed and no Declared Rare Flora and Priority plant species were identified in the area designated for interpretation and future proposed development.

4.1 Field Categories

Three categories are used to define the field interpretation:

1. *Phytophthora cinnamomi* free (Pc Free)

   Areas apparently free of *Phytophthora cinnamomi* symptoms.

2. Uninterpretable (UI)

Areas in which susceptible plants are absent or there are too few to enable the interpretation of Pc presence or absence. The Uninterpretable category can also apply in the following situations;

- Non forest areas such as powerlines, rock outcrops and areas of cleared forest.
- Areas of dense vegetation that obscure indicator plants eg: dense Karri understorey.

3. Phytophthora cinnamomi Present (Pc Present)

   Areas that show current symptoms of dieback and are supported by laboratory recoveries/identifications of Pc from soil and tissue samples.

4.2 Interpretation - Initial and Field

Initial and field interpretation was completed according to the methods described in the Detection, Diagnosis and Mapping Volume 2 – Interpreters Guidelines, **Appendix A**, (DEC 2007). The interpretation works were overseen by a qualified and accredited interpreter who has conducted similar surveys in a wide range of WA bushland environments over the past 15 years.

All clearing and construction boundaries of the AWTS were downloaded onto a GPS prior to field survey works commencing. From these waypoints interpreters followed the boundaries within the field to ground truth all disturbance areas and include all vegetation complexes. These GPS interpretations are illustrated in **Figure 2** (PC Occurrence Map) and reflect the direct input from field observations and recordings. Due to the limited availability of indicator or susceptible dieback species within the required area for interpretation, it was decided to record all these vegetation complexes to provide the most thorough assessment of disease risk. By assessing and recording these potential dieback areas, the probability of missing any potential infections was greatly reduced.

Although current best practice and DEC guidelines state that Dieback free areas are required to be four hectares and above to warrant protection and management isolation, the decision was taken to map these areas at Alkimos to illustrate the difficulty of field assessment of Dieback in this area. Although management of these areas will be discussed further in **Section 7**, the assessment and mapping of them within the field has provided the best opportunity for identifying any potential infections of dieback.

4.3 Sampling

Four soil and tissue samples were taken according to the method described in the Detection, Diagnosis and Mapping Volume 2 – Interpreters Guidelines, **Appendix A**, (DEC 2007). Sampling is the process of collecting tissue from the roots and stems of plants and the soil surrounding these roots and stems. Samples are usually collected because of the difficulty in determining whether the pathogen is present or not. Samples are also taken from recently deceased plants to prove the absence or presence of infestation. This is known as strategic sampling and helps to establish a broader picture in the mind of the interpreter as to how the pathogen is expressing itself in the environment. These samples were sent to DEC Vegetation and Health Services (VHS) laboratory and are plated and cultured under controlled conditions until the *Phytophthora* spp are determined.

4.4 Mapping

The Pc Occurrence Map for the Alkimos Water Treatment Scheme (AWTS) was completed by CBSD utilising the current standard template from the DEC. This map has been produced to illustrate the field interpretation results in relation to proposed construction infrastructures and is illustrated in **Figure 2**.

5. RESULTS

5.1 Disease distribution

The priority for field assessment and interpretation for the AWTS was to determine if Pc was present in the area and how it was to be managed in relation to protection of future retention and rehabilitation of vegetation in the area. Pc symptoms were not observed in the field of interpretation and sample results indicated that the pathogen was not present in the areas where samples were taken.

5.2 Disease expression

Currently there are no expressions of disease symptoms within the area of interpretation. It would be reasonably expected that if Pc were located here it would display disease symptoms in the widespread vegetation complexes of *Banksia* spp which are commonly utilised and classified as a good indicator species of Pc infestation. As discussed previously, samples taken in the field were selected due to their expression of stress or near death. Although four samples were taken, it would be expected that if Pc was present then a wider selection of indicator species would be illustrating some form of expression, all be it subtle in this environment. The one sample that returned a positive result to *P. citrocola* did illustrate symptoms of disease expression, though this was very slight and only included one individual plant within a complex of potential indicator species. As already discussed the environment at Alkimos would not be expected to express dramatic expression of Pc due to the lack of rainfall and free draining sands on the site, though Pc disease expression would be expected to be witnessed within the damper low lying sites if the disease in fact was present in these locations.

5.3 Sampling

In areas where expression of the disease is difficult to determine from vegetation deaths alone, strategic sampling plays a larger part in confirming the absence or presence of the pathogen. At Alkimos the lack of death and disease expression within the required interpreted vegetation, increased the importance of sampling these selected plant deaths to determine if they were affected by Pc. Although sampling from a variety of species is preferable for disease identification, this can not always be achieved if the disease is not expressing clearly or is not actually present. In the case of Alkimos, the only species to be found that was showing signs of recent stress and death were *Banksia sessilis*.

The four plants that were sampled all displayed symptoms similar to disease stress and provided the best opportunity for sampling throughout the required survey area. Interpreters also observed a number of drought-affected plants during the interpretation works, though no attempt was made to sample these due to their topographical location and time since death. The plants afflicted by drought were also located within close proximity to other indicator species that were showing no sign of death or distress, further confirming the drought prognosis. **Table 1** below outlines the results from the samples taken during the interpretation field assessments with **Figure 2** illustrating the locations these samples were taken.

Table 1 Samples Results from Alkimos Waste Water Treatment Scheme Area

Sample No #	Species	Easting	Northing	Result
1	*Banksia sessilis*	374245	6501325	Subcultured (nil result)
2	*Banksia sessilis*	373653	6501626	Negative
3	*Banksia sessilis*	374618	6501832	Negative
4	*Banksia sessilis*	374735	6501214	*P citricola*

5.3.1 Drought and Fire damage

Within the area of interpretation (see **Figure 2**) drought deaths were encountered. These were mainly very small groups or isolated individuals of *Banksia attenuata* situated on the ridges of sandy dunes. There were also isolated drought deaths of *Xanthorrhoea preissii* encountered during interpretation. There is evidence of fire damage on dead *Banksias* and *Acacias* spp, especially in the lower water gaining areas. Without accurate reference to records it appears these fire scars are approximately four/five years old.

6. DISCUSSION

During this field interpretation the majority of the areas surveyed were classed and recorded as UI. As discussed this basically means they contain no or too few plant species, which are susceptible to Pc infestation to express the disease and create effective mapping boundaries. This does not necessarily mean there is no pathogen in this area, just that it cannot be readily observed via symptomatic means. Although this is often the case in south west forest plant communities, this scarcity of known susceptible indicator species in a harsh environment such as Alkimos can also decrease the chance of Pc occurring and surviving without host species.

Generally within UI areas, it is general and good practice to assume there could be a risk of Pc incipient activity within the soil and treat the area as infested. This is especially important when earth-moving operations are to occur at a site, so that no soil should be transferred from the UI area to one that is known to have no infestation or Pc Free. This is the generally followed guidance if the un-infested area is larger than 4ha and "protectable" (CALM 2003). For Pc Free areas that are <4ha it is often impractical, financially and operationally to enforce hygiene measures as is the case in the mapped instances at Alkimos.

There are some small isolated pockets of interpretable (Pc Free) vegetation encountered within the areas classified as UI, though these areas are too small to demarcate (<4ha). The demarcation and subsequent establishment of clean-down points to facilitate washdown of plant and equipment moving between these small UI and Pc Free categories, would be too costly and would not significantly reduce the associated introduction risk for preventing the spread of Pc. The perceived benefit of demarcating these areas and applying strict hygiene procedures between these plant communities would not be realised due to the low to non-existent risk of Pc occurring in this area. The majority of these pockets that have been illustrated on the Pc Occurrence Map will be removed entirely in the proposed works program, negating any benefits from the hygienic management of these areas.

No obvious disease symptoms were encountered within the area of interpretation, which comprised the eight areas as discussed in **Section 7** and including the fringing Banksia Woodlands forming the main focus for protection. This added further support to the low risk and possibility of spreading Pc from each vegetation complex and the requirements for increased hygiene procedures. Field investigations and samples were collected in places most likely to retain moisture (depressions and small gullies) and provide the best opportunity of identifying Pc. Drought deaths of indicator vegetation were also less likely to occur here, reducing the potential of sampling plants affected by this affliction.

Several drought deaths (*Banksia attenuata*) were observed on exposed sandy ridges and slopes where the effects of drying and plant stress are felt first. It was also noted that these sites had very little groundcover vegetation which would likely exacerbate moisture loss from the soil and further inhibit conditions required by Pc for survival. Fire deaths were also observed across the entire area of the interpretation. These deaths bore visible fire scars which were most pronounced in the shallow depressions where vegetation would have been thickest. *Banksia attenuata* was mostly affected and there were also some isolated stands of *Nuytsia floribunda* displaying fire scars as well as several scattered *Xanthorrhoea preissii.*

The interpretation of the AWTS site covered two distinct landform types. These were the Quindalup Dune System and the Spearwood Dune System. The Quindalup Dunes are found closest to the ocean and are calcareous in nature with predominantly covering of heath vegetation. In relative terms a low diversity of flora is supported here with few species being useful for the interpretation for Pc. The Spearwood Dune System consists of deeper soils and in eastern parts supports more traditional indicator species such as *Banksia attenuata* and *Banksia menziesii.*

There were 11 vegetation types encountered across the 2 landforms which had 5 indicator species that were used in the field for Pc interpretation. These were:

- *Banksia sessilis*
- *Banksia attenuata*
- *Jacksonia furcellata*
- *Xanthorrhoea preissii*
- *Leucopogon propinquus*

This area has historically been used for motorcycle and four wheel drive activities. As such there are numerous tracks throughout the area and these provide an ideal vector for the introduction of dieback, especially as these activities have been uncontrolled from a dieback management perspective. However, the deep calcareous sands make it difficult for water to collect in appreciable amounts and remain available for uptake by plants for any useful length of time. Any infested material e.g. mud, deposited by car or motorcycle tyres, is unlikely to find a suitable place to begin a new infestation. The rapid drying nature of the sand makes it an inhospitable medium for harbouring the pathogen. This also creates a further low risk environment when it comes to picking up the pathogen via infested soil. The passage of water through this sandy matrix is swift and without a nonporous sub-surface layer to allow water to “pond” below the surface there is little chance of the pathogen establishing here.

For Pc zoospores and active mould mycelia to survive they need constant moisture and are quick to die without it. Thus it follows that the areas most likely to be infested and support infestations of Pc are those with the greatest likelihood of holding moisture. These areas include swamps, riparian zones, wetlands etc, or places in which water can “pond” below the surface. Throughout the field interpretations within the clearing and construction footprint of the AWTS, interpreters did not locate any of these moisture holding sites and vegetation complexes that would be favourable for Pc. As further detailed in **Section 7**, the majority of the interpretation area was outside these Banksia Woodland areas and low lying dampland areas.

The negative sample results do not necessary indicate that an area is free from Pc, as it may have been missed during sampling, however the likelihood of Pc occurring within the Alkimos development is slight due to the factors and discussion that has been provided in this report.

The management of topsoil within the clearing and construction envelope has also been assessed through the TCMP, with quality and retention viability taken into account. As part of the recommendations for the protection of this resource for future rehabilitation works, all topsoil will be stored within the immediate vicinity of the cleared area. The priority for this material to be utilised within or close proximity to where it has been removed further supports effective dieback hygiene measures. This process has been discussed onsite between the field dieback interpreters and the clearing and construction operators to further improve hygiene management and reduce risk of spreading infected soils. The clearing of vegetation during the drier summer and autumn months have also further reduced the potential risk of moving Dieback around the site. The clearing and topsoil removal operations undertaken during dry soil conditions has resulted in the reduction of risk for potential of soil and vegetation to be picked up by machinery and deposited around the site. As discussed the free draining sands of the Alkimos site will also further reduce the risk of machines picking up soil and other debris during operations as winter and inclement wet conditions are encountered.

6.1 Summary

The chances of Dieback occurring within the AWTS are minimal to non-existent with the associated risk of introduction of the pathogen into this area under proposed and current hygiene conditions low to nil. Interpreters investigated all possible aspects of potential Pc habitat with no obvious disease symptoms encountered within the area of interpretation. Although *Phytophthora citrocola* has been located at the site, with other *Phytophthora* spp possibly also inhabiting the area, the impact to remaining vegetation complexes from these species is recorded as minimal to nil. The environment that is underlying the AWTS is hostile to Pc and the chance of this disease establishing itself in this habitat is also minimal to nil.

7. DIEBACK MANAGEMENT PLAN

The interpretation of the AWTS site consisted of a detailed visual survey of the flora of this area as outlined in **Section 3.2**. From these field investigations and associated sampling of vegetation a Pc Occurrence Map was produced to provide an overall picture of substantiated disease infections and potential risk of infection if introduced into the site. The following field interpretation sections will further expand on each of the construction areas and discuss the field categories that have been assigned. Although no Pc was found during the interpretation survey, the requirement for clearing approvals was conducted prior to all samples being returned from the laboratory. As two of these samples had required further subcultured samples, it was decided that clearing and construction management be undertaken from the worst case scenario and was conducted under controls implemented in cases of Pc being present. From a conservation perspective in relation to Dieback management this enabled clearing and construction to begin without compromising the integrity of the existing vegetation and increasing the risk of spreading the pathogen that had not been as yet identified.

The interpretation and mapping has included all pockets of interpretable vegetation to further increase the protection of this remnant vegetation and reduce the risk of spreading Pc if it does occur and has not been identified. The following sections act as a descriptive explanation of the Pc Occurrence Map (see **Figure 2**) and the designated categories and management procedures as recommended due to no Pc being located. General dieback management protocols as outlined in **Section 8** are to be further adhered to during clearing and construction operations to further reduce the risk of Pc entering the site. Although the following descriptions of clearing and construction areas are mainly listed as Uninterpretable, the likelihood of Pc occurring in these areas is very low to non existent. This is particularly the case in this survey due to the extended time spent on investigating the disease within the small pockets of interpretable vegetation to substantiate the presence or absence of Pc.

The *Phytophthora cinnamomi* Occurrence Map produced for the area has proposed age limits. Map boundaries should be checked before operations proceed if the map is older than one year (February 2009), and the map should not be used if it is older than three years (February 2011). These age limits have been predominantly set for maps undertaken within forest operations with active dieback fronts, so these can be reviewed for Alkimos as construction and further clearing is undertaken or required. It is envisaged that there will be no dramatic change in the existing environment or associated Pc risk for the Alkimos development.

7.1 Field Interpretation

The field interpretation has been broken down into eight sections. These sections are further illustrated on the Pc Occurrence Map in **Figure 2**.

7.1.1 Launch Pad Site

This area lies in the north western part of the area of interpretation and has been predominantly classed as UI, with the northern section containing a pocket of Pc Free vegetation. The close proximity of this development area to the ocean and the largely degraded vegetation in this area would further decrease the chances of Pc surviving in this area. The northern section of the launch pad is demarcated as Pc Free on the Occurrence Map, though there is no requirement for hygiene controls in this area due to the size of the remaining vegetation and its upslope aspect from existing access. The surrounding dunes from which access to the site is gained would also further decrease the possibility of Pc surviving due to the hostile dry and free-leaching properties of the soil. The area of Pc Free vegetation forms an island at this point and is not directly connected to the same type of dieback susceptible vegetation. This would further reduce the risk of spread of Pc even if it was introduced successfully at this point.

One soil/tissue sample (Sample #2) was taken outside the boundary of interpretation (though still within the same vegetation complex) but provided the only opportunity for sampling. The sample displayed symptoms similar to a Pc disease infection but returned a negative result. This sample (*Banksia sessilis*) was taken in a small basin which had the potential to hold some moisture with no obvious visual vectors nearby. The sample was also surrounded by a number of other indicator species, though these were not displaying signs of death or stress. The limestone formations and outcrops underlying the nearby interpretable vegetation may have also increased the possibility of retention and pooling of water, thus providing more favourable habitat for Pc.
For the purposes of clearing and construction in this area there will be no requirement for further hygiene requirements in relation to Pc to be undertaken due to the minimal to non-existent risk of introducing Pc to this area as well as the current environment unlikely to support an introduced infestation. General hygiene requirements for the Alkimos development in relation to Pc management to be followed as discussed in **Section 8**.

7.1.2 Temporary Access Chamber

This area lies approximately 260m south east of the launch pad site and interpretation of this area included the temporary access into the proposed chamber development which originates from the launch pad site access road. The launch pad site and its access road have been classed UI for the purposes of clearing and construction due to the lack of indicator species present in this area. There was one small pocket of Pc Free vegetation situated on a limestone outcrop in the middle of the temporary access track, though this area is too small to effectively demarcate and manage from the perspective of dieback management. Once again this island of Pc Free vegetation occurs within a depression and did not have any connection to other dieback susceptible vegetation. The nature of the dune formations around this access and proposed chamber area would also isolate any potential infections of Pc if it was introduced into the area.

The area of the Pc Free vegetation within this section of interpretation offered no opportunity for sampling, with all vegetation assessed illustrating healthy growth and no signs of death. As the size of the Pc Free interpreted area within this section of development is too small to effectively manage or protect completely as a Pc Free island, this area will be treated as UI for the purposes of Dieback management. There is no requirement for hygiene demarcation or wash down stations within this section of development and operations will be conducted in line with general hygiene requirements as set out in **Section 8**.

7.1.3 Launch Pad Access Road

This access road links the launch pad site and joins the main access road for the Wastewater Treatment Plant Site (WTPS). This access road also passes past the above access route into the temporary access chamber and has generally been located low in the profile. Other than a very small pocket of Pc Free vegetation located approximately mid way along this access track, the access road has been classed as UI. The majority of this access road also passes through degraded vegetation complexes and includes a number of dune formations which again provide a hostile environment for the successful colonisation and continued survival of Pc.

7.1.4 Workshop and Office Site

This area is located immediately west of the WTPS and has been classed as UI due to the lack of susceptible indicator species. Predominantly this area is situated over raised dune systems with and would again lead to inhospitable conditions for Pc if it was to be introduced into this area. During the field interpretation works, discussions over the location of the workshop area were underway with a view of moving the proposed workshop facilities to the opposite side of the haul and access roads. Further investigations were made in relation to Pc for the alternative location and as can be seen in **Figure 2** this location would include further disturbance of Pc Free vegetation. The current location for the Workshop and Office site would be preferable in relation to Dieback management as there are no susceptible vegetation complexes at all within the construction envelope or within the immediate vicinity.

7.1.5 Wastewater Treatment Plant Site

The largest of all the areas to be interpreted, the WTPS also includes an outlying buffer zone for vegetation disturbance. This area covers the most diverse range of vegetation types and included the largest areas of potentially Pc Free vegetation within the Alkimos development site. The area of interpretation also presents the first real representation of the Banksia Woodland communities that have been highlighted for protection in regards to Dieback management in the TCMP. Although the majority of these Banksia communities are outside the proposed development areas, these transition zones (edge of buffer) were included in interpretation field works to increase the protection offered by potential sampling of these areas. Generally the WTPS can be broken down into three interpretable or mapped sections and these are discussed below.

At the entrance to the WTPS there is a small patch of interpretable vegetation; Pc Free made up of plants species such as *Banksia sessilis* and *Xanthorrhoea preissii,* located in the south west corner. This area has not been demarcated but has been captured on GPS and included on the Pc Occurrence Map. Sample #1 *(B.sessilis)* was taken on the southwest edge of this island and was upslope of the track leading from the south into this area. The sample result from laboratory testing was returned as a positive result, though required further subculture to determine the exact species of fungal disease. This identification had still not been completed at the time of preparation of this report, though it was confirmed however that it was not Pc. Initially due to the sample being sent for further subculture, it was decided to treat the clearing area as a worst-case scenario, so the area was demarcated and no soil material was moved out of this sample area. As the area was within an area of fill construction all fill material was brought from upslope and down to cover the sample area and any potential infection of plant disease. This resulted in the sample area having approximately three metres of fill material covered over the top and no material moved up-slope from this location.

Although further subculture has confirmed that Pc was not present in this location, the soil and clearing management that was undertaken in this case further eliminated any chance of mechanical movement of infestation from this area. The sampling of the *Banksia sessilis* plant in this location offered the only opportunity for sampling within this vegetation complex and further reinforced the unlikelihood of Pc occurring in this area. Although not always achievable during construction due to cut and fill requirements, this was an excellent example of soil management and highlighted the importance of not moving potentially infected soil and vegetation material upslope.

Another interpretable patch of vegetation made up of *Banksia attenuata, Banksia sessilis* and *Xanthorrhoea preissii* scrub in the northeast corner of the WTPS has been included on the Pc Occurrence Map and includes the transition zone as discussed in the introduction of this section. This *Banksia* woodland patch is <4ha and has not been demarcated in the field as it straddles the clearing and disturbance boundaries and does not offer a large enough area for clear delineation. One soil/tissue sample (Sample #3) was taken outside the clearing area within the Pc Free vegetation to verify the absence or presence of Pc. It was taken down slope of a track (a vector for dieback) and in the lower part of the landscape, so offered the best opportunity for Pc to be introduced and exist. Several young drought deaths were present in the vicinity of where the sample was taken which may have been the cause of death for the sample taken as it returned as negative. The purpose of this interpretation outside the clearing and construction boundaries was to provide further opportunity for sampling within this Banksia community and eliminate potential movement of infected soil.

The remainder of the WTPS has been classed as UI due to the lack of susceptible indicator species and the degraded vegetation that predominantly covered the area. For the purposes of Dieback management, the entire area covered by the WTPS will be treated as uninterpretable, with all operations conducted in line with general hygiene requirements as set out in **Section 8**.

7.1.6 Wastewater Treatment Plant Site Haul Road

The haul road runs between the WTPS and the access road and has been predominantly located low in the profile and over degraded vegetation. Interpretation of this area was difficult due to the lack of susceptible indicator species present, with the entire area classed as UI due to this. The management of this road in relation to Dieback will be undertaken under general hygiene requirements as set out in **Section 8**.

7.1.7 Wastewater Treatment Plant Site Access Road

This access road follows an alignment west of the haul road and has been classed as UI due to the lack of available susceptible indicator species. Although the vegetation on this access route was in far better condition than that of the above haul road, the lack of susceptible indicator species along this access road did not allow any opportunity for sampling. The risk of dieback entering this area and causing impact through infestation would be minimal to non-existent due to the lack of these available susceptible species. The vegetation complexes in this area also contain a prominence of *Acacia* spp that are not affected by the pathogen. Again the management of this road in relation to Dieback will be undertaken under general hygiene requirements as set out in **Section 8**.

7.1.8 Quinns Main Sewer

The remaining section of development is the Quinns main sewer construction area which is located north of the previously discussed infrastructure. It has been classed as UI due to the lack of susceptible indicator species present. However, there is a very small island of *Banksia attenuata* and *Banksia sessilis* located at the end of the section which again is too small to demarcate (<4ha) within the field, though has been illustrated on the Pc Occurrence Map. From this area a recently deceased *Dyrandra sessilis* was sampled (Sample #4) from a shallow gully to provide an opportunity to verify the presence or absence of Pc. This sample was sent to subculture and was not returned prior to the requirement of clearing the area. It was decided to quarantine the area and restrict movement of machinery between this and the other development areas unless effective hygiene and clean down procedures were undertaken. The sample result that was eventually returned from laboratory testing was that of a positive result of *Phytophthora citrocola*.

As discussed in **Section 3.2** the identification of *Phytophthora citrocola* in the area does not necessitate the same level of management and quarantine as that of identifying Pc. Due to the nature, expression and the potential impact of *Phytophthora citrocola*, identifying the pathogen in this location will not require further demarcation or increased hygiene standards for operations in this area. However the movement of topsoil will be restricted within this development area, with topsoil removed from this sample site quarantined and stored so as to further reduce the potential risk of spreading this infestation. Management of this area in regards to further hygiene requirements will be conducted as listed in **Section 8**.

8. HYGEINE PROCEDURES

The following list of hygiene procedures form the basic set of requirements that must be undertaken during any clearing or construction works carried out during the life of the AWTS project. They specifically relate to the control and potential spread of Pc and are set within the site specific conditions of Alkimos and its existing environment. These procedures have been reproduced from current best practice available supplied by the DEC, the Water Corporation, educational institutions working in Dieback management, the Dieback Working Group and experience gathered by the interpreters that completed the Alkimos field assessments. These procedures have been prepared to meet the objectives of the current TCMP whilst allowing for the Alkimos construction in line with realistic constraints as they relate to associated risk of introducing or potentially spreading Dieback disease. The review and annual audit requirements of the TCMP will allow for continued best practice and new developments in science to be included if they are seen to be pertinent to the development and continued compliance of the TCMP objectives in relation to Dieback management.

1. All plant, equipment, vehicles and machinery are to be Free of soil and vegetative material before entering the Alkimos development site:

    - All plant, equipment, vehicles and machinery are to be visually inspected before entering the Alkimos development to confirm they are completely Free of soil and vegetation material;
    - Records of inspections to confirm that plant, equipment, vehicles and machinery are completely Free of soil and vegetation material are to be kept as a register, with hygiene declaration forms utilised to achieve this requirement;
    - All plant, equipment, vehicles and machinery will be cleaned down utilising pressurised water facilities, compressed air facilities or physical brush down practices to achieve clean down requirements;
    - It is preferable for all plant, equipment, vehicles and machinery to be clean before reaching Alkimos construction depot;
    - All plant, equipment, vehicles and machinery requiring clean down upon reaching Alkimos construction depot will be directed to a clean down station constructed to DEC specifications and Pc Management Guidelines, **Appendix B**; and
    - AWA to continue to investigate the requirements for sterilisation to be added to water-based clean down operations. Currently no stated sterilisation requirements are listed from the DEC, though some trials are currently underway investigating the potential for sterilising agents. Current best practice is to ensure all plant, equipment, vehicles and machinery are completely Free of soil and vegetative material before entry to site.

2. No movement of vegetation or soil material is to be undertaken outside of current designated clearing and construction boundaries at Alkimos:

   - All construction and clearing operations to be confined to designated boundaries as illustrated in **Figure 2**, Pc Occurrence Map;
   - Any additional clearing or construction required outside these interpreted boundaries will require further field assessment to reconfirm the presence or absence of Pc;
   - All topsoil within the clearing and development footprint to be utilised for rehabilitation works as close to practicable to original location of removal;
   - All topsoil within Interpreted Pc Free areas to remain within these designated areas and where possible not be moved upslope from their original location (this has already been achieved through onsite inspection in most locations and will continue to become standard practice in future operations);
   - Where practicable all movement of soil to be down slope and remain within each section of construction development; and
   - Sourcing of basic raw materials, such as sand, gravel and soil required for the initial construction and building of roads is required to be certified as Pc Free. The use of crushed limestone for these construction batters and roads will not support the survival of Pc and will be suitable for use throughout the site.

If surface water drainage systems are required as a result of construction works or increased hard stand areas, these systems will be constructed where possible to not drain into Pc Free vegetation areas as far as practicable. Site management to address potential surface water runoff so that pooling of water outside the boundary of the clearing and construction site is avoided. The deep Free draining sands of the Alkimos site should accommodate this flow of water quite easily, though depressions and potentially water gaining sites should be avoided wherever possible.

9. CONCLUSION

The primary objectives set out in the TCMP in relation to Dieback are:

- manage infected areas so as to prevent the spread of Dieback further around the site area;
- to protect the areas that are Dieback free and to ensure they stay that way during the life of the project; and
- comply with any hygiene requirements as specified by DEC.

The preparation of this Dieback Management Plan and preceding field interpretation works undertaken over the Alkimos site has focused on these objectives and provided management actions based on current available best practice for Pc management. All field interpretation works and assessments of the site have been carried out in line with DEC guidelines and accepted industry standards. The implementation of this management plan will further reduce this risk, while also lessoning the potential impact of other *Phytophthora* species that may not have been identified through this process.

10. REFERENCES

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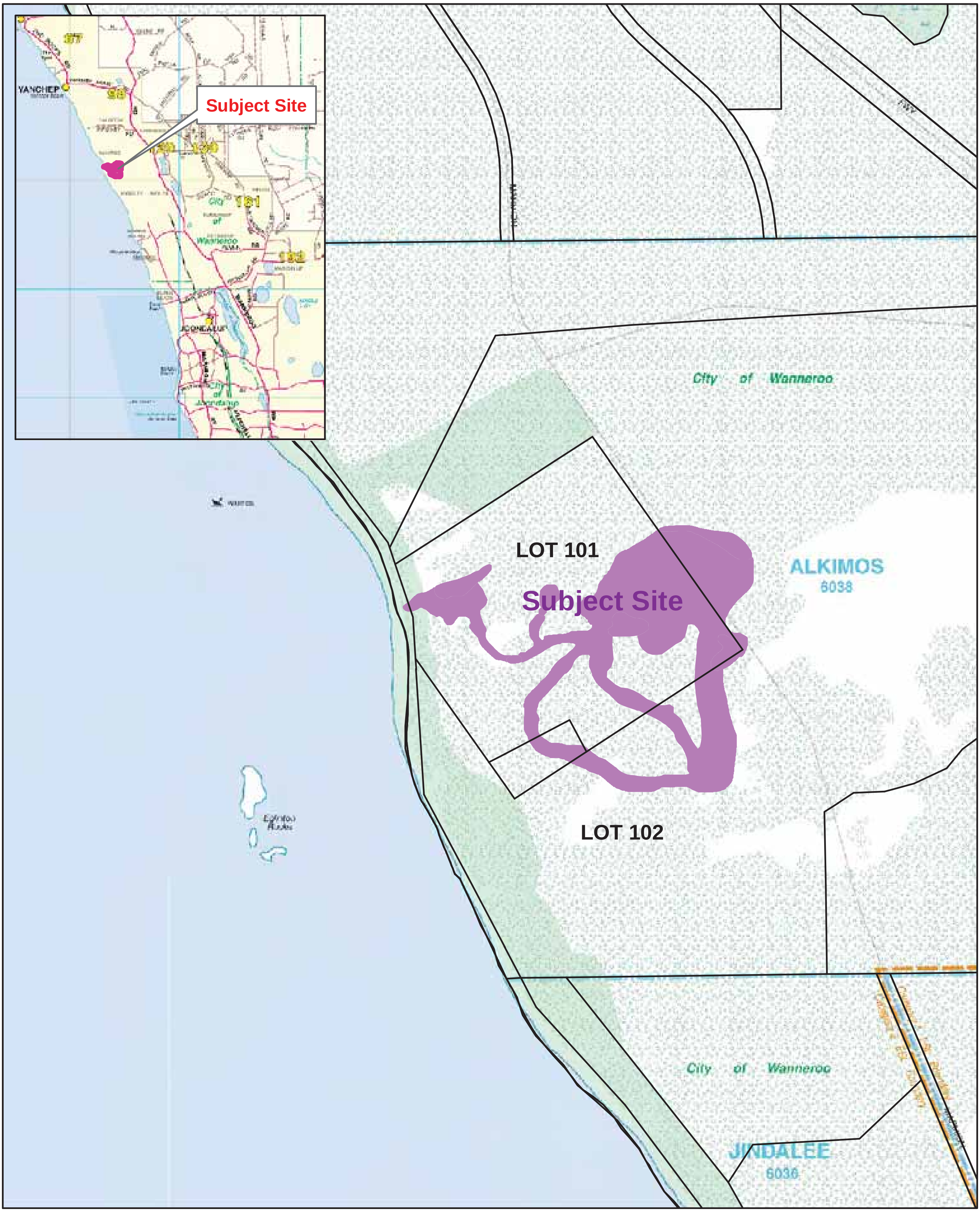
FIGURES



DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD	DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

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Scale: 1:24,000

0 300 600 1,200 1,800 2,400 Meters

PROJECT **ALKIMOS WASTEWATER SCHEME**
Dieback Mapping

DRAWING TITLE **FIGURE 1 :Locality plan**

Project Number **V7012**
Original **A4**
Drawing Number **SK01**
Revision **00**
Designed IG
Checked
Drawn MGW
Approved
Local Authority City of Wanneroo
Sheet 1 of 1
Date 28/04/08

ALKIMOS WASTE WATER TREATMENT SCHEME

PHYTOPHTHORA CINNAMOMI OCCURRENCE MAP

MAP LEGEND

UNINFESTED (PROTECTABLE)

Determined by a qualified Interpreter to be free of plant disease symptoms which indicates the presence of *P.cinnamomi.*

UNINTERPRETABLE (PROTECTABLE)

Where susceptible plants are absent or too few to enable the interpretation of *P.cinnamomi* presence or absence.

INFESTED

Determined by a qualified Interpreter to have plant disease symptoms consistant with the presence of *P.cinnamomi.*

AGE LIMITS FOR THIS MAP

Map Boundaries should be checked before Operations proceed if this map is older than 1 year (Feb 2011).

This map should not be used if it is older than 3 years (Feb 2011).

Areas that have had an Operation in them become unreliable and should be checked prior to Further / New activities.

MAP LIMITATIONS

Mapping Accruate to +/- 5 metres

MAP METHOD

Field Survey

PROJECT NUMBER
V7012
Designed: IG
Drawn: MGW
Local Authority: City of Joondalup

DRAWING NUMBER
SK02
Checked:
Approved:
Date 28/04/08

PRODUCT VERSION STATEMENT

Product	Code	Complete Date	Initials		Recheck Due	Expiry Date
			Interps	Digitised		

AREA STATEMENT

Categories	Area Ha	Notes
UNINFESTED	7.7457Ha	All samples returned negative for Phytophthora cinnamomi
UNINTERPRETABLE	67.5241Ha	
INFESTED		
UNPROTECTABLE		
TOTAL AREA	75.2698Ha	

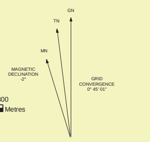
LEGEND

- Sample Locations
- GPS Points
- Uninfested Locations
- Proposed Infrastructure design
- Waste Water Treatment Plant Buffer

GDA

Scale 1:5,500

0 50 100 200 300 400 500 600 700 800 Metres



If Magnetic Declination is important for your purposes local Magnetic Declination calculations can be carried out at the GeoScience Site.
www.agso.gov.au/oarcle/geomag/agrfform.html

PROJECTION: TRANSVERSE MERCATOR C.M. 117 E ZONE 50
HORIZONTAL DATUM: GEOCENTRIC DATUM AUSTRALIA 1994.
VERTICAL DATUM: AUSTRALIAN HEIGHT DATUM 1971.

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APPENDIX A

Detection, Diagnosis, and Mapping.

Volume 2 – Interpreters Guidelines

Detection, Diagnosis,

&

Mapping

Volume 2- Interpreter's Guidelines

Department of
Environment and Conservation

January 2007

TABLE OF CONTENTS

1 INTRODUCTION

This manual describes the procedures adopted by the Department of Environment and Conservation for the detection, analysis and mapping of disease symptoms caused by the plant pathogen *Phytophthora cinnamomi* in native vegetation in south-west Western Australia. This manual should be used with reference to '*Phytophthora cinnamomi* and disease caused by it, Volume 1: Management Guidelines' (DEC/CALM, 2000).

The information provided about *Phytophthora cinnamomi* occurrence, using these procedures, is the basis for the development of long-term management systems of hygienic access to areas of land identified as 'protectable areas'. Protectable areas have been mapped as free of disease symptoms and are amenable to management to restrict disease introduction or are infested areas with special values that will benefit from chemical treatment (phosphite). The combination of maps of disease occurrence, protectable areas and hygiene management requirements are known as *Phytophthora cinnamomi* Hygiene Management Plans.

Disease caused by *Phytophthora cinnamomi* has been known as 'dieback' but 'root rot' or '*Phytophthora* root rot' could be a more appropriate name for the disease since the fungal hyphae macerate the roots causing them to rot.

Personnel who carry out the tasks of detection, diagnosis and mapping are known as 'Interpreters' as they interpret disease symptoms to draw conclusions about the health of the vegetation.

The Interpreter uses 'a logical procedure for the interpretation of dieback disease symptoms through disciplined observation and analysis of Indicator Species Deaths (ISDs), absolute location and recording accuracy and a complete *Phytophthora cinnamomi* sampling and identification procedure' (Brandis, 1983). Knowledge of plant identification, vegetation types, soils and landforms, drainage characteristics of sites and other impacts upon sites are fundamental to the task of interpretation. Only when analysis of sites has been made based on the above knowledge and using the interpretation process, can an Interpreter make accurate decisions about the health of native vegetation and prescribe subsequent management decisions.

To a lesser extent, other plant pathogens can cause concern and must be distinguished. These include: *Armillaria luteobubalina* (*Armillaria*), canker fungi, mistletoe and infrequently, other species of *Phytophthora*.

The main method of survey is the strip line. The aim is to give 100% coverage of the area in question such that data gathered is both comprehensive and accurate.

Broadscale mapping using 1 : 20 000 photography is a method used to get an overall picture of larger areas. This method does not provide management level disease diagnosis but is a useful planning tool on the broad scale. An Appendix on this method is included in this manual as a reference for Interpreters assisting in such projects.

This manual has been prepared as a guide for all Interpreters. It recognises that some interpretation methods and practices may need to vary due to local needs. In these situations the authority of the Disease Standards Officer will be required.

As procedures develop it will be necessary to revise this manual. Where changes or improvements are required, Interpreters should notify the Disease Standards Officer for approval and modification to this manual.

All new Interpreters should carefully read this manual and become familiar with the methods and procedures presented in it. Extensive experience in disease interpretation on a range of sites is critical for developing ability and credibility in personnel carrying out disease interpretation.

Landscape unit definition for the interpretation of *Phytophthora cinnamomi* occurrence

The process of identifying protectable areas through *Phytophthora cinnamomi* occurrence mapping should generally occur over whole landscape units bounded by ridges, saddles and creek lines. Activity proponents should plan to relate requests for interpretation to such landscape boundaries. This will ensure the full extent of the disease is considered in identifying potentially protectable areas, rather than artificially limiting their extent with operational boundaries.

In some instances, planners/proponents may limit the area of interest to boundaries defined by unprotectable uncontrolled access or unprotectable strategic roads or some other unprotectable feature. These unprotectable roads, tracks or other features define boundaries of protectable areas absolutely.

If however, Interpreters determine such roads to be free of *Phytophthora cinnamomi* and protectable, then their status as a landscape unit boundary should be reconsidered in conjunction with the planner/proponent. This will arise from observations such that the road is considered *Phytophthora cinnamomi* free, and the surface has had a low incidence of introduced soil or root material, and therefore has a low probability of pathogen presence. In general ‘secure’ roads (protectable), unless strategic, must be protected and access controlled to maintain the status of protectable areas.

Interpreters should continue to evaluate any influence of the pathogen from infested areas outside the landscape unit/or operational boundary, if necessary.

Safe working practices

Management of Interpreter safety is a complex association of risk management, duty of care, hazard awareness and common sense. Traditionally Interpreters across three forest regions have maintained an excellent safety record despite a hazardous work environment.

Interpreters often have to meet deadlines and pressures that are associated with harvesting, mining and general public service. These pressures must not be allowed to compromise safe practices in the workplace. It will be a primary role of Interpreter management to monitor and reduce deadline pressures where possible. Anticipation of work pressures will enable forward planning and preparation so those hazardous situations are avoided.

Interpreters will be required to use common sense and keep a cool head in difficult situations. An accident is often the culmination of a series of events (for example late night⇒fatigue⇒distraction⇒vehicle accident). Interpreters should recognise the risk factors and hazards leading up to an accident as a means of accident prevention.

Duty of care

The Occupational Health Safety and Welfare Act of 1984 places certain duties on people in the workplace towards their neighbours. These are referred to as ‘general duties of care’.

Interpreters must take reasonable care to avoid acts or omissions, which they can reasonably foresee would be likely to injure themselves or their neighbour. Specific examples of general duty of care from an Interpreter’s point of view include: wearing of all provided safety equipment, adjusting driving technique to suit conditions and reporting hazards.

Fundamentals

The Department has identified the various predictable components of disease interpretation tasks (vehicle driving, bush walking, chemical handling, etc.). Descriptions of how to carry out these tasks safely can be found in Job Safety Analyses (JSA) prepared for each task and in manuals written specifically for various tasks or pieces of equipment (for example chainsaws, motorbikes, etc.). Interpreters will be given the appropriate JSAs when they start the job (the JSA may be described in detail by the immediate supervisor). Interpreters will follow the recommendations of the JSA. In the event of a regular task not having a JSA, Interpreters are bound by duty of care to analyse the task, report the hazard and make changes to remove it.

Special attention

Vehicle accidents and slips, trips and falls, and insect attack in the field are categories of accidents that require special mention in this document even though they have been previously covered in various JSAs.

Vehicle Accidents

Interpreters spend many hours travelling in vehicles, in all conditions. It may take years of experience for an Interpreter to be at ease with off road and bush track driving conditions. Even with specific bush driving training, Interpreters may not feel comfortable driving in extreme conditions or at a regular speed. If this is the case it is imperative that the new driver adjusts driving speed to a level with which they feel safe. Complacency is the most dangerous hazard associated with bush driving. Interpreters should use the improvement of observation skills that develop with interpretation to sharpen their awareness while driving.

Slips, Trips and Falls

To the inexperienced bush walker, the forest undergrowth and floor may appear hazardous and hostile. Other industries would not tolerate an uneven or slippery walking surface. Interpreters need to work in these environments and therefore must rely on awareness, caution and skill to find a safe path through the bush. Details of safe bush walking can be found in the JSA for the task. Heightened awareness will come to new Interpreters learning from experienced walkers. Common sense should apply in all circumstances.

Search and Rescue

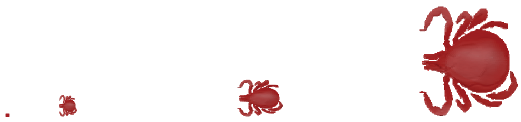
In the event of an Interpreter not returning from the bush by a specified Expected Time of Arrival (ETA), the relevant Forest Management Branch section will initiate a search and rescue procedure specified in standing orders for each work centre. The document makes special mention of flexible work arrangements.

> If you do find yourself lost, head downslope to the nearest track, road or creekline. If you find a creekline or overgrown track, keep following it downslope till you reach a navigatable track or open road. When you reach the track, **wait there**. Searchers will start by moving around the perimeter of an area. If you have made it to a track or road they will find you much sooner if you remain in one place. If you are injured and can not walk, find a shady spot and stay put. Help will arrive.

Insect Attack

The most common injury interpreters report is insect attack, especially tick bites. Ticks are very common in the Western Australian environment. Some care can be taken to lessen the chances of being bitten. Tucking your trousers into your socks and wearing gators will assist in creating physical barriers between your skin and the environment. Regular checks of your clothing will also help prevent the ticks from reaching your skin and biting you. In areas that are extremely infested with ticks the wearing of pantyhose under your trousers may be necessary.

Ticks vary in size from less than 1mm (pepper ticks) to 200mm (kangaroo ticks) Most bites are from pepper ticks as they are so small and hard to detect.



If you are bitten, remove the tick as soon as it is discovered and keep the bite extremely clean. Infection after a bite is the main cause of injury and time loss. Due to the toxin the ticks inject the bite may take months to heal.

The other common insect attacks are mosquito bites, and bee and wasp stings. Mosquitoes can carry Ross River Virus which can cause serious chronic illness. Allergies to stings can be very serious. If you are allergic to bee or wasp stings carry your medication with you when walking in the bush.

2 DETECTION AND DIAGNOSIS OF DISEASE SYMPTOMS

Essentially, Interpreters are looking for those areas that are:

- infested with *Phytophthora cinnamomi*;
- uninfested – free of plant disease caused by *Phytophthora cinnamomi*;
- uninterpretable – those areas where presence or absence of *Phytophthora cinnamomi* cannot be determined;
- unprotectable – infested areas and those areas where it is judged that autonomous spread of the pathogen will occur in the shorter term (within a few years and up to 50 years);
- protectable – free of plant disease caused by *Phytophthora cinnamomi* and likely to remain so (current determination based on 50 years spread up-slope).

Mapping definitions of these categories can be found in Section 9.

Detecting the presence of the plant pathogen *Phytophthora cinnamomi* involves the observation and interpretation of plant deaths using a logical assessment of factors that imply pathogen presence above other possible causes of plant deaths. Confirmation of pathogen presence can be made by laboratory analysis of soil and root tissue from dead and dying plants.

The range of susceptibility of hosts and the diversity of sites and climatic conditions experienced in the south-west make it difficult to present a comprehensive guide to disease expression in this manual. A knowledge of the various conditions and sites experienced in the south-west, supplemented with Interpreter's observations, will help in disease detection.

A working knowledge of the biology (see Volume 1) of *Phytophthora cinnamomi* is also essential. Brief descriptions of the pathogen and environmental factors that favour establishment and growth of *Phytophthora cinnamomi* are presented in this section. Importantly Interpreters should read the invaluable information presented in Shearer, B.L. and Tippet, J.T. (1989) 'Jarrah Dieback: The Dynamics and Management of *Phytophthora cinnamomi* in the Jarrah (Eucalyptus marginata) Forest of South-western Australia', Research Bulletin No. 3.

Assessing observable factors indicating likely disease presence

A combination of the following factors may indicate the presence of disease caused by Phytophthora cinnamomi. Experience will assist the ease of observation and analysis of these factors. Technical Paper No. 3 (Brandis, 1983) discusses these factors further. A decision-making guide from this publication is shown in Appendix 1.

Indicator species deaths (ISDs)

An indicator species is a plant species, which is reliably susceptible to *Phytophthora cinnamomi* (i.e. will die). Common indicator species include Banksia grandis, Patersonia spp., Persoonia longifolia, and Xanthorrhoea spp. (Image 1). The distribution and composition of indicator species will vary from place to place according to vegetation types.

Image 1: Examples of indicator species

Healthy *Banksia grandis*

Dying *Banksia grandis*

Healthy *Patersonia sp.*

Dying *Patersonia sp.*

Dying (left) and healthy (right) *Xanthorrhoea preissii*

Indicator species deaths (ISDs) can be grouped into classes based on the dead species and the apparent association between the deaths. Brandis (1983), recognised four classes, as follows:

Association of deaths

Isolated ISDs

These are single dead plants (any indicator plant) that have no apparent association with any other death and may be within an area populated by many other healthy indicator plants (>50m between ISDs).

Scattered ISDs

These can vary from a single dead plant (any indicator plant), to small groups of two or three dead plants. There may be many healthy indicator species between these scattered deaths which may occur over a wide area, and have no apparent association between deaths (20m – 50m between ISDs).

Groups or clusters of ISDs

Two or more dead plants of the one species within close proximity of one another, with an apparent association between the deaths, but discrete from other potential infestations (ISDs in groups within close proximity to one another, clusters may be scattered).

Multiple ISDs

Some or all the indicator species are dead within the same area (some or most indicator plants, ISDs within close proximity to one another).

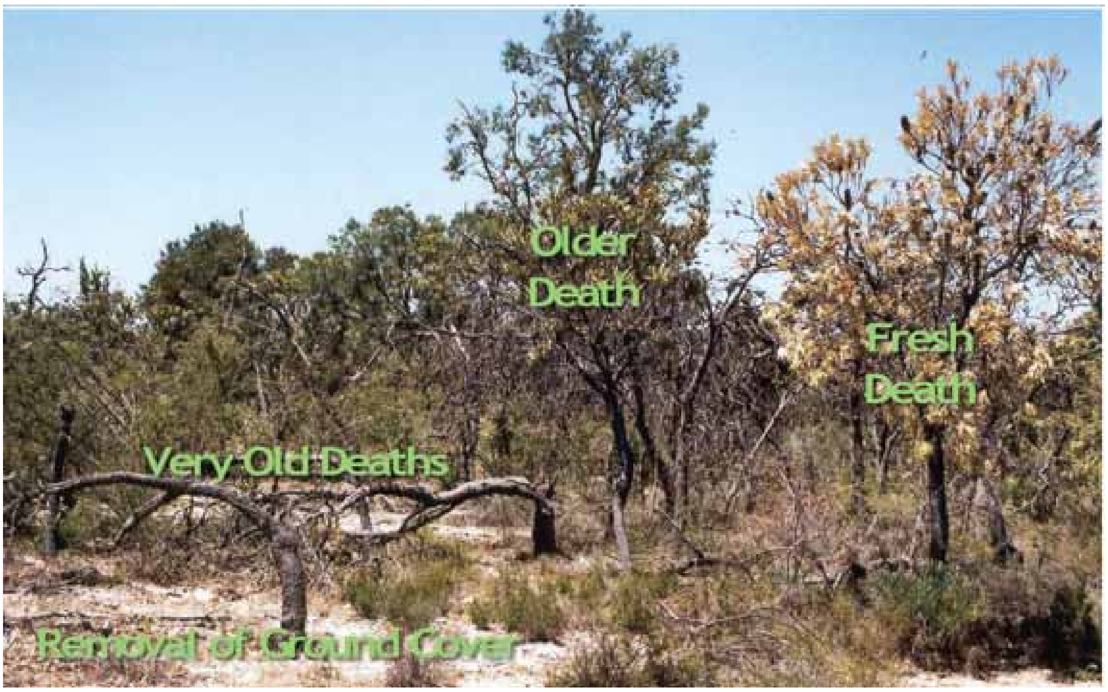
The probability of pathogen presence is greater where a range of susceptible species is dead than if an individual plant dies among other healthy indicator species.

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 (Image 2).

Image 2: Age pattern of deaths in *Xanthorrhoea preissii* and *Banksia grandis*

Image 3: Age pattern of deaths in banksia woodland



In old infestations most indicator species may have been killed by the disease and old stags and stumps may have rotted or burnt away. In these situations the area may be difficult to interpret. However, the experienced Interpreter should be able to recognise a change in vegetation type from what would be normally expected in the absence of disease and be able to identify correctly the area as an old infestation. Walking towards where one would expect a disease boundary to occur can sometimes confirm this determination. As one gets closer to the boundary, old deaths are replaced by more recent deaths and then eventually by healthy indicators.

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 (Brandis, 1983).

In less susceptible communities (fewer susceptible species) observable pattern development may be vague, for example, in wandoo forest.

Susceptibility

Phytophthora cinnamomi has a very wide host range. At least 1,000 species from taxonomically diverse families have been reported as hosts for *Phytophthora cinnamomi* of which nearly half have been recorded from research in Australia. Appendix 2 provides a list of the commonly-used indicator species.

Indigenous species most affected belong to four families:

- Proteaceae (for example *Adenanthos barbigerus, Banksia grandis, Dryandra sessilis, Isopogon sphaerocephalus, Persoonia longifolia, Petrophile diversifolia, Synaphea petiolaris, Xylomelum occidentale*);
- Epacridaceae (for example *Andersonia caerulea, Leucopogon verticillatus*);
- Papilionaceae/Fabaceae (for example *Pultenaea reticulata*);
- Myrtaceae (for example *Eucalyptus marginata*).

Neither all genera within a family, nor all species within a genus are necessarily susceptible, for example some species of *Eucalyptus* are highly resistant (including karri, wandoo and tuart) while some, such as jarrah, are affected but have the ability to resist the invasion of the fungus under certain conditions.

Environmental factors

(Summarised from Shearer and Tippett 1989)

Sites will vary in the way that disease is expressed both spatially and temporally. Environmental conditions can either favour or disfavour the growth and spread of the pathogen. Sites that are moist but not saturated are most favourable, sites that are well drained and mostly dry are least favourable. The influence of these factors can be assessed with knowledge of disease biology, host physiology and site microclimate and hydrology (the disease triangle) to aid in the interpretation process.

Why the environmental conditions of the south-west favour Phytophthora cinnamomi

Parts of the south-west have a warm, moist climate which favours the production of fungal spores, particularly after summer rains. Poorly drained soils, which typify some of the region, also favour the production of spores and spread of the fungi. Clay, organic pans and sheet laterite, are features of some of the soil types in the south-west. They can act as impeding layers and cause subsurface ponding, which assists the production of spores. On these soils, water tends also to drain laterally, thus spreading the zoospores further. Water in the root channels of the concreted lateritic layer also provides ideal conditions for spore production.

Geology and geomorphology

Several broad geomorphological features exist in the south-west of Western Australia that influence the type of site and vegetation characteristics, which in turn influence disease expression. Interpreters should familiarise themselves with the geomorphology of the south-west from the many publications available. Particular publications which should be held in the Interpreters' work centres are:

The Atlas of Natural Resources (1980), Department of Conservation and Environment WA.

Landforms and Soils of the South Coast and Hinterland, WA: Northcliffe to Manypeaks, by H.M. Churchward, W.M. McArthur, P.L. Sewell and G.A. Bartle (1988), CSIRO Division of Water Resources, Divisional Report 88/1.

Site Classification in the Southern Jarrah Forest of Western Australia, by G.J. Strelein (1988), Research Bulletin No.2. Department of Conservation and Land Management WA .

The following are very broad descriptions of the main geomorphological features where the majority of *Phytophthora cinnamomi* infestations occur.

The Darling Plateau features sandy soils as a result of weathering of the granite which underlays the majority of the plateau. Loamy or clay soils are the results of weathering of intrusive features called 'dykes' that formed the rock known as dolerite. Weathering of these soils on the plateau in turn has been by a process of laterisation that leaches specific minerals to leave behind iron and aluminium oxides and hydroxides. This layer is referred to as the laterite, ironstone or duricrust layer.

The Swan Coastal Plain in the west is generally up to about 30km wide (wider north of Perth) from the coast to the Darling Scarp in the east. The plain rises from sea level to about 25m with sandy ridges in the west up to about 40m. Between the hills of low relief are often lowlands and swampy wetlands that can be quite broad.

Sands and unconsolidated sediments are common on the Swan Coastal Plain. Nearer the coast soils tend to be aeolian (wind blown) whereas in the east nearer the Darling Scarp soils tend to be alluvial (deposited by water). Some of the older soils have been laterised.

The Darling Scarp and major river valleys cutting through the scarp from the plateau have more recent soils weathered from the bedrock. These soils tend to be loamy and have not been laterised. Occurrences of exposed granite are common.

From Manjimup the plateau slopes gradually towards the south. Laterite soils still feature but broad drainage channels and lower relief becomes more common. North-west of Walpole granite Monadnocks feature with sandy loam soils at their bases. The broad drainage channels between the hills tend to be sandy. The granite hills become more prevalent heading east towards Albany, for example the Porongurup Range.

The Stirling Range is a remnant feature of ancient sedimentary rocks. The uniqueness of this feature and its elevation (up to around 1,000m) have resulted in a unique flora common only to some of the higher peaks. Unfortunately *Phytophthora cinnamomi* is widespread and survives extremely well in this area with severe impact on the vegetation, including the rarer floral species.

Climate

The climate of the south-west is typically Mediterranean with cool, wet winters and hot, dry summers. The seasonal pattern of rainfall and temperature strongly influences temporal changes in activity of *Phytophthora cinnamomi* in south-western Australia (Shearer and Tippett, 1989).

Moisture is essential for disease activity and therefore rainfall distribution is partly responsible for the decreasing incidence of *Phytophthora cinnamomi* with distance east of the Darling Scarp. Rainfall also decreases from south to north.

Soils

Soil temperature
The optimum temperature for sporulation is 25°C to 30°C and the optimum growth range is 15°C to 30°C. Temperatures less than freezing or greater than 35°C are unfavorable to the survival of zoospores and mycelium of *Phytophthora cinnamomi*.

Soil temperature does not adversely affect survival of *Phytophthora cinnamomi* in winter in Western Australia.

Soil pH
The optimum soil pH is five to six (acid). In general the forested areas suit this pH range. Low rainfall areas tend towards alkaline soils while higher rainfall areas tend towards more acid soils.

The calcareous sands on the coast are alkaline and hostile to *Phytophthora cinnamomi* whereas the siliceous sands in water gaining flats are quite acidic and more suited to *Phytophthora cinnamomi*.

Soil fertility
Infertile sandy gravels are more favorable to *Phytophthora cinnamomi* due to:

- lower host resistance;
- free movement of water;
- little organic matter and few antagonistic microflora;
- soil texture allows easy lateral movement of motile zoospores and mycelial growth.

Fertile red loamy soils are less favorable to *Phytophthora cinnamomi* due to:

- good host resistance;
- poor movement of water;
- high organic matter and many antagonistic microflora;
- soil texture does not allow easy lateral movement of motile zoospores or mycelial growth.

Soil moisture
Moisture is critical for survival of *Phytophthora cinnamomi* in the soil and for sporangia production. The most favorable environment for *Phytophthora cinnamomi* requires the soil to have a moisture content at just above field capacity allowing for a moist but aerobic situation. Saturated soils become anaerobic and therefore don't contain enough oxygen to favour sporangia production.

Wet soil conditions and warm temperatures favour release of motile zoospores from sporangia. Lateral near-surface seepage of water is a significant factor in dispersal of *Phytophthora cinnamomi* in any area where soils of coarse textures or aggregate structure occur, particularly above a perching layer.

Jarrah trees suffering water stress are less susceptible to infection than trees that are well watered.

Soil texture
Soil texture is a very important factor affecting active dispersal. Large pores in coarse-textured soils favour dispersal while pore sizes in fine-textured soils are too small to allow the passage of fungal zoospores. Spread is therefore limited to mycelial extension.

Vegetation

Expression of disease caused by *Phytophthora cinnamomi* requires susceptible host species to be present. For example, communities of highly susceptible host species such as *Banksia grandis* are conducive to the development of the disease.

Some vegetation communities are hostile to the development of *Phytophthora cinnamomi*. For example, *Acacia pulchella* stands create high ammonia levels, which is hostile to *Phytophthora cinnamomi*.
Many native plants produce varying amounts of saponins in the soil. These natural detergents are found to be hostile to *Phytophthora cinnamomi*.

Dense vegetation on fertile soils create large amounts of organic matter in the soil, which promote a high level of microflora in the soil, many of which are antagonistic and consume *Phytophthora cinnamomi*.

In the early to mid-1980s, researchers attempted to use fire to change the understorey from one dominated by *Banksias* to one dominated by *Acacias* in order to alter the soil environment to disfavor the fungus. Practical application of this method was not easy and therefore this technique is now not actively applied.

Other causes of indicator species death

Phytophthora cinnamomi is not the only agent to cause death of native vegetation. Interpreters should learn to differentiate between death of plants by other agents and those by *Phytophthora cinnamomi*. Other agents include but are not limited to:

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

Brief field guide to symptoms of other causes of individual indicator species deaths

Some symptoms of plant deaths can aid in field determination of probable cause of death. Most of these are not conclusive but when used with the other observable factors can contribute to decision making.

Lesions
Lesions under bark of affected plants may be observable and in the case of *Armillaria* can be diagnostic. Diagnosis of lesions of *Phytophthora* and cankers is usually carried out in the laboratory. Occasionally they may be visible on the affected plant.

Phytophthora lesions move from the roots upward to the collar region (junction of stem and roots, equating roughly with soil surface) and are usually brown to black in colour (Image 3).

Image 3: Brown lesion caused by *Phytophthora cinnamomi* in collar region of *Banksia grandis*

Armillaria luteobubalina

Armillaria appears as white or yellow-white leathery mycelial sheaths, which are clearly visible beneath the bark of infected plants in the roots and lower stem (Image 4).

Image 4: *Armillaria* mycelium

The leather-like appearance of the mycelial sheath is the key to diagnosis. Many other types of white mycelium may be found but they will not be as leathery as *Armillaria*.

Other features that may be used in the diagnosis of *Armillaria* infection include:

- an inverted vee-shaped scar at the base of plant;
- clusters of fruiting bodies at or near the base of plant;
- wet, stringy yellow-white rots in roots and base of plant.

Armillaria fruiting bodies are a typical mushroom, consisting of cap, gills and stem (Image 5). They are generally short-lived and are produced in clusters at the base of infected plants, or sometimes on the stem up to 3m above the ground, in mid to late autumn to early winter. Other recognisable features of the fruiting bodies include:

- developing in clusters;
- lemon-yellow to honey-brown cap;
- persistent ring around stem;
- floccose (shaggy) stem immediately below the ring;
- cream-white gills changing to pink-brown with age;
- flesh has a bitter taste.

Image 5: *Armillaria luteobubalina* fruiting bodies

While *Armillaria* may be diagnosed it is important to ascertain by sampling that it is not working as a secondary pathogen to *Phytophthora* species.

Cankers

Cankers are characterised by lesions moving down branches toward the main stem. Plants affected by cankers exhibit often as ‘part deaths’. The lesion is usually brown or black in colour. In advanced stages of infection, the affected bark may be dotted with dark spore-bearing conidia.

The fundamental differences in biology of the pathogenic fungi discussed above are summarised in Table 2.1 (Adapted from Shearer 1992).

Table 2.1: Biological differences of pathogenic fungi

	Phytophthora	*Armillaria*	*Cankers*
Pathogen	*Phytophthora cinnamomi* *P. citricola* *P. dreshcleri* *P. cryptogea* *P. nicotianae* *P. megasperma* *P. parasitica*	*A. luteobubalina*	*Botryosphaeria* *Endothia* *Diplodina* *Cytospora* *Zythiostroma* *Cryptodiaporthe*
Reproduction	Various but either zoospores, chlamydospores or oospores	Basidiospores	Conidia
Spread	Soil/water/roots	Air/roots	Air/rain splash
Host range	Wide, mainly *Proteaceae*, *Epacridaceae*	Wide, hosts resistant to *P.c.* may be susceptible to *Armillaria*	Wide, hosts resistant to *P.c.* may be susceptible to canker
Impact Jarrah Karri Wandoo Banksia woodland Heathland Mallee	 Low to very high Low Low High to very high High Low	 Low to high Low to high High Low to high Low to high Low	 Low to moderate Low to moderate High Low to high Low to high Low

Drought deaths

Drought affected plants will often recover – they may look dead at first glance, but on closer examination will often reveal epicormic shoots or resprouting on the lower stem and sometimes on branches. The vegetation type will indicate drought-prone sites.

Fire deaths

Fire related deaths and injuries to trees and plants look similar to drought symptoms but there is often blackened bark present, which indicates the severity of scorching due to fire (Image 6).

Image 6: Fire damage on a *Banksia grandis*

With practice and guidance from experienced Interpreters, the distinctions between the various agents become quite clear.

3 PREPARATION FOR INTERPRETATION

The Senior Interpreter usually determines the method of interpretation and allocates a priority on the area to be interpreted. Interpreters will then:

- collect background and historical information from Department of Conservation and Land Management records;
- gather all materials and equipment required for interpretation;
- liaise with proponent prior to interpretation;
- update the daily disposition board at their home base and at the relevant District if required;
- carry out field reconnaissance to become familiar with the area.

With thorough preparation, the Interpreter is building knowledge of the area with information that may assist interpretation decisions.

Use of the pre-job checklist (Appendix 4) will assist Interpreters in the collection of all information, both current and historical, relevant to the task of interpretation for their specific area. It allows for a systematic check and is useful not only in the field but also aids in writing the report.

Information collected should be placed in a file where all data or information for that area is stored (including interpretation data) while the area is being interpreted.

Information collation

Previous interpretation

Check surrounding past interpretation for any influencing infestations. These may be draining directly into the new interpretation area via a stream, gully or watercourse, or they may be close enough to influence the new interpretation area. Either way they may provide an insight to potential infestation in the new area.

Silvicultural and burning history

Obtain the records of previous silvicultural and burning activities. This type of information will give Interpreters a history of activities that have occurred in the area to be interpreted. It is useful in assisting Interpreters understanding why vegetation may have a particular appearance. Silvicultural records are held within Forest Management Branch (FMB). Burning history can be obtained at the District Office responsible for managing the area.

Boundary of interpretation

Identify on a map the area to be interpreted. The boundary of interpretation must be based on the landscape unit definition.

Base map
Use a copy of the flight line plan or obtain a suitable base plan showing watercourses, topography, coordinates, reference trees, roads and any other relevant data. This will become the Interpreters' field map.

Aerial photographs
Check the latest 1:25,000 photographs (or 1:50,000 if necessary). They are useful for getting an overview of the area to be interpreted, viewing the general topography, determining forest types, assisting with navigation, determining protectable and unprotectable areas and preparing maps.

Disease Risk Area (DRA) authorisation to enter
Obtain written authorisation to enter an area, if it is within DRA, from the relevant District Office. Ensure all conditions are observed.

Aerial Photographic Interpretation (API) map
Obtain a copy of the API map for the interpretation area from FMB map cabinet. API maps are useful for identifying broad forest types and distribution.

Landforms and vegetation maps
Obtain a copy of the landforms and vegetation types likely to be encountered in the interpretation area from maps in the Interpreters' hanging cabinet.

Rainfall zone
Determine the rainfall zone of the area to be interpreted from the Interpreters' isohyet map in the Interpreters' office. Rainfall affects the distribution of *Phytophthora cinnamomi* and is also indicative of vegetation types.

Research and inventory plots
Check whether any research areas and/or inventory plots fall within the area to be interpreted. (Look in FMB's record system.) They may not be available for operations or may have special requirements, i.e. no disturbance or no taping through them.

Rare flora sites
Check for any rare flora sites with the Regional Flora Officer and whether special measures should be taken by Interpreters to protect the rare flora.

Special interest sites
Check whether any tourist spots, etc., occur in the area to be interpreted. These sites may need to be excluded from operations or may help identify the origin of infestation.

Materials and equipment

The method of interpretation will determine the equipment required (see Section 4). In addition, each Interpreter requires water bottle/s, safety helmet, safety boots, lunch, appropriate clothing, for example wet weather gear, fire-proof clothing if you are likely to be called to assist at a wildfire, and orange safety vest (when working near operations), etc.

Liaison with proponent

Liaison with proponents prior to interpretation can aid the interpretation process by defining sensitivities, proposed management of protectable areas and the landscape boundary that will form the boundary of interpretation. This allows consideration of the most appropriate survey type and extent of demarcation required and how possible options for hygienic management may influence any activities planned.

Priorities within the area

Which areas are of most importance to the customer, especially if time is limited.

Interpretation boundaries

Defined placement and identification of boundaries in the field, gives a clear indication to the Interpreters and avoids inefficiencies. This is especially important if there are no identifiable features such as roads or creek lines to signify the boundaries. In this case the proponent is responsible for demarcating the boundary of interpretation in the field according to the definition of a landscape unit.

Access

Establishing access into an area could save time, particularly if the area to be interpreted is isolated or in difficult terrain. Many options are available, from longer walking to opening walk lanes using machine access (see Section 3.5). If the latter, this will need to be organised with the proponent.

Reconnaissance

When Interpreters arrive at the area, they should familiarise themselves by driving the entire boundary and internal tracks. They should note features such as:

- the status of the internal access and boundary tracks (for example likely disease presence, type and frequency of use, etc.);
- areas of recent activity, for example firewood cutting, wildflower picking, exploration drilling;
- vegetation and landform types;
- disease distribution and impact;
- boundaries of the area as previously confirmed with proponents.

Notes should be made on the Interpreters' field map as the boundaries are driven.

Samples should be taken from obvious *Phytophthora cinnamomi* infestations to confirm *Phytophthora cinnamomi* presence and give an indication that recoveries from samples can be achieved. If there are no obvious signs of infestation in the area, take samples from the nearest available infested area.

If 230mm aerial photography is used to interpret an area then refer to Section 4.2.7 on how to calculate photo scale.

Use of machinery in dense vegetation

At times when Interpreter access is restricted into an area, it may be necessary to use machinery to:

- Open access for vehicles along existing blocked tracks. This enables Interpreters to reduce the time and distance walking from vehicles to the work area, and allows them to work closer to their vehicles in the case of unforeseen circumstances, for example injury, illness or fire.
- Provide access through large areas of dense vegetation. This increases the efficiency of interpreting in dense bush where visibility and access is restricted or non-existent.

Approval to use machinery in an area must be sought from the Senior Interpreter who will

gain approval from the appropriate person (proponent and District Office).

Any use or supervision of machinery by Interpreters must ensure conformity with the requirements of the Safety and Health Code for Native Forest/Hardwood Logging and Plantation Logging (FIFWA, 2000). Of particular note are sections dealing with operating distances from machinery, contact and communications with machine operators. Communications between Interpreters and machine operators with hand-held radios or other walkie talkie systems is highly recommended.

The Interpreters together with the Senior Interpreter and/or Disease Standards Officer should decide whether machinery needs to be used, and if so, in what areas. Interpreters must supervise machinery at all times. Where machinery access is required for interpretation of an area that is proposed for harvesting, the draft concept base map and preliminary sections of the CLM 109, Pre-Harvesting Checklist, should be checked to ensure sensitive values are not compromised by the required access. The District in which the coupe occurs holds these documents. In all other cases sensitivities should be checked with proponents and/or the management agency responsible for the proposed area.

Preferably only machinery fitted with rubber tyres should be used for establishing access. Tracked machines pose a greater risk of moving soil and root material in track components.

Machines should be operated with the blade above ground level. Except for tracks that are being opened for vehicle access the machine would only be providing access for people on foot.

Machines should be used in 'no soil movement' conditions only, as the location of *Phytophthora cinnamomi* would not be known at the time of use. If conditions are such that there is a risk of breaking the soil surface with machinery then the use of machinery should be delayed until soil conditions are dryer.

Machinery must be clean on entry into the area and kept that way at all times. Inspections should be carried out regularly and especially when moving between the following categories:

- from infested to uninfested;
- from infested to uninterpretable;
- from uninterpretable to uninfested.

The Interpreter must be diligent when supervising machinery, to ensure the categories are recognized as they occur and that immediate contact is made with the machine operator by use of radios to instruct the operator in what is required.

When inspections find soil or root material on the machine then this material must be cleaned from the machine.

Machinery should be inspected prior to arriving and departing from an area and cleaned if necessary at an appropriate cleandown point.

The position of tracks produced in this way should be recorded using a global positioning system (GPS) or surveyed with hip chain and compass and shown on the Interpreters' working map.

Interpreters working alone

Interpreters shall work in teams of at least two as much as possible. This provides for:

- safety, where Interpreters are often a long way from their vehicle and other operations;
- more effective observation of indicator plants;
- increased consideration for decision making in difficult areas;
- motivation – sharing the tasks and workload;
- belonging – part of a team.

It would be preferable to schedule work to avoid Interpreters working alone. This could be achieved by moving the single Interpreter into an existing team to hasten production in that area. The annual leave planning calendar should highlight times when Interpreter teams may be down to one Interpreter.

Occasionally, for efficiency or due to leave or other circumstances an Interpreter may need to work alone. In these circumstances the Senior Interpreter should endeavour to work with the Interpreter as much as necessary.

When working alone, daily contact must be maintained with the Senior Interpreter or the local District Office. It is preferred that this contact occur at the end of the working day to ensure the Interpreter has made it home from the field. The details of the contact procedures shall be made clear between the Interpreter, the Senior Interpreter and the Section Manager at the commencement of the period of working alone. Local search and rescue watch procedures will apply.

4 GROUND INTERPRETATION

Ground interpretation uses an array of contiguous transects (strip lines) to interpret the presence of disease caused by *Phytophthora cinnamomi*. It is used in areas which are not suitable for interpretation using 230mm aerial photography or when such photography is not available. It is a systematic way of covering an area and when used in conjunction with record sheets, field maps and GPS, it aids recording of the information needed for *Phytophthora cinnamomi* mapping.

Equipment

- Hip chain and cotton;
- compass;
- base map;
- scale rule;
- protractor;
- parallel ruler;
- booking forms and/or notebook;
- clipboard;
- pens;
- 1:25,000 or 1:50,000 aerial photographs;
- flagging tape;
- hand held radios;
- global positioning system (GPS) method.

Method

1. Prepare for interpretation using the steps described in Section 3.

2. Demarcate all areas of obvious disease caused by *Phytophthora cinnamomi* within the area. These areas may be excluded from surveying thus reducing overall interpretation time and effort.

3. On the base map select a base line from which to establish transects. A base line is normally selected along fairly straight roads or tracks that are part of the boundary of the area to be surveyed.

4. Plot and number parallel lines on the base map at an interval of not more than 50m within the area to be interpreted. Lines should be at right angles to the base line where possible.

   Notes:

Depending on the density of the vegetation and the abundance of indicator plants, a closer spacing may be required. As a guide, when walking along transects you should be able to see ISDs at least half way between yourself and the adjacent transect. If you can't see halfway, then the lines are too far apart and you will need to move lines closer together. Field reconnaissance and discussion with the Senior Interpreter and/or Disease Standards Officer will help to determine the appropriate spacing.

If transects are not at 90 degrees to the base line, the distance between the line start points along the base line will be greater than 50m. This will require accurate scaling from the basemap or interrogation in the GIS to establish correct spacings along the baseline in the field. Lines at the appropriate distance apart and with the direction (bearing) specified can be generated in GIS.

5. Working from a known start point, such as a reference tree or a track intersection, use a hip chain to mark the transect start points along the base line. Using flagging tape tied off at ground level or onto a stick, so it won't blow away, number each line with a clearly definable permanent marker. Try to avoid using tape colours that match uninterpretable or infested demarcation tape.

6. Using a protractor and the base map or GIS, determine the compass direction of the line.

Notes:

Remember to account for the difference between grid north and magnetic north when using the compass in the field, and back in the office when plotting boundaries.

True north, grid north and magnetic north are shown diagrammatically on the legend of 1:50,000 Topographical maps. As of 1996 magnetic north moves west annually. A grid bearing is obtained by subtracting the grid angle from the magnetic bearing.

7. Using a compass and hip chain or GPS in the 'go to' function, walk along the transect and record onto a booking sheet (Appendix 3) or directly on to the Interpreters' Field Map the following information:

- line number;
- bearing (magnetic or true);
- start/end point;
- disease status (distance and category);
- current impact (optional);
- landform or vegetation type (optional);
- direction of slope and drainage;
- other comments, for example identifiable features (tracks, creeks, rocky outcrops, etc.) *Armillaria* infestations, sample locations.

Notes:

Remember to zero the hip chain at the start of each line.

Ensure that sufficient detail is recorded to enable accurate plotting from the booking sheets to a map at the completion of the area.

Walk at a pace equivalent to the slowest person. Avoid getting too far in front or behind people on adjacent lines. Ensure the pace is such that anything that should be observed, can be observed.

Try to maintain visual and verbal contact with other Interpreters on adjacent lines. Use of hand-held radios is recommended for communication between Interpreters for ground interpretation.

Try to maintain sight of the hip chain cotton on the previously completed adjacent line (may be difficult in some vegetation types). Make adjustments to lines as necessary to ensure all areas are systematically covered. Any areas missed should be walked.

Discuss each line as it is completed with the person/s on adjacent lines to ensure consistency.

8. Prepare the map of the taped disease boundaries. If booking sheets have been used, use a scale rule and protractor to plot boundaries from the sheets onto the base map. Boundaries can then be digitised. GPS track files may be downloaded direct into GIS for most accurate and efficient plotting.

9. Complete the ‘Map Compilation Instructions’ form (Appendix 8) and forward it to the GIS Operator.

10. Check the final map for accurate representation of your survey.

Modified surveys

Linear survey

Where a proposed activity is linear in nature and proponents cannot reasonably be expected to fund the interpretation and mapping of all landscape units, a linear survey will be required.

Identification of protectable areas is the aim with both the easement and the adjacent vegetation needing to be considered. Having identified the protectable areas the appropriate hygiene can be applied. Alternatively, the proponent may elect to treat all adjacent uninfested areas as protectable for greater interpretation efficiency.

Identification of protectable adjacent vegetation will require interpretation of at least 150m from the edge of the easement. In most cases walking will be the most suitable method for achieving this. Other methods require approval of the Senior Interpreter on a case-by-case basis.

Pre-job checklists must be completed for all linear interpretation surveys.

A report should be written which presents results of the survey together with recommendations for protectable or unprotectable classifications and if requested, associated hygiene measures. It is important that both the status of easements and the adjacent vegetation and the recommended hygiene be very clearly presented in the report. Further discussion of management of linear operations is presented in '*Phytophthora cinnamomi* and disease caused by it, Volume 1: Management Guidelines' (CALM 2000).

A full handover is required of information for all interpretation involving linear surveys (see Section 13).

Easements with uncontrolled frequent access and uncontrolled drainage
Significant risk of the pathogen being present on the easement can be assumed where:

- uncontrolled frequent use has been occurring for considerable time;
- water flows onto the easement from infested or unprotectable areas;
- regular unhygienic earthworks associated with road maintenance occur.

Interpretation of the adjacent vegetation may therefore not be necessary in many situations. The judgement of the Interpreter in these situations is important. Discussion about judgements should be held between Interpreters and Senior Interpreters or the Disease Standards Officer to ensure consistency between analysis and judgments.

Where an Interpreter identifies a significant risk to an adjacent area from easement drainage or uncontrolled use, and that risk can not, or will not be mitigated, then the decision should be to class both the easement and the adjacent vegetation as unprotectable.

In adjacent areas where sufficient indicators are present, disease will usually be expressed already. In uninterpretable areas infestation may be assumed to occur.

Where sufficient indicators are present in adjacent vegetation and the area is of a suitable size and judged to be uninfested then that adjacent vegetation may be judged to be protectable by the Interpreter. The easement itself will remain as unprotectable. In giving the benefit of the doubt to the adjacent protectable vegetation, recommendations will be needed to alter drainage away from the area and to ensure that material used on the easement is uninfested.

Well drained easements with limited or controlled access
Where easements are well drained, adjacent to uninfested protectable on both sides and have had only infrequent light use, the Interpreter may judge that the easement itself may be incorporated into the protectable area as well. Again discussion about judgements should be held between Interpreters and Senior Interpreters or the Disease Standards Officer.

Interpretation of gravel pits, pasture, etc.

Management Plans and *Phytophthora cinnamomi* Hygiene Management Plans may recommend the use of uninfested basic raw materials (BRM) such as sand, shale, gravel and soil, for construction of various facilities such as roads and recreation sites etc. On Department of Conservation and Land Management lands, accredited Interpreters are necessary to assess and certify BRM areas. *Phytophthora* free BRM areas are a valuable resource and Interpreters should recommend to managers that integrity of the sites be maintained by putting in place long-term access control and hygiene measures. This ensures all vehicles, machinery and equipment enter these areas clean (i.e. are *Phytophthora cinnamomi* free) and that infested plant material is not introduced.

Gravel (borrow) pits

Interpretation for the presence or absence of *Phytophthora cinnamomi* in a new pit is carried out where the pit is to be placed in a previously undisturbed area where sufficient indicator plants are available for a determination to be made.

Interpretation of an existing pit is usually done in conjunction with sufficient evidence from previous interpretation and from records confirming that an effective system of hygiene has been in place to ensure that the pit has remained uninfested. Records should be found attached to the *Phytophthora cinnamomi* Hygiene Management Plan for the area in which the pit occurs.

Existing pits without a known history should be assessed according to guidelines in Volume 1 Management Guidelines. Owners of private pits or other developers may wish to have CALM Interpreters review and certify pits using this methodology. In all other cases, cleared areas of the pit or material stockpiles will be treated as uninterpretable.

Pasture

Pasture shall always be classed as uninterpretable and unprotectable. The risk that *Phytophthora cinnamomi* surviving on site by hosting on clovers or other plants is too great to assume that the pathogen is not present.

Probability survey

A procedure has been developed for mapping the presence of disease caused by *Phytophthora cinnamomi* in native vegetation east of the 900mm isohyet in Central and Swan Forest regions of the Department of Conservation and Land Management. Other areas further south and north have not been tested using this method but in areas north and east of Manjimup the method may be used with the approval of the Senior Interpreter for that area or the Disease Standards Officer. The method was developed following collection of data from all comprehensively mapped areas since intensive mapping began in 1976 for areas east of the 900mm isohyet from Qualen Forest Block in the north to Hester Forest Block in the south just north of the Blackwood River (Blankendaal, 1998 unpublished). Data collected showed that no disease was present in upland situations remote from tracks or other high-risk vectors. Based on this evidence, the ‘Probability Survey’ as it is known, focuses on mapping disease where it is most likely to occur such as low lying areas, creeks, roads, tracks and other high risk vectors. It is accepted that upland areas remote from tracks or other vectors have a very low risk of an infestation being present.

Some areas may be influenced by higher annual rainfall than is officially recorded (for example the Monadonocks north-east of Jarrahdale) or may be influenced by surface water flow from rocks, etc. These influences need to be recognised and surveys modified accordingly (for example use 230mm photography or comprehensive ground surveys for interpretation).

Office

1. Prepare for interpretation in the same way as for all other interpretation work (Section 3).

2. Identify the type of area to be interpreted (broad, or linear).

3. Identify the rainfall isohyet zone (according to base data from map reference design files).

4. The area must only be selected for probability survey if it lies east of the 900mm isohyet with appropriate vegetation and landform types. Always discuss the choice of survey with the Senior Interpreter and/or Disease Standards Officer. If an area is not clearly east of the 900mm isohyet, then it should be given a fully comprehensive survey. Some vegetation types make this procedure less advisable.

Field

1. Walk and check all tracks internal and external to the interpretation area.

2. Check artificial water gathering sites within the interpreted area (for example drains, gutters, sumps, leaking standpipes and pipes).

3. Walk and check all gullies within the interpreted area.

4. Check for unmapped gullies or depression (using map contours and stereoscopically view suitable photography to ensure no drainage lines or seeps are missed).

5. Develop a sample strategy to best suit the area (for example occasional samples in gullies to confirm field diagnosis of *Phytophthora* infestation, with scattered ridge-top remote and trackside samples). In general, artificially wet, and sites that remain wet through summer, should always be sampled if the site does not show obvious symptoms.

Mapping

All *Phytophthora cinnamomi* and uninterpretable boundaries will be recorded using hip chain and compass, or GPS unit. These boundaries will then be transferred to a base plan or downloaded to GIS using methods similar to that used for routine survey.

Report

A full report format will be used. The report will mention that the area has been mapped using the probability method described in this manual.

Rechecking

Demarcated field boundaries must be checked before operations proceed if the *Phytophthora cinnamomi* Occurrence Map or *Phytophthora cinnamomi* Protectable Areas Map is older than the recheck date shown in the map legend. The maximum time before a recheck is required is 12 months from the field completion date (see Section 9.6). The recheck date is determined by a qualified Interpreter in conjunction with the Senior Interpreter after considering the rate of spread, slope, and other environmental conditions which may affect the movement of *Phytophthora cinnamomi* boundaries.

Preparation for rechecking an area:

- obtain a copy of the previous interpretation maps;
- read the accompanying report;
- complete the pre-job checklist;
- discuss the interpretation area with the previous Interpreters and proponent/s (if available);
- begin field recheck (as per steps below), sample suspicious sites or recent deaths not already contained within *Phytophthora cinnamomi* tapelines;
- prepare new maps and write up a one-page report.

Rechecking:

- Check all disease boundaries adjacent to uninfested areas that are determined to be protectable area boundaries and if necessary, adjust the demarcation line.
- Check disease boundaries adjacent to uninterpretable areas where the boundaries are determined to be protectable area boundaries and if necessary, adjust the demarcation line.

- Check immediately adjacent to and along all open roads, tracks (both internal and external that may influence the area of interpretation), gravel pits, private property boundaries and in and around any areas of recent disturbance.
- Even if the interpreted area is completely uninterpretable or uninfested, a field check is still required to ensure that there is no new evidence of infestations (see note below).
- Ensure consistency of standards when checking areas that have been interpreted by other Interpreters. For example, Interpreters may vary slightly in the determination of uninterpretable boundaries. Generally the Interpreter should accept the classification of the original interpretation unless they feel strongly that the original classification was wrong in which case they should discuss the issue with the Senior Interpreter and/or Disease Standards Officer.
- Remove old tapes and replace with new ones where boundaries have changed and alter the maps to show the changes.
- Indicate on the map where old blaze lines need to be painted out.
- Check if possible, when disease expression is most obvious, this usually occurs in spring or autumn and occasionally in summer after a heavy rainfall event.

Notes

Uninterpretable areas vary along a continuum from areas with no indicator species (no chance of seeing any *Phytophthora cinnamomi* movement), through to thick scrub with some scattered indicator species (some chance of seeing *Phytophthora cinnamomi* movement). Interpreters will be permitted to use their judgement in consultation with the Senior Interpreter and/or Disease Standards Officer as to which boundaries will require checking.

Before the final decision is made whether or not to check, Interpreters will need to consider the boundaries in the field. For example, a check may not be required where a disease boundary is alongside permanently uninterpretable karri forest. Similarly, a check may not be required where a boundary has been placed above an infested creek that has not been demarcated as the infested area is confined to a very narrow strip along the creek itself. In both cases the decision of the Senior Interpreter and/or Disease Standards Officer must be sought.

After three years from the original completion date the map is deemed expired and should not be used. The area must be completely re-interpreted.

5 SAMPLING

Sampling dead and dying plants is an integral part of the interpretation process. It is used initially to ensure *Phytophthora* spp. can be recovered through laboratory processes from certain plant species and to establish the reliability of indicator plants used to predict the presence of *Phytophthora* in a particular area. When beginning interpretation of an area, samples should be taken from a number of known *Phytophthora cinnamomi* infestations within the area to establish a reliable recovery standard and confirm interpreted infestations. Samples should continue to be taken during interpretation to verify further interpretation decisions. In many cases sampling isolated dead plants is the only way of determining whether a *Phytophthora* sp. is present and interpretation decisions are correct.

Strategy

Often, the type of bush being interpreted and its history will determine the sampling intensity best suited to that area. An area of vegetation with multiple indicator species and little evidence of human activity will not require the same intensity of samples as an area with scattered indicators and a lot of machine activity.

There is no rule for sampling intensity although the aim is to have a number of representative samples for each type of situation encountered including those areas that may not be infested but which display symptoms similar to disease caused by *Phytophthora cinnamomi*.

Each ‘spot’ infestation should have a positive recovery from it wherever possible. Re-sampling in the case of negative results from initial samples is encouraged.

Initially, inexperienced Interpreters will need to take a greater number of samples until such time as they become confident in their decision making. Rule of thumb: ‘when in doubt, always sample’.

It is important to sample areas that are infested with *Armillaria luteobubalina* to determine whether *Phytophthora* is also present.

At the completion of an area, Interpreters should have taken samples that cover all ISD classes, a range of topographical situations and a range of susceptible plant species.

Sampling equipment

This should include:

- back pack/over the shoulder bag;
- sterilant – alcohol or methylated spirits;
- spray bottle;

- aluminium tags;
- nylon/copper tie strips
- plastic bags (150 micron);
- stick on labels;
- permanent water proof marker;
- sample information sheets;
- GPS (or compass and hip chain);
- distilled water;
- flagging tape;
- sample axe/mattock and trowel;
- ball point pen;
- gloves (optional);
- broad bandage (first aid – optional).

Sampling procedures

Selection of samples

On reaching a site and having thoroughly investigated the area, select an indicator plant that has died recently (one where the leaves have turned a lime green/yellowish colour is ideal). With older deaths there is less likelihood of a positive recovery from the sample. It is suggested that a radius of up to 100m (more if necessary) should be investigated around the sample site to help determine the cause of the ISD.

Method of sampling

1. Check the sample axe, hands, shovel and all other tools for unwanted soil and remove (this should have been done at site of previous sample).

2. Sterilise the sampling tools with methylated spirits between samples. Allow it to dry before sampling.

3. Always start by checking the site for hazards, for example:
   - overhanging limbs that may get caught on the sampling axe;
   - banksia nuts or loose limbs that may fall when a sample is being taken;
   - ants' nests, sharp objects, snakes, etc.

4. Remove leaves, twigs and other debris from around base of plant. Make the area safe to work in, i.e. position away from ants' nest, etc.

5. Dig down far enough to expose the stem base and roots of the plant. Minimum depth of 30cm.

6. Chop sections of roots and stem base (including bark and wood) from all sides of the plant and place in a plastic bag. These sections must be cut into small pieces so that

they can easily fit into a 'take-away food' style container which is used later in processing the samples.

Be aware that different plant species need to be sampled in slightly different ways, for example:

Patersonia spp. – collect all below-ground sections of the plant, including small brittle roots.
Macrozamia riedlei – collect sections of fibrous root tissue from the bole and roots.

Banksia spp. – collect sections of the collar region, including lateral roots. (Diagram 2)

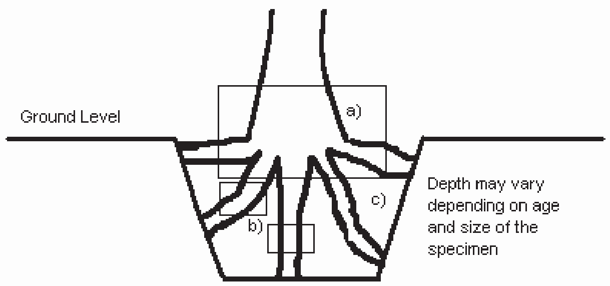


Diagram 2: Sampling a Banksia sp. - Take plant material from the root collar(a), and lateral roots(b) and soil material from around exposed root systems.

Xanthorrhoea spp. – collect pith (plant core) and small radiating brittle roots (Image 9).

Image 9: Parts of *Xanthorrhoea* sp. Roots ideal for sampling

Persoonia longifolia – collect sections of root, bark and cambium, similar to *Banksia* spp.
Podocarpus drouyniana – collect sections of large underground stem, lower stem sections (Image 10).

Image 10: Parts of *Podocarpus drouyniana* roots ideal for sampling

Note:
If a lesion and/or margin is visible in the plant (grey/black discoloured tissue invading healthy tissue), include some of this in the sample.

7. Also collect several handfuls of soil with the trowel from various depths around the roots of the plant and place these in the bag with the plant tissue. If the soil is dry, moisten with distilled water.

8. Record sample location point onto booking sheet, film or by using a GPS. If using film, locate sample point on the photograph and include sample number and date. Sample locations should be placed on the Interpreter's field map.

9. Fill in the *Phytophthora cinnamomi* 'Field Sample Information' form (Appendix 5).

10. Fill in two aluminium tags with the following information:
- area name (block/s and compartment/s);
- date;
- sample number;
- Interpreter's initials;
- Region.

11. Place one aluminium tag inside the bag and tie off with a cable tie.

12. Write the information contained on the aluminium tag on the outside of the plastic bag.

13. Tie the other aluminium tag together with some flagging tape as close to the sample point as possible but visible from a distance.

14. Sterilise the sample tools.

15. Store the sample bag in a cool place, away from direct sunlight. In warmer weather it is suggested to store the samples in an esky until dispatch.

Note:
The sampling process should be conducted efficiently with one Interpreter taking the sample while the other fills in the sample information sheet and sample tags.

Field Sample Sheet and recording in GIS

The information recorded on the *Phytophthora cinnamomi* Field Sample Information Sheet (Appendix 5) must provide the reader with a clear and concise insight of the site characteristics where the sample was taken. The short sections of the sample sheet are designed to prompt Interpreters into looking at the site and identifying those site characteristics. The information must contain reasonable detail and should reflect the final decision of each of the Interpreters.

A sample sheet must be filled in for every sample taken. Map references are required for every sample so that they can become part of the Vegetation Health Service (VHS) database of sampling records.

Samples should be numbered in the order taken. The numbering should include the sample number as well as the job or area being interpreted, for example 'Palmer No. 6'.

The *Phytophthora cinnamomi* Field Sample Sheet is used to provide information for sample processing and the sample summary contained in the report. It is also used to record sample locations for GIS.

Vegetation Health Service

The Vegetation Health Service (VHS) carries out the *Phytophthora* detection process of samples sent to them at its laboratory in Kensington. The VHS returns detection results to Interpreters to verify decisions made in the field. The VHS keeps records in a database of all samples processed by them. The database keeps track of the distribution of *Phytophthora* species and their host plants throughout Western Australia. This database can be used for various interrogations and reports (Appendix 11).

Sample dispatch to the Vegetation Health Service

Store the sample bag in a cool place, away from direct sunlight. Transport to the VHS as soon as possible, although no more than two days is recommended between sampling and processing. Ensure sample bags will not break or leak during transport.

Before dispatch to the VHS it is necessary to complete the Field Sample Sheet (Appendix 5). All information must be filled out. This sheet must accompany the samples to VHS. A copy should be kept by the Interpreters.

Laboratory processes

Detection of Phytophthora species

Soil and plant samples are processed by either the baiting or direct plating methods to detect the presence of *Phytophthora*. A sample is termed positive when *Phytophthora* is detected, a complete identification is then carried out to determine the *Phytophthora* species and the findings are reported to the sender. All information relating to samples is recorded in the VHS database. It usually takes between two and four weeks to fully identify the fungus. The process is as follows:

1. On arrival at the VHS, each sample is assigned an individual barcode on the sample sheet to ensure identification of the samples. There are four labels for every sample.
2. Soil is shaken in the bag and then placed into two 'take-away food' containers that have the same barcode as the sample sheet. The aluminium tag goes into one of these containers.
3. Containers are then taken to the controlled temperature room at 25°C. Distilled water is poured into the containers and they are stirred with a sterile popsicle stick (Image 11).
4. Cotyledons of *Eucalyptus sieberi* (east coast Eucalypt species) are floated on the water as bait for *Phytophthora* zoospores. This is known as baiting. The cotyledons of these seedlings are purple underneath.
5. The cotyledons are left for 10 days. If the cotyledons lose the purple colour by the fifth day it is presumed to be infected. They are placed onto antibiotic agar in a

petri dish. This is known as plating, which will determine whether the sample is infected with *Phytophthora cinnamomi* or some other *Phytophthora* spp. *Phytophthora cinnamomi* can be identified quickly whilst other *Phytophthora* may take considerably longer. *P. citricola* will generally take three to four weeks while *P. drechsleri* and *P. cryptogea* may take three to four months.

6. On the tenth day all the rest of the cotyledons are plated even if they show no sign of infection.

Image 11: Sampling containers flooded with distilled water prior to cotyledons being floated

7. Plated baits are left for a maximum of three days and if *Phytophthora* is not evident, by fungal growth in agar, it is discarded, and the sample will be recorded as negative (NEG).
8. *Phytophthora cinnamomi* is identified directly on the plate by the presence of hyphal swellings. This result is recorded and the plate is autoclaved (sterilised by heat) and then discarded.
9. Other *Phytophthora* species do not have hyphal swellings and must be identified by other structures. These include size measurements and shapes of oogonia and sporangia. Oogonia of species that take the least time to identify (for example *Phytophthora citricola*) are produced by growing them on a high nutrient agar known as 'V8 juice' agar. These species are known as homothallic and can produce oogonia without the presence of another mating type.
10. Oogonia of species that take longer to identify (e.g. *Phytophthora cryptogea*) are produced by pairing the unknown mating type with a known mating type, also on V8 juice agar. This is known as mating. Species, which require mating before oogonia production, are known as heterothallic. Flooding a piece of V8 juice agar containing *Phytophthora* mycelium with soil extract produces sporangia.

Currently there are 16 species of *Phytophthora* recorded within Western Australia, seven of which are known to occur in native forests. Listed below are the ones that have been isolated at the Vegetation Health Service:

- *P. cinnamomi*
- *P. citricola*
- *P. cryptogea*
- *P. drechsleri*
- *P. megasperma*
- *P. nicotianae*
- *P. boehmeriae*

Sampling to prove susceptibility of a plant species
During the course of interpreting an area, you may wish to sample dead or dying plants, which are not normally used as indicator species. This is to confirm the species' susceptibility to *Phytophthora* and its reliability as a potential indicator species.

Interpreters should keep clear and accurate records of all sampling done to test reliability or susceptibility of plants as *Phytophthora* indicators. Interpreters should ensure that the plant tissues sampled are from the infected plant and not taken from a neighbouring plant of a different species.

Sending the sample to VHS

- Send the soil and plant sample as usual to the VHS with an accompanying Field Sample Sheet. Ensure columns, with notes (1) and (2), are filled in. A Herbarium voucher specimen should be sent to the Herbarium for the correct identification of the plant species.
- A letter should accompany the sample stating that the plant requires testing for susceptibility as an indicator of *Phytophthora* and that the plant material is to be surface-sterilised and plated onto antibiotic agar. Positive recovery of *Phytophthora* from this indicates an infection of that plant by *Phytophthora*. The letter should also include the name of the plant specimen being tested, if you can not identify the plant then proceed onto the next section.

Collecting a Herbarium voucher specimen *(HVS) and sending it to the Herbarium for identification*

- Find a representative plant specimen.
- Cut off a branch containing buds, flowers, fruits, leaves, etc.
- Label the specimen (record precise locality, collector's name, and date) and note the type of forest or vegetation and soil.
- Place the specimen in a paper bag (not plastic) for transport back to office. Do not leave specimen in the car in the sun. (Note that this specimen is not used for *Phytophthora* isolation. Plant material for *Phytophthora* isolation is to be taken from the stem base and roots of an infected plant of the same species.)
- At the office, place specimen in newspaper fold.
- Ensure labels on plant parts are intact.
- Place newspaper fold between two stiff pieces of cardboard.
- Secure cardboard together with ties or tape. Place in envelope marked 'DO NOT BEND' and address to the Herbarium.

- Contact the Herbarium to let them know you are sending a plant specimen for identification, you will need to arrange with your cost centre for payment of this service to the Herbarium.
- When you receive the final identification of your plant specimen, provide the VHS with the correct name so that it can be entered into the database.

6 DEMARCATION

Interpreters will demarcate infected and uninterpretable areas and will sometimes be required to demarcate protectable and unprotectable areas where a boundary is required. Occasionally it will be necessary for Interpreters to tape a 'navigation' line into infestations that can not be easily located directly from a road or other feature.

Table 7.1: Demarcation standards

Boundary	Tape	Knots	Comments
Infested against, protectable uninfested	Day-Glo orange	Facing infested	
Uninterpretable against, protectable uninfested	Swan and Central Regions – **white** Southern Region – **pink and black striped**	Facing uninterpretable	
Infested against, uninterpretable	Day-Glo Orange	Facing Infested	Not very accurate due to uninterpretable. May not be required – check with proponent.
Optional demarcation – check with proponent			
Protectable against, unprotectable	An agreed colour used for splitting up work area units, e.g. fallers blocks	Facing unprotectable	Liaise with proponent. Use where boundary is not an infested boundary.
Infested against, unprotectable	Day-Glo orange	Facing infested	Liase with the proponent for demarcation needs.
Armillaria	As agreed	Facing infested	Not usually taped unless it has significant impact or proponent requests it. Notate on map. Liase with proponent

			for colour of tape required.
Other *Phytophthora* spp.	Day-Glo orange	Facing infested	Not usually taped unless it has significant impact or proponent requests it. Notate on map.
Navigation line	Swan and Central Regions – green Southern Region – Day-Glo yellow	Facing the direction to the target area from the start point	

There is no rule governing how small 'non Pc' areas should be to warrant demarcation and mapping. However, a good 'rule of thumb' under routine situations (not high value sites) is to target areas of approximately one hectare. If you use this as a guide it will ensure that you sufficiently cover the ground, further reducing the possibility of areas being missed. You can then make judgements on whether an area requires protection based on the guidelines in 'Determining Protectable Areas' (Section 11).

Image 12: Taped Day-Glo orange demarcation of infestation. Disease symptoms can be seen in the right of the photo.

A double tape is used to indicate the beginning and end of a demarcation line. When taping categories, place the tape on non-merchantable trees where possible. Ensure the taped demarcation lines are readily visible and easily followed by placing sufficient tapes along the line at a reasonable height (Image 12). Always assume that people who are going to blaze your taped lines may know nothing about *Phytophthora cinnamomi*.

Image 13: Blazed and painted disease demarcation

Permanent blazing and painting of the taped line is the responsibility of the District or proponent. Trees should be blazed on three sides: two of the blazes face along the boundary, while the third blaze faces the category (same side as knot)(Image 13). Colours used to paint permanent blazing are yellow for infested and purple or white for uninterpretable.

In some cases within an area, demarcation will not be required, for example places where the operations will not go such as swamps or diverse ecotype zones. While the Interpreter should still endeavour to plot disease distribution onto a map for these areas, it may not be necessary to demarcate into these areas. A double tape at the point at which taping ceases will be required. In all cases liase with the proponent and Senior Interpreter and/or Disease Standards Officer to discuss how much demarcation will be required. In cases where tapelines are terminated away from tracks or defined creeks a demarcation map should be produced to show taped boundaries.

Buffers

The system of mapping disease occurrence is based on visible symptoms that take a period of time, after becoming infested, to manifest. As the most recent indicator plant deaths occur at or near the edge of the disease infestation, it is logical to conclude that *Phytophthora cinnamomi* may be in the soil or root systems of both susceptible and resistant host plants outside the visibly affected area. This implies some risk of transporting infested soil and root material from within a zone outside of, but in close proximity to, the visible edge of the infestation. It is necessary therefore to have a zone that buffers operations in uninfested areas from infested areas. The width of buffer zones should consider likely spread of disease up-slope, down-slope and laterally, based on environmental conditions such as drainage, topography and disease expression. The following is a guide only for buffer widths used during interpretation.

Minimum up-slope buffers in susceptible vegetation will be 15m. In instances where the gradient is not steep or disease expression is subtle this may be increased based on Interpreter judgement.

The spread of *Phytophthora cinnamomi* down-slope from infestations is more difficult to predict because of the variability of factors influencing spread. However, a minimum buffer width of 25m should be applied and increased if necessary based on Interpreter judgement.

The Interpreter's judgement should be used to increase buffer width particularly where disease expression is subtle and a disease edge is difficult to determine.

In some situations down-slope buffers may be as wide as 100m or more. Direction from the Senior Interpreter or the Disease Standards Officer should be sought in these cases to relate such judgements to the protectability of areas.

Uninterpretable areas require a 10m buffer placed into the uninfested interpretable side. No buffer on uninterpretable adjacent to infested areas is required because the infested area should be buffered as standard procedure.

It is recognised that uninterpretable boundaries are not always distinct and so the aim is for the Interpreter to be sure that what is being classed as uninfested really is uninfested, and not a guess.

Grouping infestations/boundary rationalisation

Some judgement will need to be applied by Interpreters in deciding whether the distances between taped demarcation lines (in close proximity to each other) and the size and shape of uninfested areas are significant. The following guideline will assist with these decisions but will probably not address every situation. Interpreters must ensure they fully understand how to determine protectable areas as this may have a large impact on demarcation (Section 11).

In cases where two or more infestations occur close together the Interpreter must decide whether they are close enough to be grouped:

- If the distance between tapes is less than 40m, the two areas may be grouped and the whole area called infested (Diagram 3a).

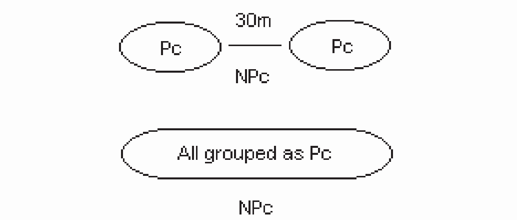


Diagram 3a: Grouping infestations less than 40m apart.

- Where tapes are greater than 40m apart, and the area between them is greater than one hectare, the infestations may be mapped separately (Diagram 3b).

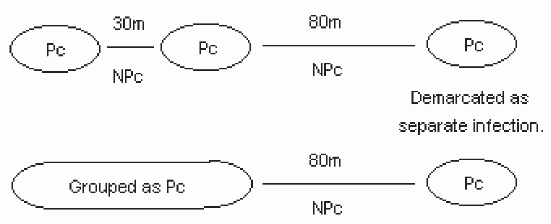


Diagram 3b: Demarcating infestations more than 40m apart

Decisions on how to operate within these areas will be made by the proponents of the interpretation with input from Interpreters at the hygiene planning meeting. These decisions will relate to protectable areas as identified.

Old blaze lines

Old painted blaze lines that indicate previous disease boundaries that are now superseded and may lead to confusion must be removed by covering over with brown paint. This will be the responsibility of the proponent of the mapping but the location of such lines will need to be communicated to the proponent by the Interpreters.

Demarcation of linear surveys

Tapelines for linear surveys are placed so that they originate on either side of the alignment, and follow the edge of the category into the bush for 10-20m. The beginning and end of the taped line should be double taped to ensure the line is clearly visible.

7 USE OF GLOBAL POSITIONING SYSTEMS

A Global Positioning System, or GPS, is an invaluable tool when interpreting an area. Its uses vary from navigational purposes, either finding your way around or mapping a boundary, to recording positions in the bush, which may be sites of interest or sample points.

In simple terms, a GPS accesses signals from a constellation of satellites to pinpoint its position or navigate from that position. To receive data from the satellites, you need a special receiver, or a GPS unit, which can interrogate the satellite information to calculate your position. The receiver will operate in 2D or 3D mode. In 2D mode only latitude and longitude will be provided using a minimum of three satellite signals. In 3D mode you receive an additional altitude reading, with the use of at least four satellites.

An unobstructed, clear view of the sky is ideal for best performance, however obstructed views may still get a reading after a longer period of time. Once a position has been fixed, the receiver will constantly shift between satellites to continuously give the best reading. As the satellites can only be read from above the horizon, the receiver must know which part of the world it is in to know which satellites to look for. This process is called initialisation and is required only when the unit is first used, or when the memory has been cleared.

Depending on the type of receiver you possess, the atmospheric conditions, the geometry of the satellites, the signal interference and strength all affect the accuracy of this calculated position. As well as receiver errors, the satellite system is governed by the United States Defence Department and they can disrupt the satellite signal through a process known as Selective Availability (SA). Designed to affect the accuracy of GPS units, this process can create errors in your position of 100m or more, when it is in operation. Unfortunately, most people cannot determine when SA is affecting their readings unless they check their receiver unit against a point of known coordinates. This is most useful if it can be checked up to three times per day. If it is determined that SA is 'on' at one or more of these times, then it is a good idea not to use your unit for that period. (In 1999 the US made the satellite signals generally available without corruption.)

Interpreters generally use non differential GPS, however, in some instances 'post processing' of corrections can be used to give more accurate positioning – 'differential' GPS post processing. 'Real time' differential GPS is also available in some situations. With GPS units, coordinates can be locked into the memory by recording a waypoint. This is useful when sample points or anomalies are found in the bush and these points need to be marked for future reference. At other times, boundaries can be recorded as a series of waypoints, which can then be transferred onto a map either by hand or downloaded through computer programs to produce a hard copy of category boundaries.

Non differential data will need to be checked and edited to ensure relative positioning with map features when downloaded (or in the field during capture). One other useful feature of the GPS unit is the track file, which shows the course taken as an Interpreter walks through the bush. This is useful to use as wayward points and directions can be deleted immediately, rather than incorporated, as errors, into map products in the office. The number of erroneous points in the track file decreases with pace and constant movement. It is therefore a useful tool for recording boundaries and tracks driven slowly by vehicle.

Field use of the non-differential GPS

It is important to read the manual for the particular GPS unit you are using before commencing its use as an interpretative aid. Remember it is an aid only. Any transect survey navigation carried out in the bush should never be attempted solely with a GPS. Compasses should be used to check accuracy and understanding of GPS use.

Accuracy and error

Accuracy for the Garmin GPS (currently in use) ranges from ± 30m to ± 100m with SA. These errors can be anticipated by monitoring the Estimated Position Error (EPE) and the Figure of Merit (FOM). The EPE shows the current horizontal accuracy and should be less than 30m for greatest accuracy. The FOM, found when averaging a marked position, is the value reflecting the estimated accuracy of the averaged position. To gain the greatest accuracy this value should read less than 15m, with 10-12 or less being ideal.

The largest source of position error is SA. To minimise its impact on readings, it is recommended that the GPS be checked at a known reference point at the beginning and end of the day, and if possible at times in between. Known reference points may be actual surveyed reference points or major road intersections, which have been mapped to an accuracy of +/-1m.

Atmospheric and environmental conditions also have an impact on reliability of readings. The temperature, humidity, density of electrons and cloud cover can all affect the readings. Heavy cloud cover can often produce very poor readings.

Sometimes in areas of dense canopy cover, the accuracy of GPS readings may be reduced as satellite signals deflect off trees producing larger errors or no readings at all. Accuracy can be improved with the use of stronger antennae mounted on a backpack.

Examples of GPS use in interpreting

- Recording sample site locations as an individual waypoints.
- Mapping *Phytophthora cinnamomi* and uninterpretable taped boundaries as a series of waypoints or as a track file.
- Finding your location within an area at any point in time.
- Using the ‘go to’ function to navigate back to a known point such as the vehicle, a sample site or a site of particular interest or to check distance to other waypoints.

- Before commencing interpretation of an area, the boundary tracks of the area can be recorded using the ‘track file’ function. This will give reference points for use when recording other points within the area.

Recording a waypoint

When marking a position, an average reading should be taken. To allow for greater accuracy the unit should be given up to one minute for the readings to stabilise. If the FOM does not drop below 15, the reading can be averaged again. Moving into a more open area or holding the unit in a higher position may also help to gain a better reading.

Mapping boundaries

A boundary can be mapped using a series of individual waypoints not more than 50m apart. By using a ‘track file’ and watching the map page, any spurious points can be detected and deleted immediately or noted down for future map compilation. It is beneficial to download recorded information every few days while it is fresh in your mind. Alternatively, good field notes to accompany the data can be used for transferring at a later stage.

The GPS has the ability to store data on several different routes thus allowing data points for each new boundary to be kept separate. Each route can have data points recorded with the same identity as on another route. This is particularly useful when several boundaries are mapped in one day or to separate sample points.

It is most important to remember that mapping of boundaries must always be related back to map features to position boundaries correctly in relation to those features (e.g. correct side of ridge).

The go to function

This is a particularly useful function when trying to locate a known point within a large area and when obvious access does not exist. By selecting the waypoint or entering the known coordinates, the unit will provide a constantly updated bearing and distance to that location. When working within larger areas it is a good idea to mark the position of your vehicle. To help with this, it is an idea to use your compass to get an accurate bearing. Driving at a reasonable speed should allow the GPS to provide updates regularly, however if on foot, the GPS can only be used reliably as a distance meter.

GPS management and care

The units are not weather proof and should therefore avoid excessive exposure to both moisture and direct sunlight. They are sensitive pieces of equipment and it is far less costly to look after them than it is to replace them.

If supplied with a 12V car adaptor lead, the GPS can be plugged into the cigarette lighter while not in the bush to conserve battery power. Batteries for the Garmin will last two to three days with constant use. A spare set of batteries should be carried in the vehicle or field bag.

All GPS units are precision instruments and should be stored in an instrument case when not in use.

Field use of the differential GPS

Differential GPS units offer a similar range of functions as do the non-differential units, the main difference being the degree of accuracy gained by each. DGPS can locate positions to within 1-2m of the actual position. The units are also subject to the same errors as the non-differential GPS.

Position Dilution of Precision (PDOP) is a measurement of the possible position error that is related to geometric quality. The value should be below six for a 3D fix and below four for a 2D fix. Anything higher and the reason for the high reading should be investigated. Do not use data with readings of seven or greater. A lower PDOP may be obtained by moving around the point to secure a better signal.

Data should be downloaded onto a computer at the end of each day to avoid data loss or confusion. If you are away from your office, even a written hard copy of the day’s work alleviates confusion. When in the office, always keep a copy of your data, either in written form or electronic.

8 MAP PRODUCTS

Interpreters produce two main types of maps, a *Phytophthora cinnamomi* Occurrence Map and a *Phytophthora cinnamomi* Protectable Areas Map. Three other types of maps may be produced, these are the field map, demarcation map and the *Phytophthora cinnamomi* Hygiene Management Map. The *Phytophthora cinnamomi* Occurrence and *Phytophthora cinnamomi* Protectable Areas Maps are formal records and are accompanied by a written report. The field map is not a formal product and the *Phytophthora cinnamomi* Hygiene Management Map is prepared in conjunction with the District and proponent.

Interpreters' field map

The field map can be a base map taken from the GIS for transect surveys or alternatively the flight line map is used if interpreting from 230mm photography, or the map could be a combination of both. A field map may contain:
the boundary of interpretation;
roads and tracks;
rivers and streams;
contours;
co-ordinates or reference grids;
run and photo numbers if using film;
cultural points, for example reference trees, airfields, powerlines, recreation sites, dam, railways, quarries, etc.;
Forest Department reference grid;
private property boundaries;
stream and/or road zones;
mining;
DRA (Disease Risk Area);
VRM (Visual Resource Management) zones;
regeneration, SILREC (Silvicultural Recording database and GIS system);
DEZ (Diverse Ecotype Zone);
forest districts, blocks, compartments;
plantations.

At the start of interpretation, the field map can be used to record the information gathered during the initial area reconnaissance. During interpretation it can be used to plot disease boundaries, arrows indicating slope from *Phytophthora cinnamomi* boundaries, sample points, direction and placement of transects and any other noticeable data about the area that an Interpreter requires, for example *Armillaria* sites.

The information from the field map is then transferred and digitised once interpretation is complete and all samples results have returned. These 'rough' maps are then destroyed, although in some instances they may be kept on file to record transects, sample points or to support hypotheses and decisions.

Where 230mm aerial photographs are used, data can be plotted directly onto each frame but it is recommended that a backup be made onto a map of the area as data may become faded or wiped from the frames over time.

Phytophthora cinnamomi Occurrence Map

This is the main map produced by Interpreters. It shows disease distribution and is used as a basis for the *Phytophthora cinnamomi* Protectable Areas Map and *Phytophthora cinnamomi* Hygiene Management Map. This map is generally produced by GIS.

Three categories are shown on a *Phytophthora cinnamomi* Occurrence Map: Uninfested, Uninterpretable and Infested. For category definitions see Section 9.9.

Other *Phytophthora* species and *Armillaria* infestations are to be put onto the map used to digitise boundaries and are recorded, however they are not shown on the final map product unless the infestation is considered to be of a significant impact.

The *Phytophthora cinnamomi* Occurrence Map may show burnt, logged or other disturbed areas excluded from interpretation. These may be annotated as logged, burnt or otherwise together with the approximate date of the disturbance.

Phytophthora cinnamomi Protectable Areas Map

This is a GIS produced *Phytophthora cinnamomi* Occurrence Map with an additional unprotectable category. Determining protectable areas is covered in Section 11. This map is used as the basis for the Hygiene Management Map.

Phytophthora cinnamomi Hygiene Management Map

This map is jointly prepared with the proponent as part of the Protectable Areas *Phytophthora cinnamomi* hygiene planning process. This map is a part of the *Phytophthora cinnamomi* Hygiene Management Plan. It records details of planned management actions and is placed in District and Forest Management Branch record systems.

Demarcation map (optional)

A demarcation map shows where all demarcation tapes have been put up including start and finish points especially where these abut other types of demarcation, for example stream zones. The demarcation map is very useful where permanent blazing of tapelines will be carried out.

Age limit for maps

Due to the dynamic movement of *Phytophthora cinnamomi*, either autonomously or through uncontrolled vectors, *Phytophthora cinnamomi* Occurrence Maps are considered a 'snapshot' of *Phytophthora cinnamomi* boundaries at a particular point in time. It is therefore necessary to allocate an expiry date for the maps produced.

Map boundaries must be checked before operations proceed if a map is older than the recheck date (also refer to Rechecking Section 5). The maximum time allowed before a recheck is required is 12 months from the field completion date as shown on the map legend. The recheck date is determined by a qualified Interpreter in conjunction with the Senior Interpreter after considering the rate of spread, slope and other environmental conditions which may affect the movement of disease boundaries.

After three years from the original completion date, the map is deemed expired and should not be used. After three years the area must be completely re-interpreted.

Areas entirely uninterpretable or uninfested require rechecking, as there may be evidence of new infestations due to recent activities or from surrounding infestations.

Note:

If an area is rechecked more than once, the expiry date is taken from the original interpretation date not the recheck date.

Those areas interpreted as totally infested or unprotectable do not require expiry dates as there is no requirement for hygiene to be applied. This can be applied to the whole of, or parts of mapping areas. In the case of the latter, where a protectable area boundary exists, then this must be checked.

Representation of boundaries shown on maps

Category boundaries shown on digitised maps represent the demarcated tapeline relating to that category which includes the buffer. These are the boundaries to be operated to in the field.

Map production

Digitising is a procedure by which Interpreter data is digitally 'captured' or encoded (using software such as MicroStation). Interpretation data recorded on base plans is normally digitised, however GPS data can be imported directly into GIS. This produces a computer-generated representation of the results of mapping, and can readily provide area statements for category size and total area interpreted.

Once a digital file is created, by either technique, the GIS software is used to add background information, legend, title blocks and other enhancements to produce the final maps to defined specifications. As well as producing a formal map, the data entered is merged into a corporate database, which enables the total areas to be accounted for and included in annual reports. It also allows the interrogation of interpretation information with other corporate spatial datasets.

A digitised map is usually first produced as a *Phytophthora cinnamomi* Occurrence Map, however in some instances, particularly where protectability may become a factor, a hand-drawn copy may be used until liaison with District Offices is complete. Once protectability has been established a digital Protectable Areas Map may be produced, or the digital Occurrence Map will be altered in GIS to accommodate the protectable areas. Then, the final stage will be to compile a Hygiene Management Map showing details of planned management actions, for example gate and washdown placement, harvesting cells and proposed road alignments.

Copies of these maps should be held at both District and Forest Management Branch offices, however it is of utmost importance that Forest Management Branch retains copies of all interpretation results so that there is an official record of all interpretation operations.

Preparation

Information for map compilation can be taken from one or many sources that are used throughout interpretation. This may include 230mm film, strip line booking sheets, hip chain and compass and/or GPS waypoints. The information gained from these sources can be transferred onto a basic map showing a representation of what is required from the person responsible for generating the digital file. In all cases, this map being delivered to the GIS operator must be clear and concise, as they may know nothing about interpreting. Ideally, the boundary of interpretation should be either highlighted or offset from the boundary on the map, so that the operator is clear on the extent of the map required. Also all annotations must be clearly defined and categories accurately shown and coloured.

It is common for a Map Compilation Instructions sheet to accompany the map on delivery to the GIS operator (Appendix 8). This sheet helps the operator to know exactly what you want. It can also be used to record the time taken to complete the job, which can be later entered into the Interpreter’s database.

Information provided to the GIS Operator may include:

- district, block and compartment;
- operation code;
- Interpreters, date completed, compilers and date compiled;
- method of interpretation, for example strip line, 230mm film, road survey, recheck, etc.;
- Department of Conservation and Land Management Operations Graphics Map location to help find the necessary reference files, such as roading and hydrology;
- file name of report, for referencing;
- notes, reminding Interpreters to include locations of *Armillaria* and other *Phytophthora* species, the annotation of unprotectable, correct naming of features, especially roads, and how the boundary of interpretation is shown;
- comments, including annotations, and difficult areas which may need explaining;
- required scale and number of copies;

- products required, for example Occurrence, Protectable, and/or Hygiene Management maps;
- a series of dates to inform Interpreters at what stage map production is at, for example dates referring to –
- when the map is required,
- when the rough map was checked,
- date given to and received from compilation,
- when the map was checked;
- an area at the bottom of the sheet may sometimes be left for the operators notes, including –
- filename,
- time taken to prepare map, and cost involved,
- operators name,
- total area and category areas,
- AMG/GDA reference coordinates.

These information sheets are variable, depending upon the requirements of the different regions, however the end result should be the same. That is, all pertinent information should be accurately and clearly translated to the operator to gain the required product.

Once the map has been returned, it is the Interpreters' responsibility to compare the digital map with the map they first produced to ensure the digital copy is an accurate representation of the field situation. Things to check include:
correct placement of categories in relation to map features, for example roads, creeks, ridges, etc.;
annotations are correct;
details concerning block, compartment, Interpreters and dates, etc., are correct;
scale measures correctly.

As templates are used, it is important that the GIS operator is made aware of the details that must be added and/or changed to produce the map needed. Once the map has been checked, more copies can be printed as required. As the Hygiene Management Plan is developed then these additions can be made to the previous maps and the final digital Hygiene Management map can be produced.

Map legend

Interpreters will represent the following categories on the *Phytophthora cinnamomi* Occurrence and Protectable Areas maps prepared.

Uninfested *(shown as green)*
Determined by a qualified Interpreter to be free of plant disease symptoms, which indicate the presence of *Phytophthora cinnamomi*. Shown on *Phytophthora cinnamomi* Occurrence Maps, *Phytophthora cinnamomi* Protectable Areas Maps and *Phytophthora cinnamomi* Hygiene Management Maps.

Uninterpretable *(shown as a purple)*
Where susceptible plants are absent or too few to enable the interpretation of *Phytophthora cinnamomi* presence or absence. Shown on all maps as appropriate.

Infested *(shown as a red)*
Determined by a qualified Interpreter to have plant disease symptoms consistent with the presence of *Phytophthora cinnamomi*. Shown on all maps when it occurs.

Unprotectable *(shown as black diagonal hatch)*
Areas into which current *Phytophthora cinnamomi* symptoms may spread autonomously.

Diagram 4: Legend for *Phytophthora cinnamomi* Hygiene Management Map

9 MONITORING AND STANDARDS CHECK

Interpreting large areas of land with a range of vegetation types can be difficult to achieve to 100% accuracy. Interpreters should strive for 100% accuracy at all times but because of poor disease expression due to climate, lack of suitable indicators, dense unsusceptible vegetation, etc., this may be hard to achieve.

Obvious expressions of disease should never be missed.

To ensure the greatest possible accuracy is achieved, training, monitoring and mentoring of Interpreters is carried out on a regular basis by Senior Interpreters and the Disease Standards Officer. The role of team leaders (however formal or informal) and working in pairs as much as possible also contribute to high levels of accuracy in interpretation.

Monitoring standards in the field is achieved either by the Senior Interpreter or Disease Standards Officer accompanying Interpreters to areas they have worked on or are working on to discuss interpretation decisions made. Alternatively the Senior Interpreter or Disease Standards Officer may independently conduct spot checks of Interpreters' work.

Monitoring of maps and reports produced by Interpreters is conducted by Senior Interpreters or the Disease Standards Officer who should check maps and reports prior to final handover to the proponent.

Results of monitoring standards are recorded on the Standards Monitoring Form (Appendix 10). The form should indicate competent work and highlight areas where improvements should be made. Improvements may be in the form of correcting work or by the identification and follow up of training needs.

Copies of the Standards Monitoring Form should go to the Interpreter(s) whose work is being monitored, the Senior Interpreter, the Disease Standards Officer and the Interpreter's Manager.

It is the responsibility of Senior Interpreter and/or the Disease Standards Officer to conduct regular standards checks on all facets of interpretation.

Checks are required for several reasons, including:

- ensuring uniformity of standards;
- ensuring guidelines are being followed and clearly understood;
- meeting policy requirements;
- meeting audit compliance;
- assisting in identifying training requirements; and
- assisting in identifying resource requirements, etc.

10 DETERMINING PROTECTABLE AREAS

Identifying protectable areas on lands managed by the Department is covered by '*Phytophthora cinnamomi* and disease caused by it, Volume 1: Management Guidelines' (CALM, 2000). Extracted from those guidelines are the *Protocol for identifying protectable areas and their priority for management, Table: Definition of Protectable Areas and steps Interpreters use in determining Protectable Areas on CALM-managed lands* – see page 59.

Protectable areas are not shown as a distinct category on their own. Protectable areas are all areas not shown as unprotectable (i.e. hatched) and are either uninfested or uninterpretable or both.

Infested areas are already unprotectable by default and so are not hatched. Some values (for example rare flora) may warrant some protection even though they occur in infested or unprotectable uninfested areas but these should be provided for in the *Phytophthora cinnamomi* Hygiene Plan.

Identifying Protectable Areas and their priority for management

The Department of Conservation and Land Management will progressively develop a set of protocols for the objective identification of protectable areas (see Table 11.1 – Definition of protectable areas) and for their prioritisation and management. In the interim protectable areas will be identified using the following process:

- on a case-by-case analysis of landscape units, establish the need for, and scope of, the mapping required and use accredited Interpreters to prepare *Phytophthora cinnamomi* Occurrence Maps based on three categories – Infested with *Phytophthora cinnamomi*, Uninfested and Uninterpretable;
- use accredited Interpreters and managers to identify protectable areas and rationalise their management boundaries;
- the steps accredited Interpreters use in determining protectable areas on land managed by the Department are described in this manual.

Table 11.1: Definition of protectable areas

Defines areas of land managed by the Department over which the hygiene rule, for the plant pathogen *Phytophthora cinnamomi*, of clean on entry will apply. May be an area suitable for phosphite application.

- Are situated in areas receiving > 600 mm per annum rainfall or are water gaining sites (for example granite outcrops, impeded drainage or engineering works which aggregate rainfall) in the 400-600 mm per annum rainfall zone.
- Does not have a calcareous soil (i.e. not Spearwood sand dune).
- Have been determined to be free of the pathogen *Phytophthora cinnamomi* by a qualified Interpreter (all susceptible indicator plant species are healthy, no plant disease symptoms normally attributed to *Phytophthora cinnamomi* are evident).
- Are positioned in the landscape and are of sufficient size such that a qualified Interpreter judges that the pathogen will not autonomously engulf them in the short term (for example > 4 ha with axis > 100m).
- Consists of areas where human vectors are controllable (for example not an open road, private property).
- Includes areas of high conservation and/or socio-economic value (for example a small uninfested area which contains a known population of a susceptible species of threatened flora).

Steps Interpreters use in determining protectable areas on lands managed by the Department

1. Prepare the *Phytophthora cinnamomi* Occurrence Map based on landscape units unless otherwise agreed by the District Manager. Use only three map categories:
   - *Phytophthora cinnamomi* infested;
   - *Phytophthora cinnamomi* free; and
   - Uninterpretable.

   All roads and tracks are to be categorised using these three categories. Other *Phytophthora* spp. and *Armillaria* are to be recorded and digitised into separate GIS files for future use.

2. Identify areas of uninfested and uninterpretable that are greater than four hectares with axis greater than 100m. Exclude any areas of uninterpretable and/or road surfaces that are determined to be infested.

3. Test each area against the flowchart (Appendix 7) and establish the protectable areas. Hatch the areas that are not protectable areas.

4. Where the uninterpretable area adjoins an infested area exclude any areas of uninterpretable that are likely to be infested (for example downstream areas and/or approximately 150m of the uninterpretable).

5. Determine the appropriate boundaries for each protectable area.

6. Hatch the areas that are not protectable.

11 INTERPRETATION REPORT

A report is a written account of the interpretation process and results, and one must be completed for each area interpreted. The report summarises the map and field observations, justifies protectable and unprotectable area decisions and provides information for the *Phytophthora cinnamomi* Hygiene Management Plan. It also reports the non-mappable areas, indicates the status of roads/tracks/gravel pits, etc., provides base line information for scientific study and discusses other forest diseases. Details from the report and maps are entered into the corporate database, which can then be used for management purposes, for example to report on the number of hectares interpreted in any one year.

The report comes in two formats: a comprehensive report (Appendix 9) or a condensed letter (one-page report). The type of the report is defined by two factors:

Report type

1. If the area of interpretation is greater than 50 hectares then a comprehensive report is necessary. If less than this size, or of a linear nature (for example easement surveys) a detailed letter (one-page report) will be sufficient.

2. If the time elapsed is less than three years from any previous interpretation, which means that the area has undergone a recheck, then a one-page report is usually sufficient. If the area requires re-interpretation due to the expiry of the three-year date, or has never been interpreted before, then a full report must be done.

Writing format – comprehensive report

Formats of reports may differ, depending on the information needs and expectations of the customer. However, a comprehensive report should contain most, or all, of the information listed below (Appendix 9).

Title page

- forest block/s;
- compartment/s;
- map file name/identification number;
- interpreter/s names;
- report author and date report written;
- total area interpreted;
- DRA status;
- method of interpretation (for example transect, linear, 230mm film);
- film data (for 230mm film interpretation);

- map scale;
- tree species in terms of canopy dominance;
- interpretation commencement date;
- interpretation completion date;
- products of interpretation, for example report, map types.

Table of contents

Outlines the order of the report.

Introduction

In this section introduce your work, state why the survey was undertaken and give a brief summary of the general and background information you have gathered. Describe (briefly) what it was you were working on and what your aims were.

- What it is you are investigating? (*P. cinnamomi* occurrence and protectable areas.)
- What will the information be used for? (Relate to proponent.)
- What is the area called? (Block/s name and compartment/s.)
- What was the method of interpretation?
- Where is the area located?
- What was the area of interpretation (in hectares/kilometres)?
- What is the DRA status?
- Who interpreted the area?
- What was the period of interpretation?
- What was the aim of the survey?

For example, 'the aim of the survey was to provide information on *Phytophthora cinnamomi* distribution for input into the Hygiene Management Planning Process for the identification and management of protectable areas'.

Background information should also be included.

- previous interpretation;
- land use;
- harvesting history;
- burning history;
- rainfall zone;
- landforms and vegetation types.

Materials and methods

In this section state how the survey was completed and how data were collected. Give sufficient detail so someone can repeat the work if required.

In most cases referencing the relevant sections of the Interpreters' guidelines, and giving any modifications used to the method described there, will assist in keeping the report brief. An example of this approach is:

'The method used was 230mm photo interpretation according to the *Phytophthora cinnamomi* Interpretation Procedures Manual (CALM, 2001) which cover the standard procedures to be used for interpretation of disease caused by *Phytophthora cinnamomi* on Departmental land.'

Results

Describe what has been found regarding distribution, symptoms, expression, etc. as listed below. Point out trends in the data or interesting facts about them, and then refer the reader to them. For example, 'the distribution of *Phytophthora cinnamomi* infestations was directly linked with the drainage pattern and/or roading network'.

The results reported here may be used for subsequent interpretation or scientific studies. You should present your results such that they will accurately describe what you observed as though you were communicating it to a person who will not have the benefit of field observations themselves.

It is not advisable to discuss reasons for or consequences of results in this section. The main purpose of a Result section is to objectively point the reader to the trends in the data. The possible reason why you achieved the results should be left to the discussion.

Disease distribution:

Report disease distribution of any previous interpretation, if available. Where did the disease occur? (Gullies, ridge tops, creek, etc.) Report disease distribution of the latest mapping. Describe the position/topography of the infested areas. What is the proportion of diseased areas to uninfested (percentage)?

Disease symptoms and expression:

List known *Phytophthora cinnamomi* indicator species occurring within the interpreted area. Comment on particular plant species that have and have not succumbed to the disease and include relative number of dead to healthy plants. Describe disease expression relative to the vegetation and landform types within the area.

Describe the impact the disease has had on the vegetation structure and important (significant) individual plant species such as a loss of all of one species or a rare plant.

Other Phytophthora species:

Report on the distribution and impact of other *Phytophthora* species infestations. Specify whether they have been demarcated in the field. If demarcated they should be shown on the *Phytophthora cinnamomi* Occurrence Map and annotated.

Drought and fire damage:
Report any significant drought or fire symptoms found within the area. For example, areas of previous intense fire activity may be having an impact on indicator species up to three to four years after the fire or burn. Interpretation of disease may be made more difficult due to this and will need to be reported by Interpreters.

Armillaria luteobubalina (Armillaria):
Report the distribution and impact of *Armillaria* infestations. Specify whether any *Armillaria* infestations have been demarcated in the field. If demarcated then they should be shown on the *Phytophthora cinnamomi* Occurrence Map and annotated.

Expression anomalies:
Report on any unusual symptoms.

Allocation of categories
Use the following table to quantify categories allocated.

Area statement:

AREA STATEMENT		
Categories	Area (ha)	Notes
Uninfested		
Uninterpretable		
Infested		
Unprotectable		Overlays other categories

Uninterpretable
Write a brief statement about each uninterpretable area. Is it permanently uninterpretable (for example dense *Trymalium* and *Bossiaea* species under karri canopy) or would the interpretability change if the area were opened up with walk lanes or some other vegetation altering process/event.

Areas burnt or logged, etc.
Areas that have been recently burnt, logged or otherwise disturbed which cannot be interpreted should be mentioned here and related to the map. These areas will not usually be counted as part of the total area mapped.

Protectable and unprotectable
Report the distribution of protectable areas and explain the reasons for judging areas to be classed as unprotectable. Identify areas where judgements about protectability will need to be made at Hygiene Planning Meetings.

Roads, tracks, easements, borrow pits, etc.

List each road, track, easement, borrow pit or other area and discuss in terms of, type and amount of disturbance, recency of disturbance, type of risks associated with the disturbance (amount and type of use, drainage, etc.) and whether in the judgement of the Interpreter the area can be classed as protectable or not.

Sample results

List the number of samples taken, and refer to the sample summary.

Discussion

Discuss what the results mean relative to the aim stated in the introduction. Refer to the results as necessary.

Discuss the level of hygiene and/or protectability of each road, track, and easement, borrow pit, etc., relative to the hygiene that should be implemented for them: what type of activity appears to be occurring along the roads, can they be closed or must they remain open?

Specific discussion should focus on:

- Access – has it been controlled or uncontrolled? Can some estimation of frequency, recency and amount of traffic be given?
- Disturbance – has it been by light (2WD and 4WD) vehicles or heavy (trucks) or machinery (tractors and loaders, etc.).
- Soil movement – has soil obviously been moved, for example by traffic, machinery or road works?
- Drainage – are areas influenced by ponded water? Is the road, track or easement well drained? Where does the run-off go?
- Indicator plants – do they exist on the road, track or easement surface? Are the indicators old enough and distributed sufficiently to interpret the area and make a determination about protectability?

Where there has been previous interpretation of the area the following should be addressed:

- Has the distribution of *Phytophthora cinnamomi* changed since previous interpretation, and if so how has it affected the amount of protectable?
- What, in your opinion was the vector of spread?
- Are differences due to actual spread of disease or changes in interpretation standards?
- Where do you expect most *Phytophthora cinnamomi* spread? This may not necessarily be in unprotectable areas, depending on recent activity within the area.

Conclusion

Summarise the report, detailing all maps produced and highlighting the map age limitations.

Recommendations

List and summarise:

- individual areas determined to be protectable;
- hygiene to be applied to those areas;
- access control including road closures.

Ensure recommendations are in line with current Departmental policy.

References

A Reference section is all the work you utilised (for example quoted, used information from, or discussed) in the production of your report.

When you refer to authors in the text or your report, the preferred format is as follows:

Single author: (Northin, 1990)

Two authors: (Withnell and Brown, 1999)

Three or more: For example, an article written by Miscamble, Moore, Watts and Lee in 1998 is referred to as: (Miscamble *et al*., 1998). The words '*et al*.' are Latin and are short for '*et alii*', which simply means 'and others'.

The full reference should be included in the reference section using the standard format as follows:

<u>Author or Authors (Date)</u> '**Title of the article or book**'. Journal or Publisher, relevant page numbers.

So for a book:

Hooper, C.H. and Miller. J. A. (1614) '**Landform and Vegetation Complexes in the Southern Forest Region**'. Department of Conservation, Western Australia.

Ensure that the references you have quoted in your text are actually recorded in the reference section and *vice versa*. List references in alphabetic order.

Appendices

Costing analysis
This is a summary of Interpreter and vehicle expenses for interpretation. It should include total costs, plus a cost per hectare. Administration and overhead costs are not included.

Sample summary
This lists the plant species sampled, the number of samples taken of that species, the number of those that returned a positive result and the percentage positive.

It includes the ISD class to which the samples belong and includes other *Phytophthora* species recovered.

Summary sheet
Attached to the back of the full-size report is a 'tear off' sheet summarising the relevant information for the proponent. This information is usually enough for the proponent. If further clarification of detail is required the full report should be consulted or the Interpreters contacted direct.

One-page report
A one-page report is a condensed version of the comprehensive report. It is up to the Interpreters in consultation with the Senior Interpreter/DSO and proponent to decide on the material it contains.

Role of Senior Interpreter/Disease Standards Officer
All reports must be checked by the Senior Interpreter (SI) or Disease Standards Officer (DSO) prior to final handover to the proponent. The report should be discussed with the SI/DSO, particularly if the Interpreter has recommended any unusual action to the proponent. The SI/DSO may decide to accompany the Interpreters to the handover session where the Hygiene Plan is put together.

For non-departmental proponents
The Section Manager must read any outside correspondence. A copy of the report must be kept on file for the manager to refer back to if required.

The format of the report may differ from the usual report as it depends on the information needs of the customer. However, the Interpreter should attempt to include as much of the information contained in the comprehensive report as is applicable.

Style and presentation
Everyone has his or her own style of writing which may show through even when put into a conventional format. Write clearly and simply avoiding colloquial phrases such as 'fresh death' or unnecessary scientific jargon. If you read a sentence and it's a mouthful you

stumble over, then it probably needs to be re-worked. Proof read your report and get your partner to read it over also.

12 HANDOVER OF MAPS AND REPORTS

A handover of *Phytophthora cinnamomi* Occurrence and *Phytophthora cinnamomi* Protectable Areas Maps and associated reports must be completed for all interpreted areas. A handover may be conducted prior to or as a part of the Hygiene Planning Meeting.

Interpreters are usually the first people to closely investigate areas while mapping disease presence. It is therefore important to pass on any information which might be useful in hygiene planning, for example drainage patterns, vegetation or forest types and structure, presence of old borrow pits, hazards – anything that may be useful to the proponent. Any information that is relevant to the Hygiene Plan should also be included in the report.

The products required at a handover include:

- a *Phytophthora cinnamomi* Occurrence Map/*Phytophthora cinnamomi* Protectable Areas Map;
- a report/summary sheet;
- a Demarcation Map (optional).

When doing a handover the Interpreter must explain all the pertinent information

contained on the maps and in the report. For example:

- why certain areas of forest were classed as uninterpretable;
- why certain areas were classed unprotectable or protectable;
- vegetation/landform/forest types encountered in the area;
- disease impact in the area;
- recommendations contained within your report;
- justification for recommendations.

If the area was particularly difficult to interpret you may wish to arrange a follow up visit in the field. This will enable you to show the proponent areas and issues of concern.

Hygiene Planning Meetings

The hygiene-planning meeting is a meeting convened by the District Manager, involving activity proponents, District representatives and Interpreters. The people at the meeting collectively plan and agree on how human access to protectable areas will be managed so that the role of humans as vectors in establishing new centres of infestation is reduced to the lowest possible level. The District Manager has final approval of the Hygiene Management Plan. The Hygiene Management Plan is a document with accompanying map, which specifies the management actions required for protectable areas on land managed by the Department.

The manual '*Phytophthora cinnamomi* and disease caused by it, Volume 1: Management Guidelines' (CALM, 2000) details the preparation and use of a Hygiene Management Plan. Interpreters should familiarise themselves with this document.

Interpreters' input into Hygiene Management Plans is important. Initially it is in the preparation and presentation of information about disease presence and likely spread patterns (maps and reports). During the hygiene planning meetings it is the Interpreters' expert knowledge about risk analysis relating to *Phytophthora cinnamomi* and appropriate risk mitigation techniques (hygiene strategies and tactics, for example Images 14 and 15) that can be used to evaluate the likely success of the Hygiene Management Plan.

Image 14: Front barrier loading

Image 15: Washdown point

13 STORAGE OF MAPS AND REPORTS

Once interpretation and mapping is complete, the final products must be stored safely for future reference. This must occur for hard copies and digital copies.

Computer files

Digital copies of both maps and reports are stored on various drives within a computer network. To enable easy retrieval, a standard naming convention must be adopted.

Naming convention for reports and map file names have been standardised.

Interpreters' database

A database is a collection of information related to a particular purpose. If your database isn't stored on a computer, or only parts of it are, you may be tracking information from a variety of sources that you have to coordinate and organise yourself. To simplify this process, Interpreters enter information into one system for convenient access.

A computer database (for example Microsoft Access) allows users to manage information from a single source. Within this file the data is divided into separate storage containers called tables, and you can view, add, or update these tables using on-line forms. You can also find and retrieve just the data you want using queries, and analyse or print data in a specific layout using reports.

Uses of the Interpreter's database may include:

- programming interpretation requirements;
- reporting on the number of hectares interpreted in a specified time period;
- archive of interpreted areas;
- providing links to other programs, for example MicroStation, Excel spreadsheets, Word documents.

Information that can be stored on the Interpreters' database may include:

- costings;
- who interpreted the area and when;
- the time taken to complete the job;
- the proponent;
- the proposed operation year;
- the method used for interpretation;
- sample information;
- type of map product and the file name;
- block and compartment information;

- type of report produced and its file name;
- identification numbers for cross referencing with other systems;
- vegetation or forest type interpreted, etc.

14 INTERPRETERS' TRAINING AND DEVELOPMENT

It is a requirement of qualified Interpreters to assist in the training of trainee Interpreters in disease detection diagnosis and mapping. The most common type of training is to provide one to one training to new Interpreters. Although, other types of training may be required in disease recognition and mapping for Departmental operational staff, interest groups such as 4WD clubs or schools and conducting formal training courses.

With one to one training the qualified Interpreter will be responsible for the bulk of training of the new Interpreter, however the Senior Interpreter and/or Disease Standards Officer will be required to provide assistance and support to this role. This manual and the Job Description Form (JDF) provide the basis of that training and the challenge for the trainer is to adjust their style of training to suit many different individuals. They should cover aspects ranging from safe driving techniques through to advanced levels of disease recognition and diagnosis. The objective for training new Interpreters is to bring the Interpreter 'up to speed' as quickly as possible while ensuring work commitments are adequately met.

Nominal career development program

Assistant Interpreter – Assistant Hygiene Officer
Has successfully met the requirements of the Department's 'Introduction to the Detection, Diagnosis and Mapping of Disease Caused by *Phytophthora cinnamomi*' Training Course and '*Phytophthora cinnamomi* Hygiene Management Course'.

Has assisted an Interpreter with the detection, diagnosis and mapping of disease caused by *Phytophthora cinnamomi* for a minimum of three months full time (or equivalent).

Carries out detection and diagnosis in the field on a relatively 'simple' area without expert advice and which has been assessed for accuracy by a Senior Interpreter or Disease Standards Officer (DSO).

Interpreter – Hygiene Officer
Has been an Assistant Interpreter for approximately 12 months full time (or equivalent).

Has successfully met the requirements of the Department's '*Phytophthora cinnamomi* Management' Course.

Carries out detection, diagnosis and mapping of a number of different vegetation types without expert advice and has been regularly assessed for accuracy by a Senior Interpreter or DSO.

Interpretation Team Leader – Hygiene Team Leader
After approximately 18 months is able to demonstrate competency in all aspects of interpretation, able to work independently and demonstrates basic staff management, motivation and organisational skills.

Able to describe, determine and map vegetation site types, soils and landform types relevant to hygiene management in the south-west.

Able to interrogate databases and generate reports, process and incorporate GPS data, access GIS data and generate base plans.

Has successfully completed relevant courses in Forest Management (for example silviculture, harvest coup planning and roading).

Senior Interpreter – Senior Hygiene Officer
Has substantial experience in a variety of vegetation types and interpretation methodologies.

Is a qualified Workplace Assessor and has successfully completed the Department's 'Performance Management' Training Course or other relevant management and team building courses.

Has successfully completed relevant courses in forest management.

Able to competently manage and motivate the hygiene management team and co-ordinate the provision of services.

Disease Standards Officer
Able to perform all the roles of a Senior Interpreter.

Can effectively establish standards of detection, diagnosis and mapping.

Can effectively measure standards of detection, diagnosis and mapping.

Can effectively communicate standards of detection, diagnosis and mapping.

Can effectively prepare and deliver nationally-accredited competency-based training programs.

Can liaise effectively with other agencies, organisations and institutions.

15 PHOTO INTERPRETATION

Photo interpretation refers to the process of visually examining photographic images for the purpose of identifying objects and judging their significance. The interpretation must be done stereoscopically and is often aided by other sources of information, such as maps (Image 7).

Image 7: 230mm photos on field light board, field stereoscopes, marking pen and flightline map ***Photography***

Since 1986, 230mm format, 1:4,500 nominal scale, colour, shadowless, aerial diapositives have been used for mapping the position of *Phytophthora cinnamomi* disease boundaries. From the mid-1970s until 1986, 70mm format photographs were used.

It is essential to use shadowless conditions for photography so that the understorey is not in shadow as the ISDs may be obscured and interpretation would not be possible using this method.

To obtain shadowless conditions, the weather for photography must consist of full cloud cover at a minimum ceiling of 6,000 feet. There are probably only two to five days in each year when this combination of conditions prevails. Usually, this occurs in summer and autumn when high level cloud moves down from cyclonic low-pressure systems in the north of the state.

Aerial photographs are taken with a forward overlap of usually 60%. This means that the ground cover of one photo overlaps the next by 60% (**photo overlap**). The forward overlap is required so that a three dimensional view is provided. This is a stereoscopic image.

An aircraft makes one run along a preset flightline and then returns, flying parallel to the previous run taking a second series of photographs, with a side overlap of approximately 30% (**run overlap**). This is repeated until the whole photography area is covered.
The camera used for the photography has marks located inside the view, which are exposed onto the negative as each photo is taken. These are known as the **fiducial marks**. When two sets of opposite marks are joined they intersect at the **principal point** (**PP**). The principle point of each photo is plotted onto a base map resulting in a **flight line map**.

The **cell number** is a numerical title given to each area photographed. It consists of two parts, the year of photography, for example 89 for the year 1989 and the consecutive cell in that year, for example 178, meaning 178th set of photos taken in 1989, shown as 89/178.

The title bar of each aerial photograph provides the interpreter with a variety of information to assist in identification and positioning. Contained within the title bar of each aerial photograph is:

- a frame number/photo number;
- eight fiducial marks per photo;
- forest block or job name;
- run number;
- first and last frame in that run, for example 5008 – 5020;
- nominal scale;
- date flown;
- north point.

There are three steps involved in interpreting 230mm aerial photography to identify disease symptoms caused by *Phytophthora cinnamomi* in native vegetation:

- initial photo interpretation in the office;
- field checking and recording onto photos; and
- transfer of data from photos to base maps for digitising.

All methods described assume that two Interpreters are working in a team.

Initial interpretation of 230mm photographs

Equipment

- 230mm photographs and flightline map of the area, or Interpreters' field map with flight lines on it;
- wild Aveopret ST4 Mirror Stereoscope or similar;
- light table with 50mm by 50mm or 25mm by 25mm grid marked onto the light table;
- permanent fine point marker pens usually black in colour;
- methylated spirits for corrections.

Photo interpretation methods

There are two methods for the initial interpretation of 230mm aerial photos. Method One is used where one or both Interpreters are experienced. Competent Interpreters who demonstrate a systematic approach, are familiar with stereo overlap and the need to ensure that ISDs are checked only once during field checking, do not need to proceed onto Method Two. The Senior Interpreter and/or Disease Standards Officer will approve use of this method.

Method Two is more formal and structured. It describes additional steps for inexperienced and trainee Interpreters to develop methods that will ensure all ISDs are visited only once especially near the edge of photo frames.

Method One *– where there is at least one experienced Interpreter in the team*

Mark the boundary of interpretation onto the even numbered photographs and the flight line map and include all road and creek names for future reference.

All photos that cover a part of the area to be interpreted must be scanned for ISDs. Each Interpreter in a team must sequentially and closely scan the 230mm frames stereoscopically, marking ISDs and sites for checking. The Interpreter must scan all the photographs using a 3-power lens and if further clarification of an ISD is needed then 8-power lens may be used. All ISDs are to be marked on the photographs using the following symbols:

Xanthorrhoea spp. death
O J *Eucalyptus marginata* death
O Banksia and other species deaths

Demarcate what appears to be obvious *Phytophthora* with a permanent marker on the even number frames. This will reduce the number of ISDs requiring subsequent field checking.

Any suspicious areas that require field checking and that are not associated with ISDs should be shown thus:

'Check'

These areas could be old gravel pits, landings, snig tracks, bare, open areas or simply areas that the Interpreter intuitively feels the need for them to be checked.

Once field checked the word check should be crossed with the marker pen and a notation written to state the finding of the check, for example 'termite mound', 'NPC', 'PC', etc.

Some areas may lack visible indicator species when viewed on the photos. These must be checked and verified in the field as either uninterpretable or interpretable and demarcated accordingly. The film should be marked:

'Check UI'

and then marked with the correct category once field checked.

The second Interpreter to view the frames must ensure they contribute to the interpretation by marking on the areas where they differ from their partner, for example extra ISDs, uninterpretable boundary differences or extra check sites.

Due to the large area covered by each photograph (approximately 100ha), great care must be exercised when scanning for ISDs and check sites. A 50mm (for 3x) or 25mm (for 8x) grid should be marked on the office light table to help with systematic scanning of each photo. It is also important to identify and record any gaps in the photography coverage over the area. If gaps exist these must be stripped out in the field using the transect or strip line method (Section 5).

ISDs may be obscured by vegetation on one frame and therefore only appear on the adjacent frame. Both the flight line sequence and the overlapping frame in the adjacent flight line need to be compared to ensure all ISDs have been circled.

As ISDs may appear on more than one frame in the flight line sequence and on adjacent flight lines the following procedure (Method Two) may be used to ensure ISDs will be checked only once in the field where frames overlap.

Method Two *– Additional steps for inexperienced or trainee Interpreters*

The first time an Interpreter uses this process they should ask the Senior Interpreter to clarify the steps to be taken. Each Interpreter should use a different coloured marker so that standard checks can be carried out. A legend should be shown on the Interpreters' field map/flightline map depicting the colours used by each Interpreter.

The aim is to have office work (ISDs and check sites) shown on **even** numbered frames and fieldwork (disease boundaries etc.) shown on **odd** numbered frames.

One Interpreter circles each ISD using 3-power magnification on the **even** numbered frames. The **odd** numbered frame is left blank to allow for field demarcation to be plotted. ISDs visible on **odd** numbered frames are plotted onto **even** numbered frames. Using the colour marker allocated to the first Interpreter, **shade** in the **even** numbered frames on the flight line map as frames are completed. A small circle on the flight line map represents the PP of each photo frame. Shade in this circle.

The second Interpreter checks the photos for missed or difficult to see ISDs using 8-power magnification. Using the second Interpreter's allocated colour marker **cross off** the **even** numbered frames on the flight line map as they are completed.

Transferring ISDs between photo and run overlaps is done to ensure field checking of ISDs occurs only once for each ISD. Use the following procedure to transfer ISDs:

- transfer ISDs in the **photo overlap** (next photo in the run) using the following method (see Diagram 1a);
- transfer one way from one **even** frame to the next **even** frame along a run;
- transfer by scanning one grid square at a time, as with ISDs;
- mark transposed edge of film onto adjacent ISD **(even)** frame;
- record which direction transfers have occurred on flight line map using allocated marker colour.

Transfer ISDs in the **run overlap** (photos in the adjacent run) using the following method (again refer to Diagram 1a):

- Transfer ISDs from one run to the next for the entire run. Maintain the same direction of transfer for the entire area (for example transfer from east to west, or north to south).
- Then as per steps 2 – 4 above for photo overlap.

The final result should appear as shown in Diagram 1b.

Diagram 1a: Example of flightline map demonstrating to indicate transfers of ISDs onto adjacent photo frames (a) and photo runs(b)

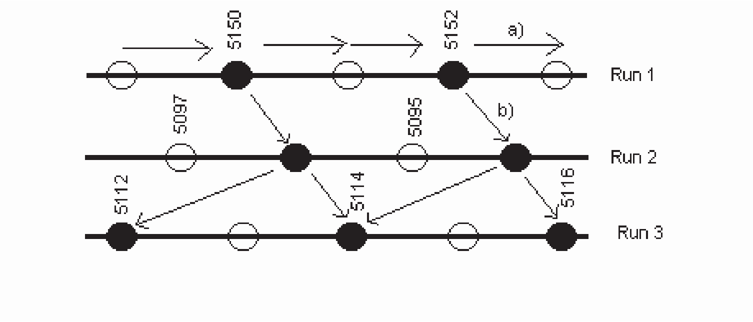
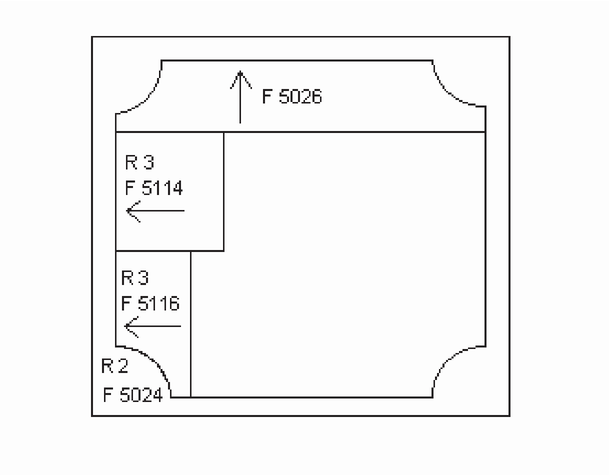


Diagram 1b: Example of a finished photo frame, with transfers complete



Exceptions:

If an area has priority for mapping, make sure all ISDs are transferred into the area regardless of the direction that they have to be moved.
If an ISD occurs on the transposed line put a deviation in the line around it and transfer it onto the frame where most of the checking is required.

Field checking and recording on photos

The 230mm photographs are used in the field for navigation, recording disease boundaries, checking ISDs and check sites visited, recording sample sites, recording slope direction, recording vegetation or landform types if required and other data that may be relevant to interpretation (Image 8).

Image 8: Photo interpretation in the field

Equipment

- 230mm diapositive photos at a scale of 1:4,500 (nominal);
- flight line plan at an appropriate scale;
- weatherproof photo satchel;
- field mirror stereoscope;
- portable translucent lightboard;
- permanent marker (fine point – take spares);
- small container of methylated spirits and cotton buds for correcting film plotting;
- compass to aid orientation;
- Day-Glo orange flagging tape;
- white flagging tape (for uninterpretable in Swan and Central Regions);
- black and pink striped flagging tape (for uninterpretable areas in Southern Region);
- sample kit.

Scale of photos

The standard nominal scale of photos used for *Phytophthora cinnamomi* mapping is 1:4,500. Due to undulating terrain, camera angle and radial distortion, the scale is not constant across a frame. It is therefore necessary as part of the area reconnaissance to calculate the true scale in different topographical locations, for example gully, mid-slope and ridge top, and different areas of photo coverage.

To calculate photo scale:

- Locate two easily identified features in the field. They should be at approximately the same elevation.
- Measure the distance between the features in the field (actual length) and on the film.
- Apply the following formula to calculate film scale for the place where measurements were taken in the field.

$$\textbf{Scale} = \frac{\textbf{LENGTH IN FIELD}}{\textbf{LENGTH ON FILM}}$$

For example: Length on film 5.8 cm
Length in field 246 m

$$\text{Scale} = \frac{246\ \text{m}}{0.058\ \text{m}}$$

Scale = 1:4241

Work method and sequence of interpretation with 230mm photographs in the field

The strategy used is designed to limit the need to check ISDs and check sites to those areas outside of obviously diseased areas. After initial reconnaissance of the area to be interpreted, locate a disease boundary and commence plotting the disease boundary onto photos, using a permanent marker, and taping the buffers.

Plotting the disease edge onto photographs and taping in the boundary with the applied buffer should be done at the same time, i.e. one Interpreter walks along the disease edge and plots it onto the photographs while the other Interpreter tapes in the line with the buffer applied.

By working this way the Interpreter doing the taping can check for any disease symptoms which may be present outside the obvious disease boundary and also inform the Interpreter plotting onto photos of useful features to enable positioning of the tape line on the photos. Sometimes it may not be possible to follow this preferred approach. If disease boundaries are complicated it may be more efficient to plot the boundaries first and then rationalise the taping accordingly.

When searching for the disease boundary it is important to cross over the boundary frequently to ensure the true edge is being followed and not a ‘false’ or ‘blind’ edge. Interpreters should switch roles frequently enough to avoid eye fatigue and lapses in concentration.

Visiting ISDs and check sites should be done in conjunction with plotting disease boundaries where they are close enough (for example within 100m). This will aid in establishing the true position of the disease boundary.

Once field checked, the ISD symbol should be crossed with the marker pen and either ‘NPC’ (not *Phytophthora cinnamomi*) or ‘PC’ (*Phytophthora cinnamomi*) written next to it depending on the decision made.

Once all obvious disease boundaries have been plotted and demarcated, then checking other ISDs and check sites should commence. All ISDs and check sites must be checked. Try to work your areas on a ‘face’, i.e. start at one end of your area and steadily work your way through to the other end. If possible, work sequentially from higher to lower areas on a catchment by catchment basis. Ensure all roads, tracks and areas of disturbance are walked. This is the most effective and efficient way to interpret an area.

Field decisions about ISDs and check sites must be recorded on the photographs, for example ‘NPC – killed by white ants’. Each ISD and check site visited and marked as NPC, is to have a short length of Day-Glo orange tape left in the centre of the site checked. This enables the Senior Interpreter or Disease Standards Officer to see that ISDs and check sites have been visited and verify decisions made. If an area is found to be infested it should be recorded onto the photo and taped accordingly.

Sample sites must be marked on the photographs using the sample number and date, for example Sample no. 2 – 26.10.99 (see Section 6).

As you map the disease boundary, mark on the photographs the direction in which the *Phytophthora* infestation will spread downslope from the tapeline. This should be marked with arrows and will assist with determination of unprotectable areas at a later stage. It is much easier indicating the direction of anticipated disease spread on the photos at the time of mapping than trying to remember later when compiling the *Phytophthora cinnamomi* Occurrence or Protectable Areas Maps.

Other data to be recorded onto the photos include:

- *Armillaria* infestations;
- lightning strikes;
- drought impacts;
- frost impacts;
- severe fire damage;
- any other relevant data that relate to plant or vegetation community health.

Plotting of disease boundaries and sample points is to be to within 5m accuracy. Plotting of tapelines is to be to within 10m accuracy.
The method for recording data can occur in one of two ways related to the method used for initial interpretation (Method One and Two). The procedures for field checking are common to both methods.

Recording data onto photos – Method One

All data being recorded onto the photos can be placed onto whichever photo frame it is convenient to use. When using this method, ensure all relevant data are transferred for digitising as some frames may contain only a small amount of data which may be missed.

Recording data onto photos – Method Two

Odd and even numbered photo frames are used for recording different sets of data as shown below.

Even numbered frames are used for marking sample sites, ISDs and check sites once they have been checked. It is often referred to as the 'ISD frame'. Other data, which may be relevant, for example *Armillaria* sites or drought impacts, etc., should be recorded on this frame.

Odd numbered frames are used to plot the disease boundary, tape line and direction of slope. It is also known as the 'mapping frame'.

Transfer data to base maps

Field data, which have been recorded onto photos and/or the Interpreters' working map in the field, are transferred to a base map for input into Geographic Information Systems (GIS) in the office.

Obtain a base map from GIS nominally at a scale of 1:4,500, but ideally at a scale that most closely matches the true scale you have determined for the photos. Ensure the scale is as close to the average scale of the aerial photos as possible and that the base map shows all watercourses, reference trees, contours and roads, including new constructions.

Plot or trace disease boundaries from the photos and Interpreters' field map onto the base map, taking care to ensure the most accurate positioning of data onto the base map occurs. Some scale differences will become apparent at this stage. The Interpreter should position the data as accurately as possible in relation to map features.

Global Positioning Systems (GPS) can be used to capture data, which can be downloaded directly into the GIS from the GPS unit. Check the positioning of these data on the maps produced. Differential GPS data should be very accurate and some features may need to be adjusted to fit. Non-differential GPS data may be inaccurate and will need to be adjusted to fit features.

Fill in the 'Map Compilation Instructions' (Appendix 8) and forward it to the GIS operator.

The *Phytophthora cinnamomi* Occurrence Map is generated from the data input to GIS and other important data (such as sample locations) can be stored in the GIS.

Relative importance of observable factors associated with the interpretation for presence or absence of *Phytophthora cinnamomi*				
Observable factors indicating high likelihood of *Phytophthora cinnamomi* presence			Observable factors indicating low likelihood of *Phytophthora cinnamomi* presence	
Observable factors				
ISD Type	Multiple	Cluster	Scattered	Isolated
Species	Some or most indicators species	Any one indicator plant	Any indicator plant	Any indicator plant
Pattern development	Obvious			Not obvious
Topographic situation	Gully/flat	Lower to mid-slope	Mid-slope to upper slope	Ridge
Casual agent	Obvious			Not obvious
Requirement for soil and tissue sample	Low	High	High	Low
(Brandis, 1983)				

Department of Environment and Conservation

Vegetation Health Service – *Phytophthora* Sample Sheet

SEND TO: Vegetation Health Service, Department of Conservation and Land Management, Kensington Research Centre, 17 Dick Perry Avenue, Kensington 6151
Phone: 9334 0317 Fax: 9334 0114

CONTACT DETAILS				Job Type (Please Indicate)			VHS USE ONLY
Name				CALM (C)	Alcoa (A)		Date
Fax No.		Phone No.		Recoup (R)	Other		Received
Region/District				Private (P)			Date
							Faxed

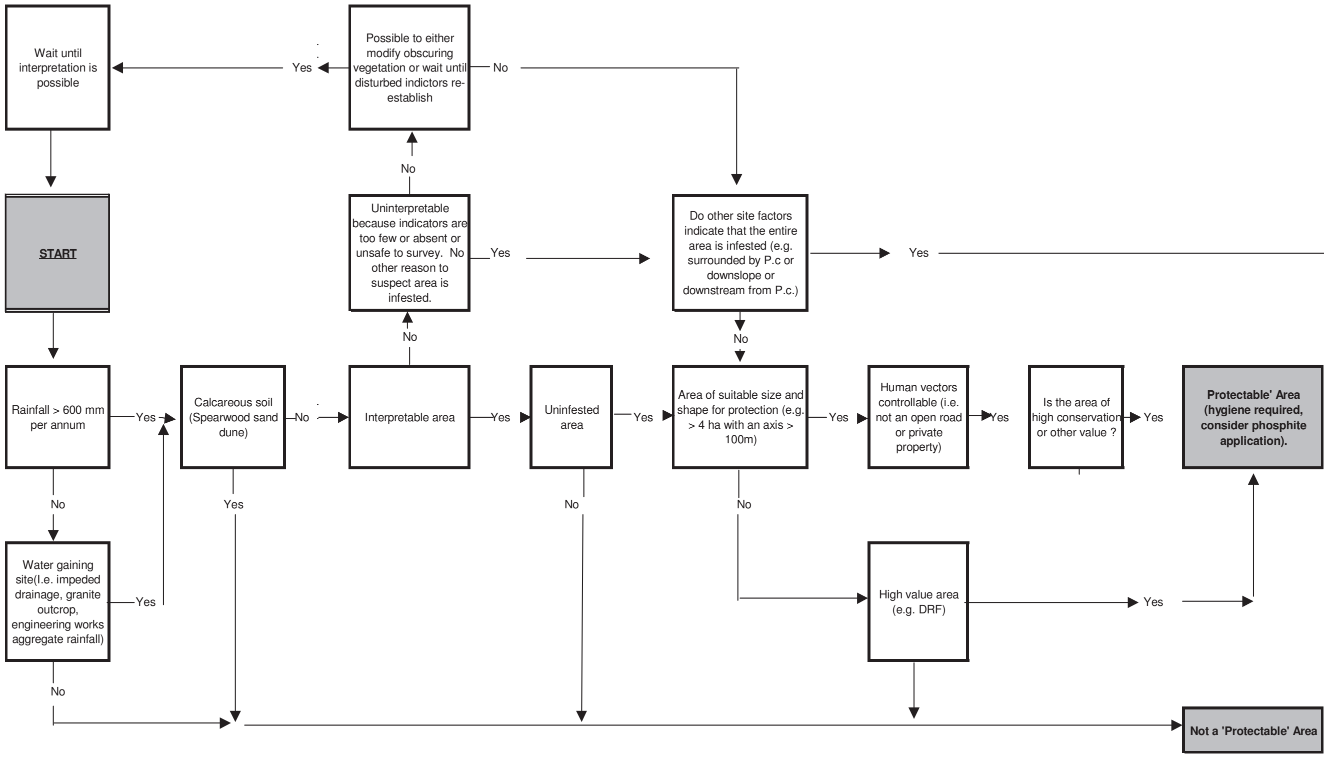
VHS Identification Number (VHS USE ONLY)	Sample Date	Sample label (Forest block, Sample number etc.)	Plant species sampled (see note (1) below)	HVS (2)	Site Impact (3)	Map Reference (4)	Land Tenure (5)	Result s/s root (6)	Result bait
						E_______ N_______			
						E_______ N_______			
						E_______ N_______			
						E_______ N_______			
						E_______ N_______			
						E_______ N_______			
						E_______ N_______			
						E_______ N_______			
								D/Base	

NOTES:
(1) When Phytophthora is to be isolated from surface-sterilized (s/s) plant tissue e.g. when interpreting a new area or when a plant is not an "Indicator Species", a Herbarium Voucher Specimen (HVS) must be supplied.
(2) Place a tick in this column when supplying a Herbarium Voucher Specimen.
(3) Site impact – Low, Moderate, High or Very High (as in the Dieback Interpreter's Manual).
(4) An AMG map reference with prefixed must be supplied for all samples.
(5) Land Tenure – State Forest (SF), National Park (NP), Reserve (R), Westrail (W), Private (P), Gravel Pit (GP), or other (describe in comments below).
(6) Result codes used – CIN = *Phytophthora cinnamomi*, CIT = *P. citricola*, CRY = *P. cryptogea*, PN = *P. nicotianae*, NEG = negative, SUB = subcultured.

COMMENTS:

Department of
Environment and Conservation

Flowchart for Determining Protectable Areas of DEC Managed Lands



Map Compilation Instructions

District: ___________________
Block: ___________________
Compartment: ___________________
Interpreted by: ____
Date completed: ___________________
Compiled by: ____ Date compiled: _________________

Method of Interpretation –

☐ Photography Cell No:________________________ Date flown: ____________________
OR ☐ Stripline assessment
OR ☐ Road survey (Burn Boundary Matrix)
OR ☐ Recheck
OR ☐ Other; please specify ____

Part of Department of Conservation Operations Graphics 1:25,000 Map: _____________________
File name of report: ____

Note:
Armillaria incidents and other Phytophthora's should be shown and clearly annotated
Annotate protectable/unprotectable areas
Annotate small areas and difficult parts of map
Ensure all features (creeks, roads, etc) are named
Boundary of interpretation (please don't draw over roads, rivers, etc), annotate what the boundary is if not obvious.

COMMENTS

Scale: __________________________ Copies Required: ____________________

Products Required:
☐ P.c. Occurrence Map
and/or ☐ P.c. Protectable Areas Map (rationalised protectable/unprotectable)
and/or ☐ P.c. Hygiene Management Map (prepared by Districts)

Waiting on sample results (= no): _____________ Date placed in digitizer's tray: _____________

Date digitized map required: _____________ Date received from digitizer: _____________

Rough map checked (SI): _____________ Digitised map checked:

DIGITISER'S USE ONLY:
File Name of plot: ________________________________
Time taken to prepare map: ________________________
Cost of digitization (time taken x hourly rate): __________
Prepared by: ____________________________________

mE	
mN	

Free =	Ha	Total UP (unihat + frehat) =	Ha
Uni =	Ha		
Pc =	Ha	Total FRE (fre + frehat) =	Ha
Unihat =	Ha		
Frehat =	Ha	Total UI (uni + unihat) =	Ha
TOTAL =	Ha		

Phytophthora cinnamomi Report Format

Access Id.
No.
Date:

Phytophthora cinnamomi (P.c.) REPORT
BLOCK/s:
COMPARTMENT/s:

INTERPRETERS:

REPORT AUTHOR AND DATE:

MAP FILE NAME/IDENTIFICATION NUMBER:

Total area interpreted (ha)	
DRA – Yes / No	
Method of interpretation 230mm film/ Stripline/Recheck/ Road Alignment/Other (specify)	
Scale of film: Date of photography	
Major tree species:	
Map Scale:	
Commencement date	(/ /)
Completion date	(/ /)
Products	Phytophthora cinnamomi Protectable Areas Map, Demarcation Map and Report

FMB Copy

CHECKED BY SI/DSO: ______________________
DATE: ______________________

Department of
Environment and Conservation

Phytophthora cinnamomi Interpretation Standards Monitoring Form

P.c. Interpretation Standards Monitoring Form

District:	Area Name/Cell Number:
Forest Block/s:	Compartment/s:
Area (ha):	
Interpreter/s and no. year's interpreting	
SI/DSO Name:	Date:
Overview of Area:	

Na = not assessed or not applicable

				Comments
1. Preparation for interpretation				
Has the pre-job checklist been completed?	**yes**	**no**	**na**	
Has the District been informed interpretation has commenced?	**yes**	**no**	**na**	
2. Safety				
Has the disposition board been updated?	**yes**	**no**	**na**	
Is the vehicle driven to the supervisor's satisfaction?	**yes**	**no**	**na**	
3. Interpretation				
Have all *Pc* indicators been recognised?	**yes**	**no**	**na**	
Has the disease caused by Pc been correctly identified?	**yes**	**no**	**na**	
Have all category boundaries been correctly determined in field?	**yes**	**no**	**na**	
Have boundaries been recorded correctly on photos or base map?	**yes**	**no**	**na**	
Have the buffers been applied correctly?	**yes**	**no**	**na**	
Is the demarcation adequate and visible?	**yes**	**no**	**na**	
How many samples taken from area?				
Is the sampling technique appropriate?	**yes**	**no**	**na**	
Have the sample information sheets been filled out correctly?	**yes**	**no**	**na**	
Do the Interpreters regularly communicate?	**yes**	**no**	**na**	
Have unprotectable areas been determined in the field?	**yes**	**no**	**na**	
Is reference material consulted when required?	**yes**	**no**	**na**	
Have other impacts on native vegetation been recognised?	**yes**	**no**	**na**	
Has Armillaria been correctly identified?	**yes**	**no**	**na**	
4. Stripline method				
Has the appropriate stripline width been applied?	**yes**	**no**	**na**	
Has the difference between grid north and magnetic north been accounted for in the field and on base map?	**yes**	**no**	**na**	
Has each stripline start point been marked in field?	**yes**	**no**	**na**	
Have interpretation details been recorded onto a booking form or base map?	**yes**	**no**	**na**	
Were interpretation details discussed at the end of each line?	**yes**	**no**	**na**	
Has the area been covered systematically?	**yes**	**no**	**na**	
5. Modified Surveys (e.g. linear, probability survey)				
Were all interpretation procedures followed re: manual?	**yes**	**no**	**na**	

6. Photo interpretation				
Were all visible ISDs identified on film?	**yes**	**no**	**na**	
Were all visible check sites and uninterpretable areas identified on film?	**yes**	**no**	**na**	
Is there a system for recording who and what was ISDed?	**yes**	**no**	**na**	
Have ISD/s been located accurately in field?	**yes**	**no**	**na**	
Have ISD/s once visited been marked off on film?	**yes**	**no**	**na**	
Have ISD/s once visited been marked in field (with tape)?	**yes**	**no**	**na**	
7. Rechecking				
Were all disease boundaries checked adjacent to protectable areas?	**yes**	**no**	**na**	
Were all open roads, tracks and areas of disturbance checked?	**yes**	**no**	**na**	
Were old tapes removed and replaced with new ones if required?	**yes**	**no**	**na**	
Have old blaze lines been indicated on a map for removal?	**yes**	**no**	**na**	
8. GPS use				
Is the GPS checked against known co-ordinates daily?	**yes**	**no**	**na**	
Is the EPE monitored constantly for reliability?	**yes**	**no**	**na**	
9. Hygiene				
Have hygiene requirements been considered while interpreting?	**yes**	**no**	**na**	

General Comments:

Action Items	Done
	Yes/no
	Yes/no
	Yes/no
	Yes/no
	Yes/no

TABLES FOR VHS REPORTS

1. Interpreters are about to commence work in Barrabup Block prior to logging and want to know the last time it was interpreted, where and how many samples were taken and what the results were (Table A 11.1)
2. Interpreters in Albany are interested to know which plant species they have sampled in the past two years that have been associated with positive results (Table A 11.2)
3. The DSO wants to compare the sampling intensity between major offices in the last month (Diagram 3).

Table A 11.1: Sample sites in Barrabup Forest block, their location and the result.

Wednesday, 15 December 1999

Id no	Office sending	Date sampled	Sample label	TaxonID	Spcode	AMG east	AMG north	Zon e	Result
16379	ALBA	6/10/1998	GULL ROCK SAMPLE 2	1600	BANATT	59525 0	6124700	50	CIN A2
14922	ALBA	4/03/1998	FRNP SAMPLE 2	1803	BANBAX	73065 0	6244300	50	CIN
14924	ALBA	4/03/1998	FRNP SAMPLE 4	1811	BANCOC	73065 0	5244300	50	CIN A1
19465	ALBA	18/05/1999	SRNP 1	15067	DAVGLO	61745 5	6192833	50	CIN
14921	ALBA	4/03/1998	FRNP SAMPLE 1	2246	LAMINE	73065 0	6244300	50	CIN A1
18466	ALBA	4/05/1999	FRNP 1	2248	LAMINE	73045 0	6244500	50	CIN
14923	ALBA	4/03/1998	FRNP SAMPLE 3	2304	PETPHY	73065 0	6244300	50	CIN

Albany Species associated with positive results.

Wednesday, 15 December 1999

Id no	Office sending	Date sampled	Sample label	AMG east	AMB north	Result	Forest Blk
3701	BUNB	10/09/1993	RUN 6 FRAME 5157 S-1	382161	6244984	NEG	BARRABUP
3702	BUNB	10/09/1993	RUN 6 FRAME 5176 S-1	372001	6244664	NEG	BARRABUP
3703	BUNB	10/09/1993	RUN 6 FRAME 5176 S-2	381833	6244526	NEG	BARRABUP
3704	BUNB	10/09/1993	RUN 7 FRAME 5150 S-1	382601	6245304	NEG	BARRABUP
3715	BUNB	14/09/1993	RUN 5 frame 5185 S-1	381382	6246135	NEG	BARRABUP
3721	BUNB	15/09/1993	RUN 3 FRAME 5029 S-1	379933	6245997	NEG	BARRABUP
3722	BUNB	15/09/1993	RUN 7 FRAME 5150-S-2	382641	6245144	NEG	BARRARUP

Diagram 3: Number of samples processed by the VHS in October

Indicators Commonly Used by Interpreters

Family	Genus & Species	Common Name	District/Zone					
			Swan Coastal Plain	Northern Jarrah Forest	Central Jarrah Forest	Southern Jarrah Forest	Karri Forest	South Coast Coastal

Indicators Commonly Used by Interpreters									
Family	Genus & Species	Common Name	District/Zone						
				Swan Coastal Plain	Northern Jarrah Forest	Central Jarrah Forest	Southern Jarrah Forest	Karri Forest	South Coast Coastal

Indicators Commonly Used by Interpreters									
Family	Genus & Species	Common Name	District/Zone						
				Swan Coastal Plain	Northern Jarrah Forest	Central Jarrah Forest	Southern Jarrah Forest	Karri Forest	South Coast Coastal

16GLOSSARY

Cotyledon
First leaves to shoot from a seed, part of the embryo in a seed plant.

Disease Risk Area (DRA)
Any areas of public land which in the opinion of the Executive Director may become infected with a forest disease and has been gazetted by the Governor as such on the recommendation of the Minister. Also known colloquially as ‘Quarantine Areas’. A special permit is required to enter these areas. Contact local District Office for details.

Heterothallic
Zoospores that are sexually self-incompatible, which need to mate with another mating type to produce oogonia.

Homothallic
Zoospores that are sexually self-compatible, and can produce oogonia without the presence of another mating type.

Hygiene
Actions which decrease the risk of the pathogen’s introduction, spread, intensification or survival.

Hyphae
Threadlike strands or filaments that constitute the body of a fungus. Some hyphae are specialised for penetrating host tissue or producing spores.

Impact
The effects of disease on plant health.

Incipient disease
Vegetation in which *Phytophthora cinnamomi* may be present but symptoms are yet to appear.

Infested
Vegetation determined by a qualified Interpreter or by sampling evidence to have plant disease symptoms consistent with the presence of *Phytophthora cinnamomi*.

Lesion
An evident but limited diseased area of part of a host.

Mini-catchments
An area within a larger catchment, in which the surface water run-off is contained to one drainage line.

Mycelium
A mass of fungal hyphae which forms the body of the fungus.

Oogonia
Sexual reproductive structures of oomycete fungi including *Phytophthora* that can also be used in the identification procedure.

Risk
The probability of an operation introducing, spreading or intensifying dieback disease, or allowing the pathogen to survive at the site.

Soil movement
The movement of moist soil sticking to the wheels, tracks or other parts (for example forks and blades) of vehicles and machinery.

Split phasing
The separation of component tasks of an operation in time and/or space, so as to minimise opportunities for dieback disease spread.

Sporangium
An ovoid or ellipsoid spore sac approximately 00.057 x 0.033 mm (of *Phytophthora cinnamomi* only) that vegetatively produces zoospores. Used in the identification procedure.

Zoospores
A motile spore approximately 0.01 mm (Pc) in diameter produced asexually within a sporangium and released in free water.

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APPENDIX B

Phytophthora cinnamomi and Disease Caused by it, Volume 1 - Management Guidelines

GOVERNMENT OF WESTERN AUSTRALIA

DEPARTMENT OF Conservation AND LAND MANAGEMENT

Conserving the nature of WA

PHYTOPHTHORA CINNAMOMI AND DISEASE CAUSED BY IT

Volume I – Management Guidelines

2003

CONTENTS

SECTION 1 - INTRODUCTION

1.1 BACKGROUND - *PHYTOPHTHORA CINNAMOMI* & PLANT DISEASE CAUSED BY IT

The colourless microbe known to science as *Phytophthora cinnamomi* is infamous world wide for its capacity to invade and destroy the function of the root systems of an extraordinary range of plants. The slow moving epidemic of destructive root disease the pathogen causes in native vegetation in Australia is known as *Phytophthora* dieback. The impact of this now widespread pathogen, believed by many to have been first introduced to Western Australia at or soon after European settlement in 1828, varies greatly across the landscape. (Figure 1.1)

In Western Australia *Phytophthora cinnamomi* will continue its autonomous spread from all its established disease fronts. The rate of uphill spread via root to root contact amongst host plants has been reported as approximately one meter per annum under idea environmental conditions. The cross slope and down-slope rate of spread occurs at a faster rate due to the influence of surface and sub-surface water-flows on the dispersal of zoospores. Native animals, feral animals and people act as vectors aiding the wide and rapid spread of *Phytophthora cinnamomi*, thereby enabling it to establish new centres of infestation in previously uninfested areas.

Limited control of *Phytophthora cinnamomi* and disease it causes is possible over small areas through repeat application of phosphite. Phosphite can be used to increase the resistance of threatened flora, threatened ecological communities and the habitat of threatened native fauna.

The only other direct management action that the Department and other land managers can take at present is to control human vectoring of the pathogen. This can be achieved through the application of rigorous hygiene to ensure that all who have a valid reason to enter uninfested areas are clean upon entry. (i.e. do not carry the pathogen with them into uninfested areas).

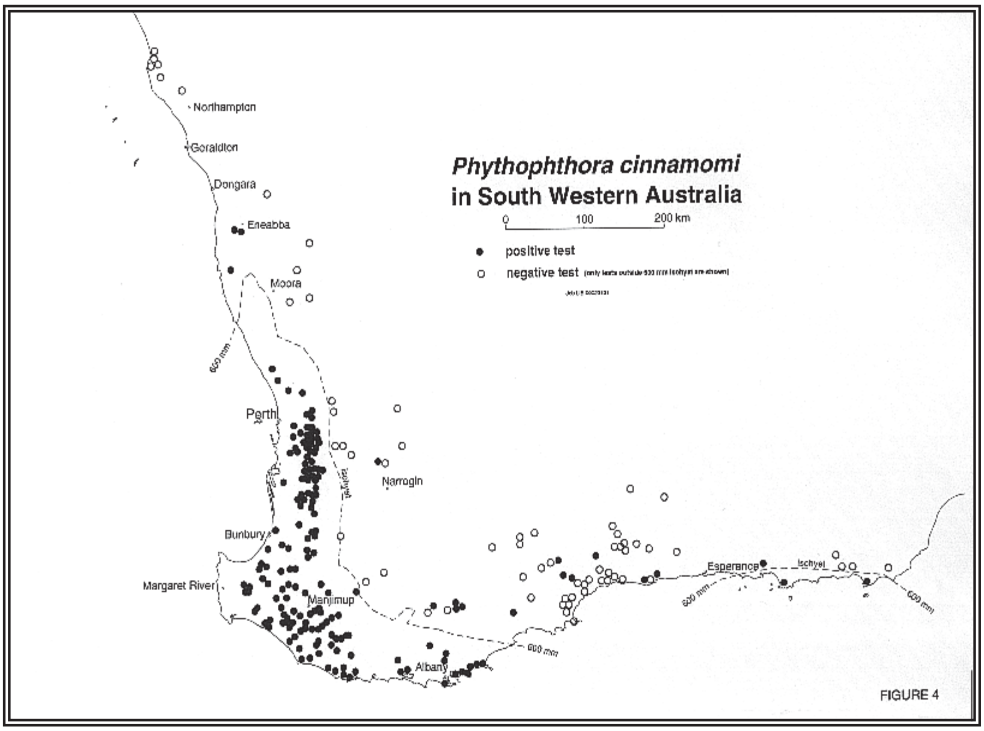


Figure 1.1 Distrubution of disease in native vegetation caused by *Phytophthora cinnamomi* in Western Australia

1.2 PURPOSE OF THIS MANUAL AND EACH OF ITS VOLUMES

This manual :-

- Provides the Department with a single source document on :-
  a) Information about the pathogen *Phytophthora cinnamomi* and diseases it causes (*Phytophthora cinnamomi and disease caused by it. Volume I - Management Guidelines* and *Phytophthora cinnamomi and disease caused by it. Volume II – Guidelines for Detection, Diagnosis and Mapping of Disease caused by Phytophthora cinnamomi.*),
  b) Management guidelines (*Phytophthora cinnamomi and disease caused by it . Volume I - Management Guidelines*),
  c) Disease detection, diagnosis (interpretation), demarcation and mapping guidelines (*Phytophthora cinnamomi and disease caused by it. Volume II –Guidelines for Detection, Diagnosis and Mapping of Disease.*)
  d) Phosphite operational guidelines (*Phytophthora cinnamomi and disease caused by it . Volume III - Phosphite Operations Guidelines*), and

e) Training curriculum and syllabi (*Phytophthora cinnamomi and disease caused by it . Volume IV - Training Curriculum and Syllabi*)

- Eliminates the need for detailed information about the pathogen, the diseases it causes hygiene practices and phosphate use being included in the Department's other manuals.
- Replaces Administration Instruction No. 46 "Departmental Procedures for Approval of 7-Way Tests", the Hygiene Evaluation form and the Hygiene Manual.

1.3 PROCEDURE FOR UPDATING AND MAINTAINING THIS MANUAL

1.3.1 Manual Updates

Each page of this manual is numbered and date stamped. The Department's *Phytophthora* Management Coordinator is responsible for authorising all updates to the manual.

1.3.2 Maintaining manuals

Manuals are issued to individual managers and their staff who are responsible for ensuring that their copy is up to date through regular liaison with the *Phytophthora* Management Coordinator and by regularly down loading updated versions from the Department 's website.

SECTION 2 – TERMINOLOGY, CONCEPTS AND GLOSSARY

2.1 NEED FOR USE OF PRECISE TERMINOLOGY

Understanding the correct meaning of words prevents confusion in the use of terms and their conceptual basis. Correct word use stops the invention of new ambiguous words that in turn encourage tautological and counter intuitive language. Clear, concise and accurate communication leads to major savings and improved conservation outcomes.

2.2 GLOSSARY OF COMMON WORDS

Basic Raw Materials means rocks, stone and sand.

Consequence means the outcome of the introduction of *P. cinnamomi* into an uninfested area of native vegetation being a loss, injury, disadvantage or gain.

Hazard means a source of potential harm or a situation with the potential to cause loss.

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

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

Hypha means a single tubular filament of a fungus, oomycete, or chytrid; the hyphae together comprise the mycelium.

Infested areas means areas that accredited person have determined have plant disease symptoms consistent with the presence of the pathogen *P. cinnamomi*.

Landscape unit means the area used in the analysis of the need for, and the determination of the boundaries of, areas to be mapped for *Phytophthora cinnamomi* Occurrence, for determining 'protectable' areas and their appropriate boundaries, and for preparing *Phytophthora cinnamomi* Management Plans. A landscape unit is an area bounded by features such as creeks, ridges, saddles, open roads and/or freehold land.

Pathogen means any organism or factor causing disease within a host.

***Phytophthora cinnamomi* Management Map** means the map prepared as part of 'protectable' areas *Phytophthora cinnamomi* management planning process. It records details of planned management actions and is placed in District and FMB records systems.

***Phytophthora cinnamomi* Management Plan** means the document (includes appended maps) that describes and controls how human access to uninfested 'protectable' areas is to be managed so that the role of humans as vectors in establishing new centres of infestation will be reduced to the lowest possible level.

***Phytophthora cinnamomi* Occurrence Map** means the main map produced by Interpreters. It shows *Phytophthora cinnamomi* occurrence, *Phytophthora cinnamomi* free areas, uninterpretable areas and may show un'protectable' areas.

'Protectable' area means areas, include areas of high conservation and/or socio-economic value (E.g. a small uninfested area which contain a known population of a susceptible species of threatened flora) within the vulnerable zone that:

- Are situated in zones receiving > 600 mm per annum rainfall or are water gaining sites (E.g. granite outcrops, impeded drainage or engineering works which aggregate rainfall) in the 400-600 mm per annum rainfall zone
- Do not have a calcareous soil (e.g. not a Quindalup dune system)
- Have been determined to be free of the pathogen *P. cinnamomi* by a qualified Disease Interpreter (all susceptible indicator plant species are healthy, no plant disease symptoms normally attributed to *P. cinnamomi* are evident)
- Are positioned in the landscape and are of sufficient size. (E.g. > 4 ha with axis > 100m) such that a qualified Interpreter judges that the pathogen will not autonomously engulf them in the short term (a period of a few decades)
- Consists of areas where human vectors are controllable (E.g. not an open road, private property)

Phosphite means an aqueous solution of mono- and di-potassium phosphite

Precaution means an action(s) taken beforehand to avoid environmental degradation or to ensure a good environmental outcome.

Precautionary Principle has the meaning as stated in the Intergovernmental Agreement on the Environment (1992):

> " Where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. In the application of the precautionary principle, public and private decisions should be guided by:
> (a) careful evaluation to avoid, where-ever practicable, serious or irreversible damage to the environment: and,
> (b) an assessment of the risk-weighted consequences of various options."

Principles of Sustainability has the same meaning as Section 19(2) of the *Conservation and Land Management Act 1984.*

Risk means the chance of uninfested area becoming infested through the autonomous actions of the pathogen or the actions of people and animals or a combination of these factors, measured in terms of the magnitude of consequences of that event should it occur and the likelihood of the event and its consequences occurring, assessed in the context of existing controls.

Risk analysis means a systematic use of available information to determine how often specified events may occur and the magnitude of their consequences.

Risk control means that part of risk management that involves the implementation of policies, standards, procedures and physical changes to eliminate or minimise adverse risks.

Risk evaluation means the process used to determine risk management priorities.

Risk management means the culture, processes and structures that are directed towards the effective management of potential opportunities and adverse effects.

Risk treatment means the selection and implementation of appropriate options for dealing with risk.

Susceptible means influenced or harmed by *P. cinnamomi*.

Threat means an indication that serious or irreversible environmental damage may occur.

Uninfested areas means areas that an accredited person has determined to be free of plant disease symptoms that indicate the presence of the pathogen *P. cinnamomi.*

Uninterpretable areas means areas situated in areas receiving > 600+ mm per annum rainfall or are water gaining sites (eg. granite outcrops, impeded drainage or engineering works which aggregate rainfall) in the 400-600mm per annum rainfall zone where indicator plants are absent or too few to determine the presence or absence of disease caused by *P. cinnamomi.*

Vulnerable means is susceptible to physical injury.

Vulnerable zone means that part of the South West Land Division and the areas adjoining it to the north western and the south eastern that receive greater than 400 mm per annum rainfall and in which susceptible native plants occur in conjunction with the environmental factors required for the pathogen *P. cinnamomi* to establish and persist.

SECTION 3 - BIOLOGY OF *PHYTOPHTHORA CINNAMOMI*

3.1 DESCRIPTION OF *PHYTOPHTHORA CINNAMOMI*

Phytophthora cinnamomi and other members of the genus *Phytophthora* are not part of the Fungi kingdom but instead belong to the water moulds or Oomycota (class Oomycetes) which are placed in the Kingdom Chromista (or Stramenopila).

Phytophthora cinnamomi is an introduced soil-borne pathogen that kills a wide rage of plant species in the South West by attacking their root system. *Phytophthora cinnamomi* can also survive and reproduce on a wide range of native plants without killing them. It has a widespread but discontinuous distribution in areas of the South West with an annual rainfall above 400mm.

There are over 50 species of *Phytophthora* which occur around the world and all of them cause plant diseases. *Phytophthora cinnamomi* is the *Phytophthora* species most frequently isolated from areas of dead vegetation in the South West.

Phytophthora cinnamomi has a superficial resemblance to fungi but they are different in that their cell walls are cellulosic rather than chitinous. The pathogen grows as microscopic sized filaments (mycelium) on the surface of plant roots (Figure 3.1) and invades the cells of susceptible host plants Figure 3.4). Their food source is the root and basal stem tissue of living plants.

The pathogen consumes the host plant causing lesions (areas that appear rotten). This weakens or kills the plants by reducing or stopping the movement of water and nutrients within the plant. Once attacked susceptible hosts rarely recover. Most succumb to a "sudden death" syndrome, rather than a "dying back or dieback" syndrome.

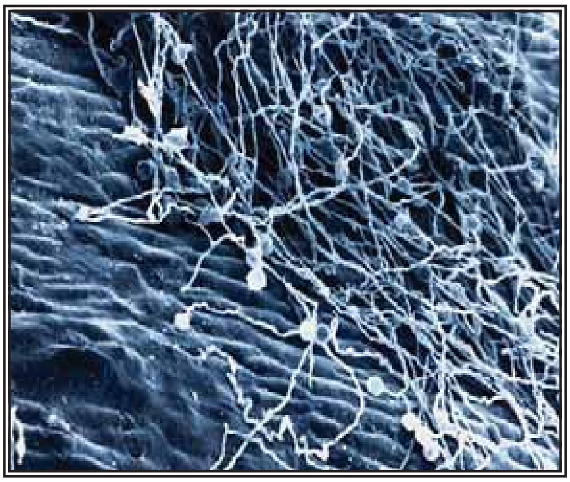


Figure 3.1 Mycelium growing on a the surface of a root

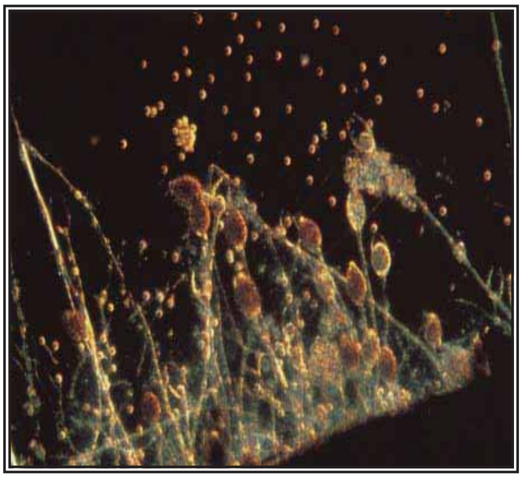


Figure 3.2 Spore sacs of *P. cinnamomi* release zoospores that swim in free water and infect nearby roots

Figure 3.3 Hyphal swellings of *P. cinnamomi*

Figure 3.4 Germ-tubes penetrating a root

Figure 3.5 Zoospore growing sporangia

Figure 3.6 *Phytophthora cinnamomi* growing on agar plate

3.2 LIFE CYCLE OF *PHYTOPHTHORA CINNAMOMI*

The life cycle of *Phytophthora cinnamomi* (Fig. 3.7 & 3.8) depends on moist conditions that favour survival, sporulation and dispersal.

The pathogen is not capable of photosynthesis and so it needs to extract food from living plant tissue. It does this via a mass of microscopic threadlike mycelium that form the body of the organism that grows through host tissue. Mycelia continue to growth within the host tissue when it is above 80% moisture ambient. Mycelia may be transported in soil and host tissue and deposited where it may infect new hosts. The mycelium, given warm, moist conditions are capable of producing the millions of tiny spores that reproduce the pathogen. Two kinds of spores are likely to be found.

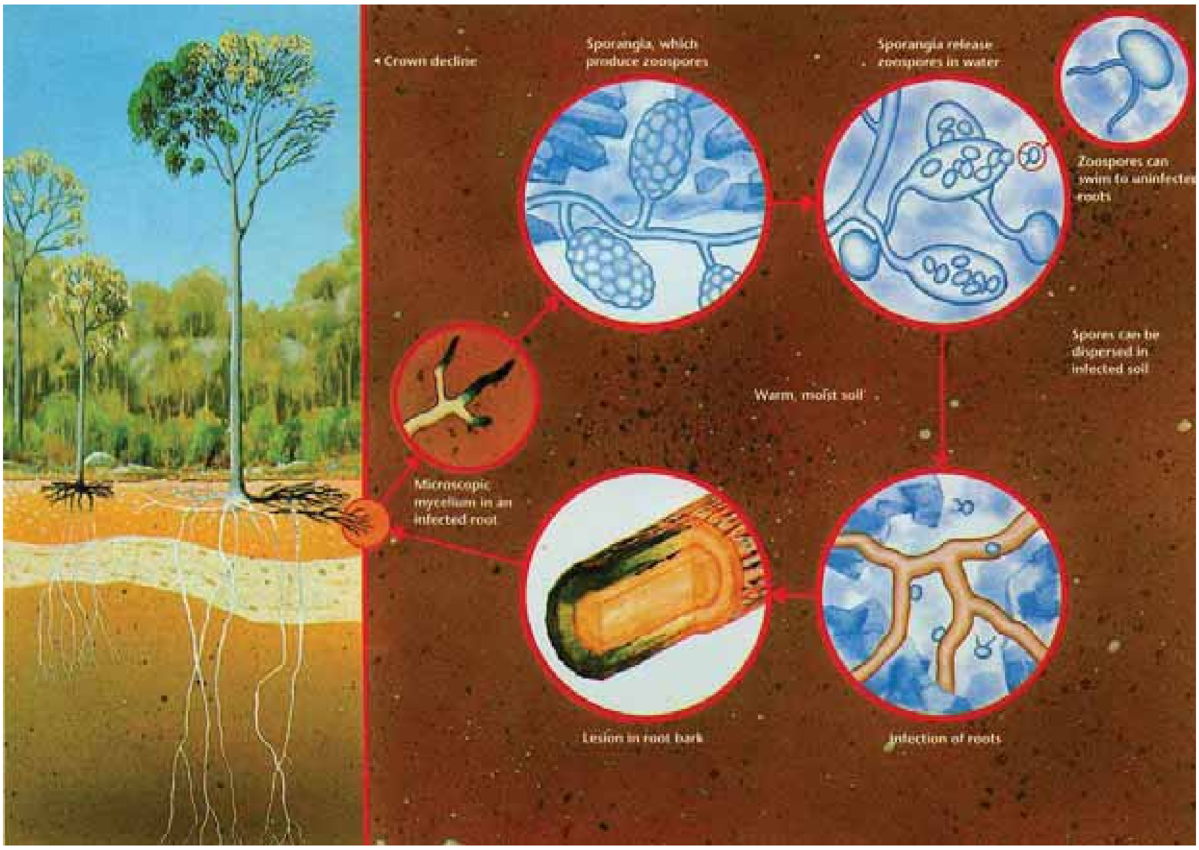
<u>Zoospores</u>
Very small spores that can actively swim very short distances towards new hosts and initiate new infections. They are short-lived and fragile but produced in large numbers, and are the mode for the spread of the disease from one plant to the next. They can also be carried along in moving water over large distances. As they move through the soil zoospores lodge on plant roots, infect them, and in susceptible plants produce mycelia. The mycelium grows, feeding on the host, rotting the roots and cutting off the plant's water supply. The mycelium may grow from plant to plant via root to root contact points and/or root grafts.

<u>Chlamydospore</u>
Larger spores that are tough and long-lived (within dead plants and the soil). They are produced under unfavourable conditions and are the resistant resting phase of the pathogen. They may be transported in soil or roots and then germinate to cause a new infection when they encounter favourable conditions. The chlamydospores produce mycelium and zoospores.

When conditions are warm and moist, microscopic spore sacks called sporangia and thick walled chlamydospores are produced vegetatively from mycelia strands that form the body of the pathogen in the soil or host tissue. The sporangia release motile zoospores in free water to infect host roots. Mycelia of different mating types may grow together inducing the production of thick walled sexual spores called oospores. The mating types are called A1 or A2. Only one mating type (A1) occurs in WA. Currently the pathogen cannot reproduce sexually in WA and relies on vegetative reproduction for survival and dispersal.

After infection, the pathogen invades root bark and forms lesions that may extend in to the plants stem collar. In susceptible species infection of roots and collar results in death of the host. Once dispersed, the spores may infect a wide range of resistant and susceptible hosts.

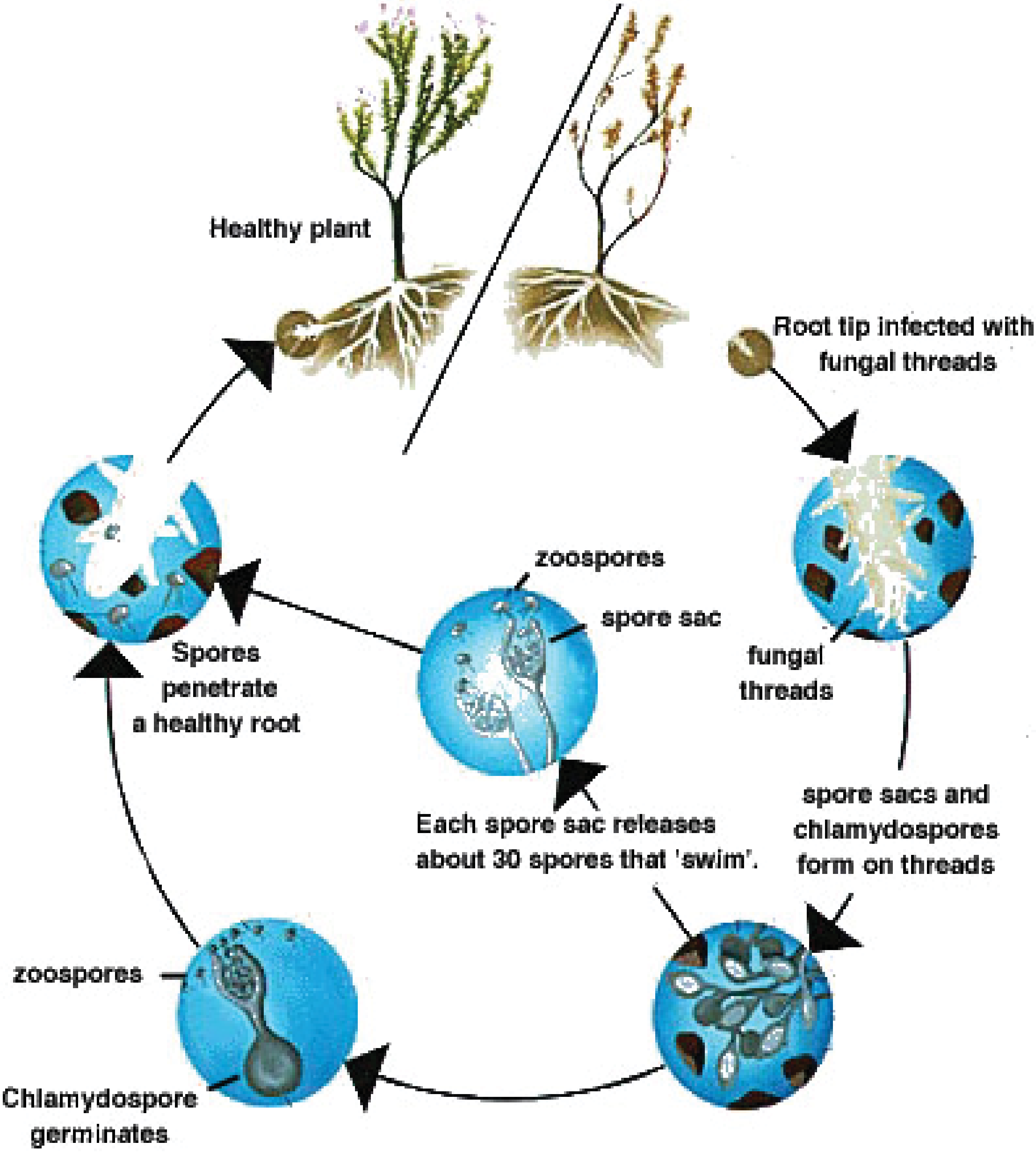
Figure 3.7



Created on: 13/01/99
Last updated: 02/03/03
Custodian: ***Phytophthora* Management Coordinator**
Approved by: **Director Nature Conservation**

Figure 3.8

Generalised Life Cycle of Phytophthora cinnamomi



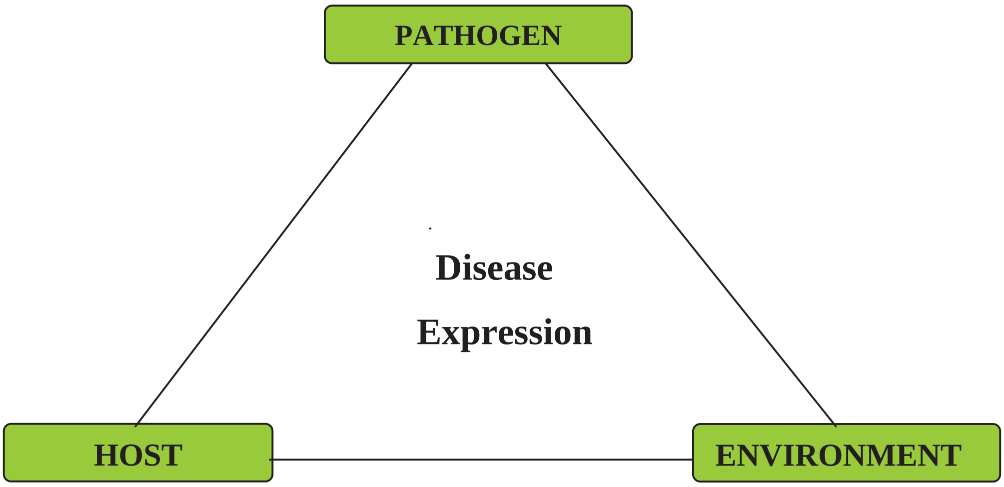
3.3 DISEASE TRIANGLE

DISEASE: A combination of a pathogen, host and correct environmental conditions, which results in the expression of disease symptoms in the host.

ENVIRONMENT: The sum of all the factors that act on an individual organism during its lifetime.

HOST: The plant which is invaded by a pathogen and from which the pathogen derives it's energy.

PATHOGEN: Any organism or factor that derives its energy or nutrients from a host, often causing disease in the host.



The lack any one at a particular field site means that disease in native plants will not occur.

3.4 INTERACTION OF THE PATHOGEN WITH THE HOST

Phytophthora cinnamomi has a very wide host range. At least 1000 species from taxonomically diverse families have been reported as hosts for *Phytophthora cinnamomi* of which nearly half have been recorded from research in Australia. Indigenous species most affected belong to four families:

- Proteaceae
- Epacridaceae
- Papilionaceae/Fabaceae
- Myrtaceae

Not all genera within a family or all species within a genus are necessarily susceptible. E.g. some species of Eucalyptus are highly resistant (including Karri, Marri, Wandoo and Tuart) while some, such as Jarrah, are affected but have the ability to resist the invasion of the pathogen under certain conditions (Tissue moisture content < 80%).

Broad estimates are that perhaps 1500 to 2000 species of the estimated 8000 species of vascular plants in the South West of WA may be susceptible to the degree that successful infections result in the death of the host.

The interaction between pathogen and host starts with infection, with zoospores and mycelium growth via root to root contact initiating most infections. Zoospores are attracted to the growing tips of roots chemotacticly, they encyst and germinate to produce germ tubes which penetrate roots. Hyphae proliferate within roots, macerating tissues and causing the roots to rot. The mycelium feeds on sugars within the plant's cells

Once the pathogen has established within the roots of a prospective host, it establishes within unlignified cortical tissue and the phloem. This blocks the conductive tissue and prevents the uptake of water and nutrients

Host plants can resist the attack with the formation of blocking lesions or resist entry by having tough epidermal cells on root hairs. Those that do not die will, once the destruction of their conductive tissue reaches the point where they are unable to sustain themselves.

Figure 3.9 illustrates the progressive spread of *Phytophthora cinnamomi* and its impact on various elements of the vegetation.

The top section of figure 3.9 shows a horizontal view of a transect in uninfested jarrah forest prior to introduction of *Phytophthora cinnamomi*. The three tiered stand structure of ground cover, dense *Banksia* understorey, and eucalypt overstorey. Three structural arrangements are shown:

1. Selection logged old growth.
2. Seventy year old uniform regrowth arising from clear felling of old growth.
3. Virgin old growth. Note also dead branches protruding above the canopy of a number of the large veteran old-growth trees.

The lower section of Figure 3.10 shows the same transect 3-5 years after introduction *of Phytophthora cinnamomi* at point X, with concurrent death ("mass collapse") of understorey of *Banksia grandis* and mature jarrah of the overstorey on a high impact site. The distribution of *Phytophthora cinnamomi* in soil beneath the forest is indicated by circles, the vertical columns indicate the relative intensity of infestation. Arrows indicate the direction of spread and relative rates of spread downslope left and upslope right.

Figure 3.10 illustrates the movement of a “wave front” of high density *Phytophthora cinnamomi* at the perimeter of a diseased area and the decline in pathogen numbers in the wake of infection.

The top section of figure 3.10 shows the relationship of infestation to disease expression zones.

a) outer limit of pathogen free buffer zone (wider downslope left than upslope right)
b) outer limit of cryptic infection and disease symptoms.
c) inner limit of wave of active disease.

The lower section of figure 3.10 shows the variation in disease impact on jarrah trees:

1) e-f low impact on jarrah but elimination of *Banksia* .

2) f-g "graveyard" site of high impact on both jarrah overstorey and *Banksia* understorey with gradual colonisation by marri in an open woodland.

Figure 3.9

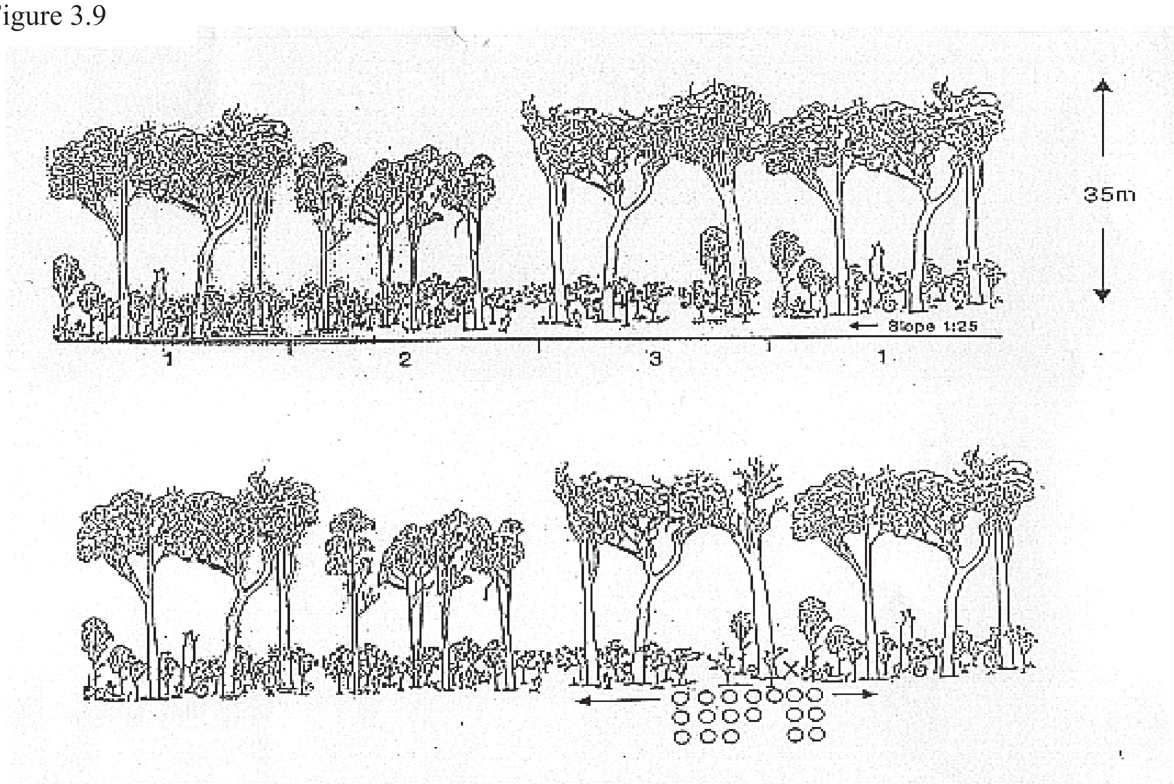
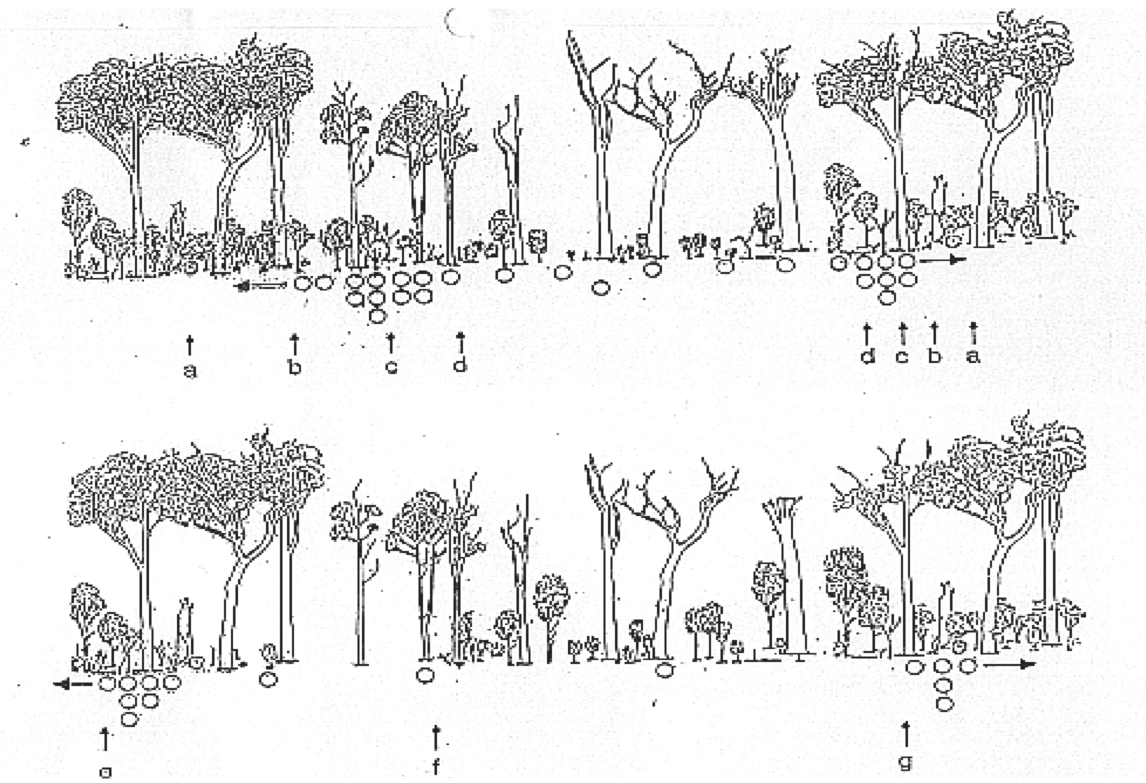


Figure 3.10



3.5 DETECTION, DIAGNOSIS, DEMARCATION AND MAPPING

A detailed field survey by trained observers is necessary in order to discriminate between areas that exhibit the visible symptoms of plant disease in native vegetation attributable to the pathogen *P. cinnamomi,* from those areas that appear to be free of visual disease symptoms (Figure 3.11 & 3.12). Confirmation of the presence of the pathogen may often be made by the laboratory analysis of soil samples and root tissue taken from dead and dying plants

Detection of disease symptoms, sampling of soil and plant tissue for laboratory analysis, diagnosis, filed demarcation and mapping for the presence of *Phytophthora cinnamomi* is described in detail in '*Phytophthora cinnamomi and disease caused by it. Volume II –Guidelines for Detection, Diagnosis and Mapping of Disease caused by Phytophthora cinnamomi'*.

The boundary between infested and uninfested areas is generally demarcated using red flagging tape or yellow painted blazes (Figure 3.13 & 3.14).

Figure 3.11 Small ground cover and undestory plants exhibit symptoms of the lethal disease caused by *P. cinnamomi*.

Figure 3.12 Impact of *P. cinnaomi* on *E. marginata* (Jarrah) forest

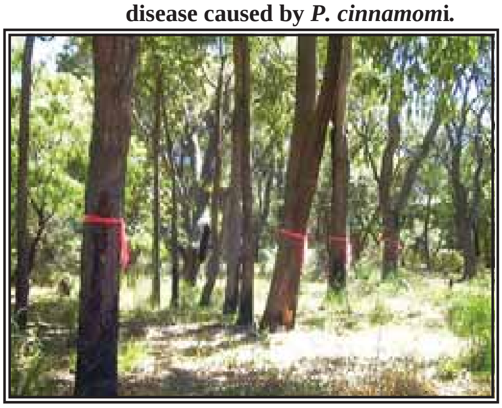


Figure 3.13 Field demarcation.

Figure 3.14. Field demarcation – separating infested areas from uninfested areas

SECTION 4 - THE NATURE OF THE THREAT POSED BY *PHYTOPHTHORA CINNAMOMI* IN WESTERN AUSTRALIA

4.1 HISTORY OF INTRODUCTION AND SPREAD

Since 1921 it has been evident that an increasing number of patches of formerly healthy jarrah forest have become afflicted with a lethal disease known as "jarrah dieback" ('JDB').

Until 1964, the cause of this malady had been the subject of contending speculation. In that year proof of the role of the plant pathogen *Phytophthora cinnamomi* as the cause of 'JDB' was established. At the same time, it was recognised that this exotic microbe was also intimately associated with similar damage in other plant communities of sclerophyllous natives, whether jarrah was dominant, a minor component only, or not present at all. The period of intensive research that followed is ongoing and has resulted in revised perceptions of the nature of the pathogen and of the diseases that result from its interactions with the enormously diverse native vegetation of south western Australia.

Phytophthora cinnamomi is a soil-borne micro-organism of foreign origins. It almost certainly entered Western Australia for the first time on soil around the roots of cultivated plants, shortly after European settlement in 1827. Until the effective implementation by Australia of quarantine of import of exotic soil and plant products, there must have been innumerable introductions at many points of entry around the continent and its redistribution within the country over a period of some 150 years.

Phytophthora cinnamomi has now extended its largely unfettered colonisation of the southwest by human and animal (native and feral) movement of infested soils and autonomous spread (the latter largely by growth of the pathogen in the root systems of highly susceptible native plants, but also assisted by sub-surface and over land flow of water carrying zoospores). This epidemic of colonisation, which has produced a complex mosaic of infested and uninfested areas, is now well on its way toward the middle stages of its ultimate potential to occupy all of those sites which are environmentally suited to its establishment, survival and multiplication. Such sites are very widely distributed over some 20% or more of the natural vegetation in areas throughout that part of the South West Land Division that receives mean annual rainfall in excess of 800mm and occur sporadically at lower rainfall.

Within the 600 – 800mm rainfall zone the occurrence of *Phytophthora cinnamomi* is also widespread but much less extensive. In this zone, severe damage to native vegetation is largely confined to water-gaining sites or to years with an abnormally high summer rains. In these circumstances localised patches of the vegetation may periodically suffer severe damage with intervals of recovery during drier periods.

In areas receiving < 600mm rainfall per annum, root rot caused by *Phytophthora cinnamomi* is restricted to circumstances where localised hydrological effects, such as the shed from granite bosses or rising ground water tables associated with up-slope land clearance in the catchment, cause effective rainfall to substantially exceed the regional patterns.

There is no record of *Phytophthora cinnamomi* establishing in natural ecosystems in regions receiving < 400mm rainfall per annum. It may occur in irrigated horticultural activities.

4.2 DISEASE SYNDROMES

The effect of *Phytophthora cinnamomi* upon the health of plant communities, and upon the species in them, varies greatly. In many places, lethal root-disease destroys the structure of many native communities, reduces their floristic diversity, decimates their primary productivity and destroys habitat for much dependant native fauna, particularly its value as protection against feral predators. In some places the pathogen causes little damage at all. Unfortunately the extent of susceptible communities in vulnerable environments is much greater than that of communities which occur in environments which are inherently unfavourable to the pathogen.

No simple or single relationships exist between the presence of *Phytophthora cinnamomi* and the development of disease because of :-

i) the considerable variability which exists within and between native plant species in their responses to the presence of *Phytophthora cinnamomi*,

ii) the differential influence of temporal and spatial variation in environmental forces, However, within the spectrum of variable disease, response of numerous hosts to particular environmental circumstance, at least four specific nodes can be recognised. These are due to either distinct processes or to different stages in the development of disease which occur upon and after the arrival of the pathogen and its persistence in previously uninfested areas. Each of these circumstances presents a different problem that requires a separate management response. It is now evident that among the variety of plant communities, which occur within that part of the South West Land Division that receives more than 800mm mean annual rainfall the four sets of distinctive consequences are:

i) **<u>No apparent disease at all</u>** :

This applies *inter alia* to those areas of karri and wandoo forest which contain no floristic elements of the dry sclerophyll (jarrah) forest type and to plant communities on the calcareous soils of the Spearwood and Quindalup Dune Systems and of the Swan Coastal Plain and pedogenically related landscapes.

ii) **<u>An extremely destructive epidemic of root rot</u>** :

This applies within the highly susceptible understorey elements of the dry sclerophyll forest, in *Banksia* woodland and in heathland on podsols, podsolic and lateritic landform. It is characterised by:

a) devastation soon after the first arrival of the wave front of infestation,
b) steady extension of epidemic disease soon after arrival of the pathogen,
c) complete or near complete elimination of important structural elements of the plant community.
d) a relative insensitivity of the degree of damage to variation in soil characteristics.

iii) **<u>A variable epidemic within the dominant jarrah tree component of the forest</u>** :

This is characterised by :-

a) a much more erratic and often protracted onset of mortality ranging from early localised onset of mass collapse (similar to type above) through delayed and patchy mortality to no apparent effect at all on health of the jarrah overstorey.
b) high sensitivity to subtle differences in soil characteristics particularly those effecting drainage.

All variants in the response of jarrah are coincident with, or preceded by, mass deaths in susceptible elements of the understorey. In jarrah, their behaviour varies from that characteristic of epidemics of disease due to invasion by an exotic organism to which the vegetation has not been previously exposed to that typical of long established endemic disease.

iv) An 'endemic' pathogen

Where *Phytophthora cinnamomi* has been long established (some 50 years or more) in sites formerly dominated by jarrah/banksia forest and has been very heavily impacted *Phytophthora cinnamomi* behaves in a manner characteristic of endemic pathogen. The forest is often replaced by an open woodland of marri/parrot bush. Periodic outbreaks of mortality in parrot bush (*Dryandra sessilis)* follow, with subsequent regeneration by seed. At this late stage, *Phytophthora cinnamomi* causes more muted disease than at the wave front.

4.3 PROGNOSIS – SPREAD, ERADICATION AND CONTROL

The Department has accepted that eradication and prevention of the establishment of new centres of infection is not a realisable objective, even were it to involve both a socially acceptable strategy of denial of human access for any purpose and an eradication program of native animals which vector the pathogen. Similarly insurmountable problems of scale and cost would attend efforts to map and treat the thousands of kilometres of invasion front now established within 17 million ha of remnant native vegetation in the Southwest Land Division.

Further, despite intensive research and extensive field tests over three decades (1970 to 2000), the delivery of ameliorative treatments (which might favourably modify those environmental influences responsible for destructive interaction between plant species which are susceptible to the pathogen) though biologically well founded have so far proved to be impracticable.

Ultimately this pathogen will occupy through autonomous and vectored spread all of the sites where the correct combination of host and environment occur (See figure 4.1 and 4.2)

4.4 IMPACTS

Estimates of annual losses caused by *Phytophthora* in WA provided by officers of Agriculture WA for a Rural Resources Development Corporation survey in 1993 total $1,200,000 for horticulture and $500,000 for floriculture. Losses due to *P. clandstina* in clover crops have not been estimated but are believed to be substantial.

Plant Crops, even to longer-lived perennials such as avocado, are amenable to a variety of techniques of control including drainage, organic amendment, chemical treatment and the use of resistant lines.

The arrival and spread of *Phytophthora cinnamomi* in the native vegetation of WA is now seen to be a biological disaster of global significance for conservation of areas of great bio-diversity (Figure 4.3.and 4.4) and a major problem for wood-based and other extractive industries. A number of plant species face extinction unless the use of programs of phosphite treatments, cryogentic storage of genetic material and the use of appropriate fire regimes to exploit the phenomenon known as “disease escape” are effectively implemented and maintained.

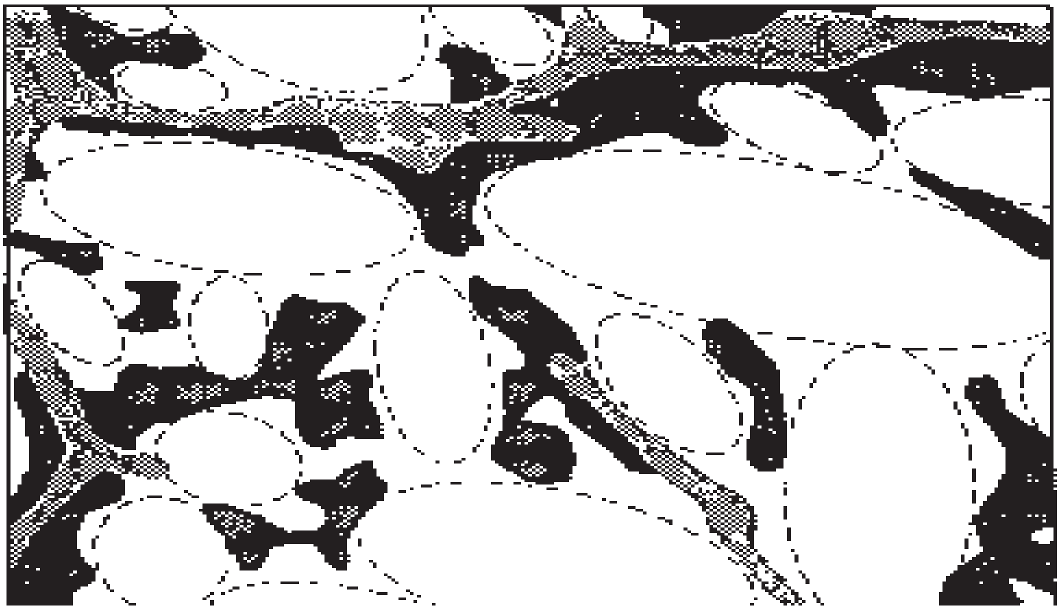


Figure 4.1 Sample area of pre 1976 dieback mapping (after Shea, 1975), with notional compact areas of dieback-free forest (shown as dashed ellipses). Light grey : riparian non-forest communities; Dark grey: *Phytophthora* affected jarrah forest.

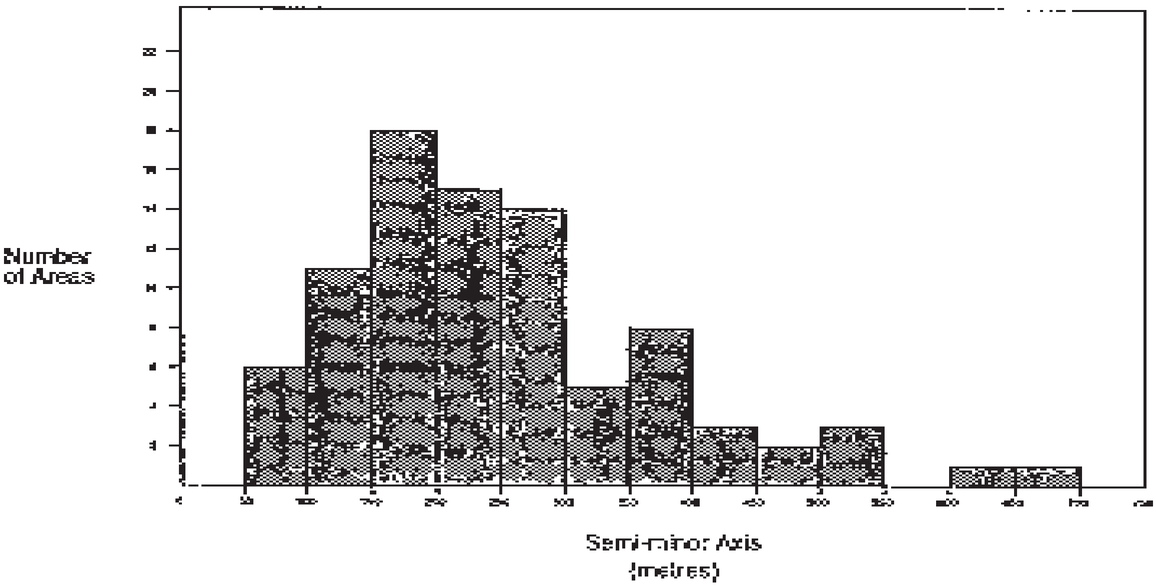


Figure 4.2 Histogram showing the frequency of compact areas (approximated as ellipses) verses the distance of their most remote point from the nearest dieback (semi minor axis of the ellipse). The behaviour at the lower end of the distance axis is strongly influenced by the cut-off in the sampling of small areas.

Figure 4.3 Impact on proteaceous shrubland, Gull Rock

Figure 4.4 Impact on montane community, Stirling Range NP

SECTION 5 - *CONSERVATION AND LAND MANAGEMENT ACT 1894*, REGULATIONS AND DEPARTMENTAL POLICY

5.1 *CONSERVATION AND LAND MANAGEMENT ACT 1984* AND REGULATIONS

The Department is responsible for administering the *Conservation and Land Management Act 1984*, *Conservation and Land Management Regulations 2002*, the *Forest Management Regulations 1999* and the *Wildlife Conservation Act 1950*.

The long title of the *CALM Act 1984* is:

> "*An Act to make better provisions for the use, protection and management of certain public lands and waters and the flora and fauna thereof, to establish authorities to be responsible therefore, and for incidental purposes*".

This *CALM Act 1984* establishes the Department as the agency charged with the responsibility for the management of lands and waters vested in the Conservation Commission of Western Australia and the Marine Parks and Reserves Authority.

The *CALM Act 1984* influences the management of *Phytophthora cinnamomi* and disease caused by it through the following:

Section 62 which states:

(1) Subject to this section, the Minister may, on the recommendation of the Conservation Commission and, where applicable, any associated body, by notice published in the *Gazette*, classify any land that is vested in the Conservation Commission as —

- (a) a wilderness area;
- (b) a prohibited area;
- (c) a limited access area;
- (d) a temporary control area;
- (da) a forest conservation area;
- (e) a recreation area for a purpose or purposes specified in the notice; or

(f) such other class of area as the Minister, on the recommendation of the Conservation Commission, thinks necessary to give effect to the objects of this Act, and, subject to section 62A, may in like manner amend or cancel a notice previously so published.

Regulation 41 *Access to certain areas classified under s. 62* of the *Conservation and Land Management Regulations 2002* states that:

A person must not, without lawful authority, enter any land or waters classified -

(a) under section 62(1)(b) of the Act as a prohibited area;
(b) under section 62(1)(d) of the Act as a temporary control area;
(c) under section 62(1)(f) of the Act as a plant disease management area; or
(d) under section 12A(2) of the Wildlife Conservation Act 1950 as a prohibited area where that classification remains in force.

Penalty: $2 000.

Part VII Section 79 - 86 of the *CALM Act 1984* deals with the *Control and Eradication of Forest Disease.* The purposes of Part VIII is to identify the areas of public land in which trees may already be, may become, or are infected with any forest disease and to control and eradicate such forest diseases as are detected in such areas.

Part VIII defines "public land" as —

(a) a State forest or timber reserve;

(b) any land vested in the Crown and not contracted to be granted or transferred in fee simple and includes —

 (i) land of which pastoral leases are held under Part 7 of the *Land Administration Act 1997*;

 (ii) land held as mining tenements under the *Mining Act 1978*; and

(c) any land reserved or dedicated under the *Land Administration Act 1997* but the care, control and management of which are placed with in some person other than the Crown;

Section 124 - *Powers of rangers and conservation and land management officers*

(1) A ranger or conservation and land management officer who finds a person committing a relevant offence on or in any land or waters or who on reasonable grounds suspects that such an offence has been committed or is about to be committed, may without warrant -

(a) stop, detain and search any vehicle, vessel or conveyance;

(b) remove any vehicle, vessel, animal or other thing from the land or waters;

(c) require the person to give to him the person's name and address;

(d) require the person to leave the land or waters and,

(e) in addition, a ranger may enter and search any hut, tent, caravan or other erection which is not a permanent residence.

(2) A ranger may detain the person until he can be delivered to a police officer if, when required to do so, he does not give to the ranger or officer his name and address, or gives him a false name and address.

(3) Instead of so detaining the person the ranger may take him into custody himself, to be dealt with according to the law, pursuant to section 50 of the *Police Act 1892*, as if he had not given his name and address, or had given a false name and address to a police officer

(4) A person shall not remain on or in any land or waters after being required to leave the same by a ranger or conservation and land management officer.

(5) A ranger or conservation and land management officer shall not exercise any power specified in subsection (1) (a) or (b) and a ranger shall not exercise the power to enter and search conferred by that subsection unless he has first taken all reasonable steps to communicate to the person who owns or is in charge of the vehicle, animal, vessel, conveyance, hut, tent, caravan or other thing concerned (if the identity of that person can reasonably be ascertained) his intention to exercise the power and his reasons for believing that he is authorised to exercise the power.

(6) Nothing in this section derogates from the powers of a ranger who is a police officer

Enforcement Officers (Section 45)

The Minister can designate any person employed in the Department to be

a) a wildlife officer;

b) a forest officer;

c) a ranger

d) a conservation and land management officer

Wildlife officers, forest officers, rangers and conservation and land management officers have the functions conferred in theme respectively by or under this [CALM]Act. In addition, wildlife officers, have the functions conferred on them by the *Wildlife Conservation Act 1950*.

Forest Management Regulations 1993 contain twenty one (21) regulations pertaining to *the control and eradication of forest diseases.* (The penalties under each regulation vary - refer to the *Forest Management Regulations 1993*)

106 Written authorization states:

1. An authorised person in writing may authorize:
   a. the taking of a potential carrier into a risk area
   b. the possession, use or movement of a potential carrier in a risk area
2. Written authorisation may be subject to conditions
3. Authorised person may revoke a written authorisation or vary, or remove conditions.

107 Verbal authorisation may be given in an emergency to take into and move around a potential carrier in a risk area.

108 It is an offence to enter, use or move around a potential carrier in a risk area or disease area contrary to instruction or direction.

109 Entry, use or movement of a potential carrier in a risk area or disease area contrary to instruction or direction .

Any person who takes a potential carrier into a risk area or disease area, or uses or moves a potential carrier in a risk area or disease area, contrary to any instruction or direction given by -

(a) an authorized person in relation to that potential carrier; or

(b) the Executive Director in relation to potential carriers of that class by notice published in a newspaper circulating in that risk area or disease area,

or who causes a potential carrier to be so taken, used or moved contrary to any such direction or instruction, commits an offence.

110 An authorised person may erect signposts or barricades to prohibit or restrict admission or potential carriers into risk or disease areas.

111 Written authorisation must be carried, by a person in charge of a potential carrier in a risk area, at all times. It is an offence not to produce written authorisation when requested by an authorised person.

112 Written authorisation will terminate immediately on breach of any condition.

113 A person shall provide information upon request by an authorised person or any occurrence or suspected occurrence of a Forest Disease. It is an offence not to do so.

114 An authorised person may stop and examine a potential carrier whether or not it is infected and may erect signs or barricades on roads:

- in or leading to a risk area.
- In or leading out of a disease area.

115 An authorised person may direct an infected or potential carrier entering or leaving a risk area to a quarantine station.

116 An authorised person may direct a person in charge of an infected or potential carrier entering a risk area or leaving a disease area to cleanse and disinfect the carrier.

117 The Executive Director may establish or arrange for the establishment and maintenance of a quarantine station for the cleaning of carriers entering a risk area or leaving a disease area.

118 The period for which an infected or potential carrier is kept in quarantine for cleansing is determined by an authorised person.

119 It is an offence if a person does not cleanse or disinfect a carrier as directed by an authorised person.

120 Owner of a potential carrier to inform an authorised person of the identity and address of a person in charge of a potential carrier at the time of the offence.
If the information is not provided within 14 days the owner will be deemed to have committed the offence.

121 An authorised person may detain, control or remove a potential carrier from a risk or disease area if:

- in contravention to any part of these Regulations or conditions of written authorisation
- failed to comply with directions of an authorised person
- Authorised person considers there is a greater risk of the spread of infection

122 Authorised person may remove a person from a risk area if suspected of contravening these Regulations or written conditions.

123 It is an offence for a person to refuse giving their name and address to an authorised person while in a disease risk area.

124 A driver or potential carrier commits an offence if they:

- fail to stop hen requested by an authorised person
- ignores or fails to comply with a signpost
- avoids or breaks through a barricade

125 It is an offence for a person to hinder or obstruct, or fail to comply with a direction given by any authorised person.

5.2 GOVERNMENT POSITION – WESTERN AUSTRALIAN DIEBACK REVIEW PANEL

In 1996 an independent review of the matter of dieback in Western Australia was conducted for the Government, a process of public input completed, and an appraisal of the recommendations of the Western Australian Dieback Review Panel (WADRP) [Podger *et al* 1998] completed by the Department.

The WADRP report was endorsed by Government in 1998 and the Department is progressively implementing all 33 of the Review Panel Recommendations

In 2002 the Minister for the Environment and Heritage wrote to the Department, the Conservation Commission of Western Australia, and the Dieback Consultative Council requesting:

a) The further development of the scoping requirements for an Environmental Protection Policy (EPP) for the "Management of *Phytophthora cinnamomi* and disease caused by it (Dieback) in native vegetation in Western Australia";

b) The development as a priority of a *Phytophthora cinnamomi* management policy for CC of WA vested lands which encompasses the Precautionary Principle and has a clear commitment to the principles of Sustainability;

c) The development of a set of *Best Practice Management Principles, Guidelines and Standard*s *for the Management of Phytophthora cinnamomi and Disease caused by it in native vegetation in Western Australia* and *Codes of Practice* where applicable to the protection of lands vested for conservation; and

d) The development of a set of *Best Practice Management Principles, Guidelines and Standard*s *for the Management of Phytophthora cinnamomi and Disease caused by it in native vegetation in Western Australia* and *Codes of Practice* suitable for wider purpose [application beyond the lands vested in the Conservation Commission of Western Australia].

5.3 DIEBACK CONSULTATIVE COUNCIL

The Minister for the Environment and Heritage established the DCC in November 1998 in response to recommendations no. 24 of the Western Australian Dieback Review Panel in its report to government.

The DCC has a current membership of 14 drawn from a wide cross section of interest groups and agencies and encompasses a broad range of dieback management and research expertise as well as key industry and other interest groups concerned with the management of disease caused by *Phytophthora cinnamomi* .

Functions of the Council

The primary function of the Dieback Consultative Council is to provide high quality advice to the Minister for the Environment and heritage in relation to *Phytophthora* root-rot disease in Western Australia, particularly in relation to;

- Establishing close liaison between planners, managers and research scientists;
- Ensuring that a high degree of priority is given to research generated by management needs;
- Publishing reviews of research findings and their implications for both management and further research;
- Recommending on acquisition and allocation of research funding according to its perceived priorities; and
- Advising on appropriate institutions to carry out the work. .

Issues dealt with by the Council to date include:

- Advice to the Hon. Minister on the policy *of Protecting the 'Protectable' Areas* and *Protocols for Defining Protectable Areas;*
- Funding for dieback management and research;
- Research priorities and processes;
- Raising public awareness in regard to Dieback disease; and
- Input into the national 'Threat Abatement Plan for Dieback Caused by the Root-rot Fungus (*Phytophthora cinnamomi*)'

5.4 DEPARTMENTAL POLICY STATEMENT NO.3 OF DECEMBER 1998

This section (following pages) is a reprint of the Department's current policy document.

MANAGEMENT OF *PHYTOPHTHORA* AND DISEASE CAUSED BY IT

POLICY STATEMENT No.3 of DECEMBER 1998

BACKGROUND

This document replaces Department of Conservation and Land Management Policy Statement No.3 of January 1991 and should be read in conjunction with other Policy Statements and the background paper (see Appendix 13.6):

> " **Management of *Phytophthora* and disease caused by it: A revision of Department of Conservation and Land Management Policy Statement No.3 of January 1991 " prepared by F.D. Podger & K.R. Vear July 1998**

INTRODUCTION

1. The Department has a responsibility to monitor the health of native plants, ecological communities and fauna habitat and to respond according to need on a case by case basis.

2. At least 8 distinct species of *Phytophthora* occur at various places in native plant communities of Western Australia. Whilst the potential importance of several of them still require some further elucidation, *Phytophthora cinnamomi* alone represents by far the greatest ongoing threat to conservation and other benefits to society which native plant communities provide. This policy therefore concentrates on *Phytophthora cinnamomi*.

MANAGEMENT OBJECTIVES

1. Progressively identify uninfested 'protectable' areas and manage human access to them so that the role of humans as vectors in establishing new centres of infestation is reduced to the lowest possible level,

2. Manage already infested and un'protectable' areas in a manner which sustains an appropriate level of environmental and social benefits,

3. Implement, as a component of broader management programs to protect threatened flora, threatened ecological communities and the habitat of threatened fauna, a program for the use of the protective chemical phosphite,

4. Implement programs of interagency research and liaison which are closely linked with:

    a) management requirements, and

b) other Western Australian, interstate, Commonwealth and international institutions involved in research and management on *Phytophthora*.

5. Encourage community interest and participation particularly through support of the Dieback Consultative Council (DCC) and its prospective Regional Coordination Groups.

MANAGEMENT STRATEGIES

A. MANAGEMENT OF UNINFESTED AREAS WHICH ARE 'PROTECTABLE'

1. Establish and maintain a set of protocols, founded on science and logic, which guide land managers in identifying and managing 'protectable' areas and prioritise the allocation of available resources for protecting them.

2. Implement a <u>long term</u> management system of hygienic access to 'protectable' areas which incorporates the following elements :-
   a) The use of accredited Interpreters, supported by the Vegetation Health Service, to prepare up-to-date maps of the distribution of *Phytophthora cinnamomi* through the detection and analysis of the disease symptoms in native plants characteristic of disease caused by *Phytophthora cinnamomi*.
   b) The progressive identification of 'protectable' areas, which are free of the evidence of infestation by *Phytophthora cinnamomi*, and which are amenable to being protected from the establishment of new centres of infestation arising from the activities of man through the imposition of hygienic management practices.
   c) The documentation, implementation and regulation of plans for hygienic human access to all 'protectable' areas,
   d) The implementation of appropriate monitoring and review programs.

3. Provide protection, as appropriate, through phosphite application.

4. Provide and maintain appropriate management guidelines and training programs.

B. MANAGEMENT OF LANDS ALREADY INFESTED WITH *PHYTOPHTHORA CINNAMOMI* OR THOSE THAT ARE NOT 'PROTECTABLE'

1. Develop and maintain a set of protocols, founded on science and logic, which establish guidelines for identifying and managing infested and un'protectable' areas and for setting priorities among management options for them.

2. Where appropriate provide protection through the application of phosphite.

3. Provide appropriate management guidelines and training programs.

C. PROTECTION OF THREATENED FLORA, THREATENED ECOLOGICAL COMMUNITIES AND THE HABITAT OF THREATENED FAUNA BY THE USE OF A SCHEDULE OF TIMED APPLICATIONS OF THE PROTECTIVE CHEMICAL PHOSPHITE

1. Develop and maintain a set of protocols founded on science and logic which:
   a) guide land managers in identifying threatened flora, threatened ecological communities and the habitat of threatened fauna that may benefit from protection through phosphite application, and
   b) may be used to establish realistic priorities for use of available resources.

2. Implement and monitor a program using scheduled applications of the protective chemical phosphite for protection of threatened flora, threatened ecological communities and the habitat of threatened fauna.

D. RESEARCH AND LIAISON

As a component of broader programs of research and liaison:

1. Implement coordinated programs of research and collaboration, which are closely linked to management requirements, and involve other Western Australian, interstate, Commonwealth and international land management and research institutions.

2. Through interaction with the *Phytophthora* Research Advisory Group establish clear research priorities and agreed allocation of those priorities amongst relevant institutions.

3. Provide appropriate levels of support to the Dieback Consultative Council, its Regional Coordination Groups, and the team responsible for the implementation of the National Threat Abatement Plan for *Phytophthora spp*.

E. ENCOURAGE COMMUNITY INTEREST AND PARTICIPATION

1. Encourage community interest and participation particularly through support of the Dieback Consultative Council (DCC) and its prospective Regional Coordination Groups.

2. Provide appropriate levels of information to the public on the matters related to *Phytophthora cinnamomi* and disease caused by it.

Responsibility for the maintenance and review of this policy rests with the Executive Director.

Executive Director
December 1998

5.5 WRITTEN AUTHORITY TO ENTER DRA

Any member of the public and/or the Department's staff, who has a valid and legal reason to take a potential carrier [vehicle, machine or equipment] of the plant pathogen *Phytophthora cinnamomi* into a Risk Area or Disease Risk Area (DRA), must gain a written authority from an authorised officer prior to entry and must carry the written authority when entering a Risk Area or DRA. (See Appendix 13.8)

5.5.1 Definition of Disease Risk Area

Is any area of public land where the Executive Director considers that the earth, soil or trees may be, or may become infected with a forest disease.

5.5.2 Process for authorising entry to DRA

FIRST STAGE

Ascertain whether the applicant has had authority previously. If they haven't then they need to be briefed on why authority is required. In all cases ascertain whether the person has a valid and legal reason for wishing to take a carrier into the DRA.

If the applicant has previously had authority given to them then reiterate the reasons as to why authority is required.

SECOND STAGE

Take details from applicant as per "authority"

NOTE:

- "Forest Officer" or "Conservation and Land Management Officer" only has authority to approve entry.
- Applicant must be made aware 'authority' must be carried at all times whilst in DRA.
- Applicant must be made aware of all conditions on authority.
- Authority only valid for dates indicated on permit.

5.5.3 Conditions which the Forest Management Regulations, 1993 place on entry to Disease Risk Areas.

There are at 21 Regulations governing DRA's (See Section 5.1.3). Authorising Officers must be aware of all the requirements of the Regulations, in particular:

- **Written Authorisation may be issued subject to such conditions as are specified in the authorization**

  A written authority will normally be issued subject to compliance with the requirements of any relevant *Phytophthora cinnamomi* Management Plan(s) or in the absence of such a plan(s) the requirement for the proponent to ensure the potential carrier is clean prior to entry to, and that it will not pick up an move soil while within, a proclaimed risk area or disease risk area

- **Written authorisation to be carried and produced upon request**

  A person in charge of a potential carrier in a risk area, shall carry any written authorisation issued in respect of that potential carrier, at all times when the potential carrier is being used, operated or moved in that area, and shall produce that authorisation when requested to do so by an authorised person

- **Written authorisation to terminate on breach of condition**

  Written authorisation shall terminate immediately on the breach of any condition specified in that authorisation

- **Person to provide information upon request**

  A person shall when requested to do so by an authorised person, provide all information within that person's power relating to any occurrence or suspected occurrence of a forest disease

- **Authorised person may stop and examine potential carrier**

  An authorised person may stop and examine any potential carrier to determine whether or not it is infected and may, for that purpose, erect signposts or barricades, or both, on roads -
  (a) in or leading to a risk area; or
  (b) in or leading out of a disease area.

SECTION 6 - NATIONAL THREAT ABATEMENT PLAN FOR *PHYTOPHTHORA SPP*

6.1 EXECUTIVE SUMMARY

A Threat Abatement Plan has been prepared in order to meet the Commonwealth Government's obligations under the *Environment Protection and Biodiversity Conservation Act 1999* following the listing of 'Dieback caused by the root-rot fungus *Phytophthora* cinnamomi' as a 'key threatening process' in 2000. The *EPBC Act 1999* requires the preparation and implementation of a threat abatement plan for nationally coordinated action to mitigate the harm to Australian species, particularly threatened flora and threatened ecological communities, caused by *P. cinnamomi.*

The following is an extract from Environment Australia's *Threat Abatement Plan forDieback caused by the root-rot fungus Phytophthora cinnamomi:*

> Australia's native vegetation and its dependent biota are threatened by a plant pathogenic [fungus] called *Phytophthora cinnamomi*. *P. cinnamomi* causes the roots of susceptible plants to rot. It is thought that it was introduced at some time after European settlement; it is now well established in many of the country's higher rainfall areas—areas with a mean annual rainfall greater than 600 millimetres—in a mosaic of infected and uninfected areas. Its effects range from devastating to inconsequential, depending on environmental factors, which vary both within and between regions. The only biomes that appear to be least threatened are the wet-dry tropics and the arid and semi-arid regions. The level of threat and its distribution, however could easily increase if human activities were to alter the site conditions to favour the spread and intensification if the species. The latter activities may include the alteration of the hydrology of an area as this could subsequently foster a rising water table and a subsequent intensification of spread of P. cinnamomi. In addition, *P. cinnamomi* can spread independently or with the assistance of animals or humans.

Detailed information on the nature of *P. cinnamomi* and its history in Australia can be found in the technical report entitled 'A National Overview of *Phytophthora cinnamomi* in Australia: supplementary information to accompany the draft national Threat Abatement Plan' (Podger 1999).

'Dieback caused by the root-rot fungus *Phytophthora cinnamomi*' is listed as a 'key threatening process' in Schedule X to the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999*. When it is determined that having a threat abatement plan is a feasible, effective and efficient way to abate the process a nationally coordinated threat abatement plan must be prepared and implemented to manage the impact of *Phytophthora cinnamomi* on Australian ecosystems.

While eradication is not possible at present, well developed management plans based on current knowledge can assist in restricting the intensification and spread of known infestations and limit spread to new sites.

This Threat Abatement Plan, therefore, has two main goals:

- To protect nationally listed threatened species and ecological communities from *Phytophthora cinnamomi*; and
- To prevent further species and ecological communities from becoming threatened by reducing the chance of exposure to the pathogen.

To abate the threat posed by *P. cinnamomi*, action in four important areas is prescribed:

- Implementation of management programs in specific areas that are a high conservation priority as a result of the species or ecological communities under threat.
- Encourage better understanding through the collection of information that expands our understanding of the ecology and biology of *P. cinnamomi* in Australia, its effects and of methods for managing the pathogen.
- Education of land managers and relevant organisations to increase their knowledge of the effects of *P. cinnamomi* and the role of humans in

spreading the pathogen and to ensure skilled and effective participation in management activities.

- Coordination of national, regional and local management activities and administration.

Specific actions in the Plan describe the measures to be used to mitigate the harm caused by the *P. cinnamomi*. The strategy advocated in the Plan involves the use of available methods to restrict the intensification and spread of *P. cinnamomi* in manageable areas that are critical to the conservation of threatened species and ecological communities. In addressing the conservation of species, close links must be established with species recovery plans and with existing State and Territory programs. Action will also be taken to ensure that *P. cinnamomi* does not become established in important 'islands' that are at present free of the pathogen. In addition, there will be a focus on collecting and disseminating information to improve our understanding of *P. cinnamomi* control methods and their effects, particularly in areas that have not been infected for very long.

Implementation of the Plan will allow for consolidation and coordination of the process of managing *P. cinnamomi* impacts on native flora and vegetation. The main priority is to provide support for on-ground control programs that are necessary for the recovery of threatened species and threatened ecological communities. Control programs will have to continue for some time and the costs of this will be considerable. This Plan therefore establishes a framework for allowing the best possible use of resources that are available for managing *P. cinnamomi* infestations.

6.2 THREAT ABATEMENT PLAN – GOALS, OBJECTIVES AND ACTIONS

The following goal, objectives and actions are an extract from Environment Australia's ***Threat Abatement Plan forDieback caused by the root-rot fungus Phytophthora cinnamomi***

GOALS

This Threat Abatement Plan (the Plan) has two broad goals:

- To protect nationally listed threatened species and ecological communities from *Phytophthora cinnamomi*;
- To prevent further species and ecological communities from becoming threatened by reducing the chance of exposure to the pathogen.

These goals will be achieved by implementing currently available *Phytophthora cinnamomi* management techniques, providing for the development of new techniques, and collecting information to improve our understanding of the pathogen and its effects. A critical performance indicator will be the degree of security achieved for species and ecological communities that are currently or potentially threatened by this pathogen.

OBJECTIVES

There are five primary Objectives for the Plan:

- **Objective 1:** To promote the recovery of nationally listed threatened species and ecological communities that are known or perceived to be threatened by *Phytophthora cinnamomi*.
- **Objective 2:** To limit the spread of *Phytophthora cinnamomi* into areas where it may threaten threatened species and ecological communities or into areas where it may lead to further species or ecological communities becoming threatened.
- **Objective 3:** To improve the effectiveness and efficiency of the management of the *Phytophthora cinnamomi* through appropriate research and monitoring programs.
- **Objective 4:** To inform Commonwealth, State and Territory management agencies, landholders and the public about the Threat Abatement Plan's actions and their outcomes.
- **Objective 5:** To effectively coordinate management activities.

The choice of any strategy for abating the threat posed by *P. cinnamomi* will differ according to the management purpose. If the purpose is to mitigate harm in areas already infected by and vulnerable to the pathogen, currently the choices of abatement are few, the actions may be difficult to undertake, but not impossible and, except in small areas of unique value, the financial cost could be high.

If the objective is to reduce the rate of introduction of uninfected native plant communities that are both susceptible and vulnerable to the disease, a number of more affordable strategies are available. They may not, however, be always or everywhere practicable.

Wherever possible, cost-effective and efficient management measures will be applied through regionally coordinated management partnerships involving landholders, community groups, nursery growers and all levels of government. Management of *P. cinnamomi* should be integrated with other actions relating to the management of other pest species identified as contributing to threatening processes.

To abate the threat posed by *P. cinnamomi*, action in four important areas is prescribed:

- Implementation of management programs in specific areas that are a high conservation priority (Objectives 1 and 2).
- Encourage better understanding through the collection of information that expands our understanding of the ecology and biology of *P. cinnamomi* in Australia, its effects and of methods for managing the pathogen (Objective 3).
- Education of land managers and relevant organisations to increase their knowledge of the effects of *P. cinnamomi* and the role of humans in spreading the pathogen and to ensure skilled and effective participation in management activities (Objective 4).
- Coordination of national, regional and local management activities and administration (Objective 5).

SECTION 7 - MANAGEMENT OF UNINFESTED 'PROTECTABLE' AREAS

7.1 MANAGEMENT OBJECTIVE

The Western Australian Government and the Department have adopted a strategy for the management of *Phytophthora cinnamomi* and the diseases caused by it, that identifies significant 'protectable' areas (those for which the values at risk are significant and the benefits likely to be sustained for more than a few decades – see also Table 1 *Definition of 'protectable' areas),* prioritises them, and concentrates available resources on protecting them. The Department's objective is to progressively identify uninfested 'protectable' areas and to protect them by minimising human access to them and managing hygiene on entry into them.

Table 1. ***Definition of 'protectable' areas***

'Protectable' areas, include areas of high conservation and/or socio-economic value (E.g. a small uninfested area which contain a known population of a susceptible species of threatened flora) within the vulnerable zone that:

- Are situated in zones receiving > 600 mm per annum rainfall or are water gaining sites (E.g. granite outcrops, impeded drainage or engineering works which aggregate rainfall) in the 400-600 mm per annum rainfall zone
- Do not have a calcareous soil (e.g. not a Quindalup dune system)
- Have been determined to be free of the pathogen *Phytophthora cinnamomi* by a qualified Disease Interpreter (all susceptible indicator plant species are healthy, no plant disease symptoms normally attributed to *Phytophthora cinnamomi* are evident)
- Are positioned in the landscape and are of sufficient size (E.g. > 4 ha with axis > 100m) such that a qualified Interpreter judges that the pathogen will not autonomously engulf them in the short term (a period of a few decades)
- Consists of areas where human vectors are controllable (E.g. not an open road, private property)

This is best achieved through the preparation, on a bioregion or sub-bioregion basis, of a "Threat Abatement Plan for the Protection Of Vulnerable Areas of Native Vegetation From *Phytophthora cinnamomi* & Disease caused by it" that aims to provide land managers, activity proponents and interested members of the community with a range of measures for the management and protection of biological diversity, including:

- Adaptive management and accredited environmental management systems;
- Detection, diagnosis and mapping of infested areas;
- Assessment of the threat to the conservation and protection of Western Australian biological diversity posed by *P. cinnamomi,* including the threat to uninfested areas of high conservation value, to the residual conservation values of infested areas and to the commercial values of uninfested areas;
- Analysis and evaluation of the risk of introduction of *P. cinnamomi* into uninfested areas;
- Identification, evaluation and application of effective and efficient risk treatment measures to prevent serious and irreversible environmental damage in uninfested areas, including systematic planning for, and implement of, the long term management of uninfested areas.
- Planning and implementation of hygiene regimes for all activities within uninfested areas;
- The use of repeated treatments of the chemical phosphite to protect susceptible threatened species, threatened ecological communities and the habitat of threatened native fauna;
- Identification of the need for, and where appropriate the planning and implementation of, measures for the restoration of serious environmental damage in infested areas, including specific measures for the maintenance of gene pools; and
- Community communication and education program the and involvement of the community in deploying agreement management programs

In turn *Phytopohthora cinnamomi* management plans can be prepared on a local area basis that minimises the number of roads and walk-trails within uninfested areas and ensures entry into them is hygienic (i.e. vehicles, equipment and foot-ware are clean).

Vehicles and machines may operate within the vulnerable zone prior to the identification of any uninfested 'protectable' areas when the prevailing weather and soil moisture conditions enable them to do so without picking up and moving soil and plant material.

7.2 MANAGEMENT STRATEGY

The Department will:

1. Establish and maintain a set of protocols, founded on science and logic, which guide land managers in identifying and managing 'protectable' areas and prioritise the allocation of available resources for protecting them.

2. Implement a long term management system of controlled and hygienic access to 'protectable' areas which incorporates the following elements:
   a) The use of accredited Disease Interpreters to prepare up-to-date maps of, and field demarcate, the distribution of *Phytophthora cinnamomi* through the detection and analysis of the disease symptoms characteristic of root rot disease caused by it in native plants. This is to be supported by the laboratory analysis of soil and tissue samples by the Vegetative Health Service.
   b) The analysis and identification of 'protectable' areas, which are free of the evidence of infestation by *Phytophthora cinnamomi*, and which are amenable to being protected from the establishment of new centers of infestation arising from the activities of man through the control of access into them and the imposition of hygienic management practises on entering them.
   c) The documentation, implementation and regulation of plans for the management of 'protectable' areas,
   d) The implementation of appropriate monitoring and review programs.

3. The preparation and maintain appropriate management guidelines and training programs.

7.3 BEST PRACTICE MANAGEMENT METHODS AND STANDARDS FOR 'PROTECTABLE' AREAS

Best practice management of *Phytophthora cinnamomi* and disease caused by it will minimise the human assisted spread of the pathogen into uninfested areas and strategically apply repeated treatments of the protective chemical phosphite. It will involve the preparation and use of written procedures for suitably qualified people to:

- Detect, diagnosis, demarcate and map uninfested 'protectable' areas;
- Analyse the effect on the conservation and commercial values of uninfested areas;
- Systematically plan for, and implement, the long term management of uninfested areas

- Plan and implement hygiene regimes for all activities within uninfested areas;
- Strategically use repeated treatments of the protective chemical phosphite.
- Identify, evaluate and apply where appropriate measures for the restoration of serious environmental damage in infested areas, including specific measures for the maintenance of gene pools;
- Evaluate the need for, and levels of, monitoring and audit of the implementation of, and compliance with, planned preventative measures; and
- Inform the community and engage interested parties in the development and implementation of landscape wide strategies.

The best practice methods and standards are described below:

7.3.1 Detection, diagnosis, demarcation and mapping of infested 'protectable' areas

Although the pathogen is now widely distributed throughout the South West Land Division many areas have not yet been infested. The first step in minimising the human assisted spread of the pathogen into the remaining uninfested areas is to conduct a survey using suitably qualified people to identify and demarcated them in the in the field and to record their location on a map. The survey by trained observers will discriminate between areas that exhibit the visible symptoms of plant disease in native vegetation attributable to the pathogen *Phytophthora. cinnamomi,* from those areas that appear to be free of visual disease symptoms. Confirmation of the presence of the pathogen may often be made by the laboratory analysis of soil samples and root tissue taken from dead and dying plants.

Protocol for identifying 'protectable' areas and their priority for management

The Dieback Consultative Council will progressively develop a set of protocols for the objective identification of 'protectable' areas (see Table 1 - *Definition of 'protectable' areas*) and for their prioritisation and management. In the interim 'protectable' areas will be identified using the following process:

(a) On a case by case analysis of landscape units establish the need for, and scope of, the mapping required and use accredited Disease Interpreters to prepare *Phytophthora* cinnamomi Occurrence Maps based on three categories – Infested with *Phytophthora cinnamomi*, Uninfested and Uninterpretable.

(b) Use accredited Disease Interpreters and managers to identify 'protectable' areas and rationalise their management boundaries. The steps accredited Disease Interpreters use in determining 'protectable' areas on land managed by the Department are fully described in *Volume II –Guidelines for Detection, Diagnosis and Mapping of Disease caused by Phytophthora cinnamomi.*

7.3.2 Analysis of the effect on conservation and socio-economic values

The impact of *Phytophthora cinnamomi* upon conservation and socio-economic values is propelmatic since its effect on the health of plant communities, and upon the species in them, varies greatly. In many places, lethal root-disease destroys the structure of many native communities, reduces their floristic diversity, decimates their primary productivity and destroys habitat for much dependant native fauna, particularly its value as protection against feral predators. In some places the pathogen causes little damage at all. Unfortunately the extent of susceptible communities in vulnerable environments is much greater than that of communities that occur in environments that are inherently unfavourable to the pathogen.

No simple or single relationships exist between the presence of *Phytophthora. cinnamomi* and the development of disease because of:

- The considerable variability which exists within and between native plant species in their responses to the presence of *Phytophthora cinnamomi*; and
- The differential influence of temporal and spatial variation in environmental forces.

Despite this complexity it is evident that within the vulnerable areas a stratagem should be applied that will minimise the human assisted arrival of the pathogen into the remaining large uninfested 'protectable' areas.

7.3.2 Long term management of uninfested 'protectable' areas – methods and standards

Best practice for the long-term management of uninfested ' protectable' areas will involve on a priority basis:

- Permanently closing and rehabilitating unwanted roads and walk trails within them;
- Controlling the hygienic use of roads and walk trails retained within them; and
- Directing drainage from infested areas away from them (Figure 7.1)

Permanent road and walk trail closure

When permanently closing a road or walk trail sufficient work must be done to ensure that unauthorised use of the old road does not continue. Ripping of the road surface and covering it with logs, branches and rocks etc .is often necessary (See Figure 7.2 and Table 2. *Road Closure - Methods and Standards*). Where the past use of a road has been at high levels signs warning of the closure should be installed.

Managing the use of roads and walk trails retained within uninfested 'protectable' areas

Temporary closure and the controlled use of roads and walk trails are best affected using a system of gates and signs. Gates must be designed to be highly visible to oncoming vehicles. Signs that provide clear information and guidance to potential users should be installed with all gates. The need for "gate ahead" warning signs to be installed must be evaluated. (Figure 7.3)

Vehicles, machines, equipment and in some cases foot-ware must be clean before using roads retained within uninfested 'protectable' areas or the bushland within them.

Figure 7.1 Drainage is captured and prevented from entering uninfested areas

Figure 7.2 An example of effective closure of an unwanted road

Figure 7.3 Managing the use of roads retained within uninfested areas with gate & warning sign

Figure 7.4 Clear simple signage is required at entry points to uninfested 'protectable' areas

Managing drainage from infested areas

Water draining from road that are likely to be infested and drainage from known infested areas should be directed away from uninfested 'protectable' areas or taken to the lowest possible point in the landscape before being directed into areas on native vegetation. (Figure 7.6).

7.3.4 Management of activities scheduled within the uninfested 'protectable' areas – methods and standards

Best practice management of activities scheduled within uninfested 'protectable' areas will involve:

- Ensuring, by visual inspection and/or cleaning, that vehicles, plant, equipment, and in some cases foot-ware are clean when entering uninfested 'protectable' areas;
- Minimising (and clearly signposting) the number of entry points into uninfested 'protectable' areas;
- Preventing cross contamination, often by the use of barrier systems, across the boundaries (of infested areas) during works in uninfested areas;
- Allowing only uninfested basic raw materials to be used for earthworks within uninfested 'protectable' areas.

Entry Points into Uninfested 'Protectable' Areas

Where possible only one entry point (Figure 7.4) should be provided into each uninfested 'protectable' area. Entry points into uninfested 'protectable' areas that are effective in minimising the human assisted spread of *Phytophthora cinnamomi* will be characterised as appropriate by:-

- Signage;
- An inspection and/or cleandown point (Figure 7.5 & 7.6) and cleaning equipment;
- A gate; and
- A safe place for large vehicles and equipment to turnaround and exit the area if on inspection are not clean or cannot be effectively cleaned in the field.

The timing of the installation of managed entry points is critical in minimising the probability to introducing the pathogen into uninfested 'protectable' areas. In the case of new roads being built into uninfested areas the entry point should be installed where practicable on the same day as the commencement of the clearing of the road alignment.

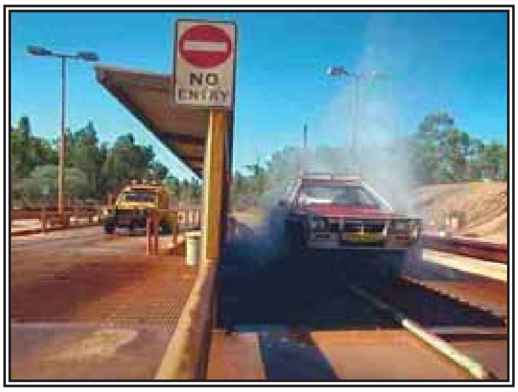


Figure 7.5 Vehicles are cleaned before entering uninfested areas

Figure 7.6 Simple boot cleaning station

Cleandown Specification

A visual inspection is necessary to determine whether or not boots, vehicles, machinery or equipment is free of a build up of:

- Clods of soil and plant material and/or
- Slurry consisting of a mixture of soil, plant material and water.

Dust and grime adhering to the sides of vehicles need not be removed before entering uninfested areas.

Records of inspections and cleandowns should be maintained.

Construction Standard for Cleandown Points

A cleandown point will meet the following standards:

- Provide a physical separation between the object being cleaned and the effluent being produced;
- Provide a physical separation from the object being cleaned and any infested soil and plants; and
- Provide easy and safe access for both the placement of the object to be cleaned and for the person doing the cleaning.

Field Location Standard for Cleandown Points

Cleandown points will be sited to ensure:

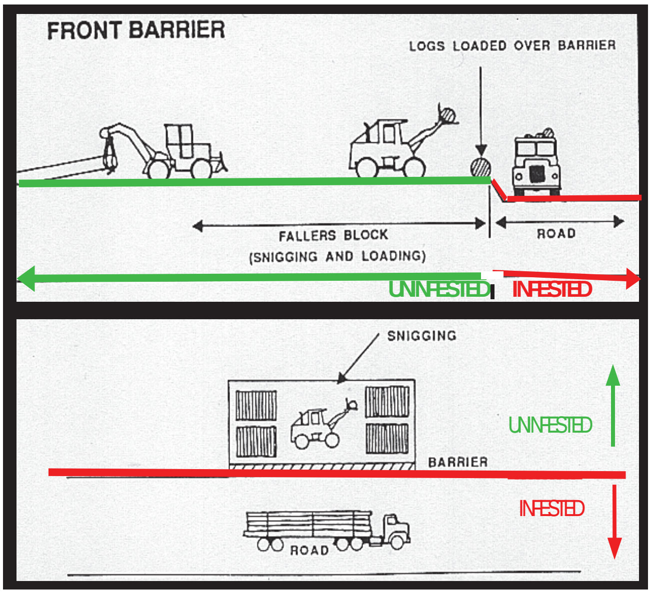
- Either that the effluent will fall directly onto infested soil or will be constructed to capture effluent for later transport and disposal;
- Cleaned objects enter uninfested areas without becoming re-infested; and
- Safe entry and departure of vehicles and plant and use by operators.

Preventing Cross Contamination during Works within Uninfested Areas

Vehicles, machinery, equipment and foot-ware can enter uninfested areas (e.g. nursery sterile areas, gravel pits, mining pods, logging coupes) when they are clean and be used to carry out a range of activities over time within taht area without the need for further cleaning provided they do not come into contact with infested soil. Cross contamination can be prevented by:

- The use of barrier systems (Figure 7.7, 7.8 & 7.9) that ensure that the clean equipment within the uninfested area does not come into direct physical contact with infested soil or unclean equipment operating outside the uninfested area;
- The use of demarcation and barrier systems to ensure that vehicles and equipment do not cross inadvertently into infested areas;
- Ensuring that drainage, soil and plant material from the infested areas does not enter the uninfested areas; and
- Limiting entry to periods when the soil is not moist enough to be picked up and moved by vehicles and equipment.

Figure 7.7 - Examples of the use of barriers to prevent cross contamination



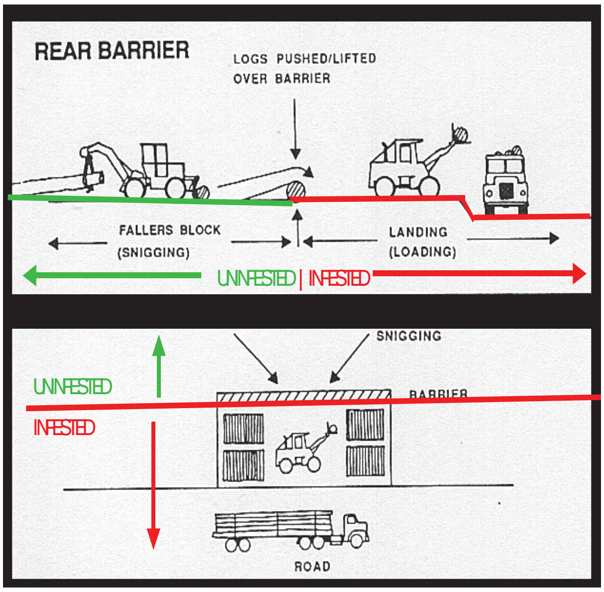


Figure 7.8 A simple front log barrier helps prevent cross contamination from the road to the uninfested forest

Figure 7.9 A simple rear log barrier helps prevent cross contamination from the infested areas to the uninfested forest

Uninfested Basic Raw Materials

Accredited personnel are required to assess and certify that basic raw material (BRM) borrow pits are free of the pathogen. Borrow pits can only be certified as being free of the pathogen under the following circumstances :-

- For a new pit that is to be located in undisturbed areas where sufficient indicator plants are available for an assessment to be made or

- For an existing pit that has records confirming that it was originally free of the pathogen, and for which sufficient evident exists that an effective system of hygiene has been maintained to ensure that the pit has remained free of the pathogen.

Existing pits without a known history that can be effectively placed in quarantine and kept free of all living and dead plant material of all species for a period of three years may then have their status reviewed. *Phytophthora cinnamomi* requires plant tissue from which to derive its energy (food source) to survive in the long term. (I.e. the pathogen does not photosynthesise so it cannot survive free in soil in the long term without access to plant tissue.) A three year quarantine period, during which no new plant tissue (living or dead), mycelia, chlamydospores or zoospores are introduced into to pit either autonomous spread or human vectoring, in most cases will allow sufficient time for any previously introduced mycelium, chlamydospores and zoospores to desiccate and die.

Where BRM is being extracted from deep pits, such as mines and quarries, where there is no obvious source of inoculum (e.g. mixing of top-soil and plant material, sub-surface water flow from adjacent infested areas likely to be carrying zoospores or unhygienic entry of vehicle, machine or equipment into the area) this material may also be certified as free of the pathogen.

New road construction into 'protectable' areas

Managing hygiene when building a new road into a 'protectable' area is a critical element in the long term protection of the area.

Where possible first 50 meters of the new alignment should be left un-cleared until after the remainder of the clearing has been completed. Light vehicle and machine tender vehicle access to the new alignment can be provided with appropriate attention to the hygiene requirements, provision of clean-down facilities and signage.

The retained section should be maintained relatively undisturbed for as long as is practicable.

Often it will be necessary for the bull-dozer that clears the alignment to open up the retained section prior to the commencement of the road formation and gravelling works e.g. to allow logs in pushed trees to be cut and removed. The bull-dozer should work from inside the 'protectable' area towards the boundary of the infested area.

At the time of opening up the retained section *Phytophthora cinnamomi* information signs need to be set-up and portable traffic control barriers placed across the road at the demarcated boundary of the 'protectable' area. If gravelling operations are to be delayed over substantial periods (e.g. winter) consideration should be given to temporarily blocking the new alignment with several substantial logs.

During the formation of the road the graders should work from inside the 'protectable' area up to the demarcated boundary working infested areas last.

Where possible to simplify the process on being clean on entry gravelling activities should work from the 'protectable' area into the infested area, e.g. especially where the gravel pit is within the 'protectable' area.

The installation of permanent gates and signs is to be programmed to coincide with the completion of the surface gravelling activities and the removal of the temporary signs and barriers.

Water binding

Water binding should be kept to a level where run-off into does not occur. The early installation of correctly designed table drains will ensure that un-seasonal rainfall does not flush material from the road building operation across large areas of adjoining land.

Basic Raw Materials

Site works and road building and maintenance works within uninfested 'protectable' areas often require the use of basic raw materials [BRM] such as sand, gravel and soil which are certified as 'Free of *Phytophthora cinnamomi*'.

On lands managed by the Department accredited plant Disease Interpreters are available to assess and certify BRM borrow pits. Disease Interpreters will only certify borrow pits as 'Free of *Phytophthora cinnamomi*' under the following circumstances:

a) For a new pit to be located in undisturbed areas where sufficient indicator plants are available for a determination to be made or

b) For an existing pit that has records confirming that it was originally free of *Phytophthora cinnamomi*, and for which sufficient evident exists that an effective system of hygiene has been in place to ensure that the pit has remained free of the pathogen.

Existing pits without a known history that can be effectively placed in quarantine and kept free of all living and dead plant material of all species for a period of three years may then have their status reviewed. *Phytophthora cinnamomi* requires plant tissue from which to derive its energy (food source) to survive in the long term. I.e. The pathogen does not photosynthesise so it cannot survive free in soil in the long term without access to plant tissue. A three year quarantine period, during which no new plant tissue (living or dead), mycelia, chlamydospores or zoospores are introduced into to pit by either through autonomous spread or human vectoring, in most cases will allow sufficient time for any previously introduced mycelium, chlamydospores and zoospores to desiccate and die.

Where BRM is being extracted from deep pits, such as mines and quarries, where there is no obvious source of inoculum (e.g. mixing of top-soil and plant material, sub-surface water flow from adjacent infested areas likely to be carrying zoospores or unhygienic entry of vehicle, machine or equipment into the area) this material may also be certified as 'Free of *Phytophthora cinnamomi*'.

Owners of private pits or developers may wish to have Departmental Disease Interpreters review and certify pits using this methodology.

Phytophthora cinnamomi free BRM is a valuable resource and managers are encouraged to ensure the integrity if the sites are maintained by ensuring foot-ware, vehicles, machinery and equipment entering these sites is clean.

Uninfested Nursery Stock

When undertaking rehabilitation works in uninfested 'ptotectable' areas that involve the supplementary planting of seedlings raised in nurseries it is essential that only uninfested (sterilised soil) planting stock is utilised and that care is taken during seedling transport to ensure that seedling trays do not come in contact with infested soil or plants.

7.3.5 Entry into uninterpretable areas

Areas that are uninterpretable and located higher in the landscape than any adjoining infested areas will be treated as uninfested 'protectable' areas. Unwanted roads wind them will be closed and rehabilitated. Vehicles, machines, equipment and in some cases foot-ware must be clean when entering them.

Uninterpretable areas located below infested areas may have entry into them restricted for most activities to periods when vehicles, machines, equipment and in some cases foot-ware will not pick up and move soil (except for road works).

7.3.6 Guidelines for preparing *Phytophthora cinnamomi* Management Plans for ''protectable'' areas

Using a process that analyses entire landscape units (the boundaries of landscape units are established by such features as creeks, ridges, saddles, open public access roads and/or freehold land) managers must plan for, deploy and enforce the rule of being clean on entry for all human activities approved in uninfested 'protectable' areas and close and rehabilitate unwanted roads into them. It is not possible to survey the entire conservation estate for the presence of *Phytophthora cinnamomi*, therefore areas to be mapped annually (and the disease boundaries demarcated) will be determined on a case by case analysis of likely 'protectable' areas and the amount of information needed to prepare a *Phytophthora cinnamomi* Management Plan for them. In most cases a whole of landscape unit approach to mapping and planning will be required.

The Department's management objective is to progressively prepare and implement *Phytophthora cinnamomi* Management Plans for all uninfested ''protectable' areas.

Linear mapping of *Phytophthora cinnamomi* Occurrence may be adequate for activities such as walk trail development, prescribed burn boundary maintenance and the use of utility easements. However, Disease Interpreters will be required to survey at least 150 meters either side of the disturbed areas to be able to make a reliable determination of any 'protectable' areas adjoining them.

Best practice long term land management of the uninfested 'protectable' areas will utilized the following tactics applied within practical management boundaries:

- Permanently closing and rehabilitating unwanted roads and walk trails;
- Ensuring the hygienic use of roads retained within the uninfested areas; and
- Directing drainage from infested areas away from the uninfested areas.

Best practice management of approved activities within uninfested 'protectable' areas will involve:

- Effective separation and field demarcation of disease boundaries, including in the case of uninterpretable areas where there is a high probability that past activities may have introduced the pathogen the separation of these areas from uninfested areas;
- The requirement of visual inspection and/or cleaning, of vehicles, plant, equipment, and in some cases foot-ware to ensure they are free of *Phytophthora cinnamomi* when entering uninfested 'protectable' areas;
- Minimising (and clearly signposting) the number of entry points into uninfested 'protectable' areas;
- Preventing cross contamination (often by the use of barrier systems) across the boundaries (of infested areas) during works in uninfested 'protectable' areas;
- Allowing only uninfested basic raw materials to be used for earthworks within uninfested 'protectable' areas.

The following steps are used by the District Manager, in consultation with the various activity proponents and accredited Disease Interpreters, when preparing *Phytophthora cinnamomi* Management Plans for a vulnerable area of land vested in the Conservation Commission:

a) Use a whole of landscape unit approach to analyse the *Phytophthora cinnamomi* Occurrence Map and identify the uninfested 'protectable' areas and rationalise their management boundaries;
b) Identify all *bona fida* activities current and planned for the 'protectable' areas;
c) For each 'protectable' area Managers must determine:
    i) Long term access control, and

ii) The measures to be taken to minimise human vectoring of the pathogen into them during short term activities that are scheduled to take place within them;

d) Document (Figure 7.10) the *Phytophthora cinnamomi* Management Plan (using the form "*Phytophthora cinnamomi* Management Plan" - see Appendix 13.1) listing the required management actions and accountabilities for each action. This will include the preparation of a '*Phytophthora cinnamomi* Management Map' (to be attached to the completed form) that uses the standard legend (see Appendix 13.2); and

e) Review the results of implementing the plan and periodically audit compliance using the 'Environmental Standards Checklist – *Phytophthora cinnamomi* Managemennt Plans' (see Appendix 13.3).

Figure 7.10 Example of a *P. cinnamomi* Management Plan and Map

7.3.7 Administration and review of *Phytophthora cinnamomi* Management Plans

The administration process of managing *Phytophthora* cinnamomi Management Plans is often triggered by a request to go upon the land anywhere within the South West Land Division. District Managers are responsible for determining whether there is a current *Phytophthora cinnamomi* Management Plan in place and if not whether one is required before authorising entry to the land managed by the Department.

A fundamental requirement is the need for the District Manager as an integrator and the custodian of the land vested in the Conservation Commission is to:

a) Ensure that broad agreement is reached early in the process with the activity proponent on the scope of the planning and management task.;

b) Undertake a preliminary analysis of likely ‘protectable’ areas and likelihood of new centres of infestation being initiated within them by the autonomous or vectored spread of the pathogen;
c) Initiate an early reconnaissance and input from an accredited Disease Interpreter; and
d) Program works to effect immediate road closures and establish entry points where appropriate.

Once the *Phytophthora cinnamomi* Occurrence Map is prepared, the District Manager should re-convene, as appropriate, a working session with the proponent to analyse and agree on the details of the management plan. At this point consideration must be given to integrating the management of all the activities occurring within each ‘protectable’ area. Proponents may signify their understanding and agreement by counter-signing the activity management plan.

The District Manager is accountable for designing and implementing an appropriate review of each *Phytophthora cinnamomi* Management Plan and ensuring that there is a reliable feedback loop in the planning and management process so that new information is incorporated into the ongoing management of the ‘protectable’ areas and the activities that occur within them using the ‘Environmental Standards Checklist – *Phytophthora cinnamomi* Managemennt Plans’. Any corrective action is recorded on the checklists. The Department’s *Phytophthora* Management Coordinator will also conduct regular reviews of *Phytophthora cinnamomi* Management Plans using the “Environmental Standards Checklist - *Phytophthora cinnamomi* Management Plans”.

Copies of current and past *Phytophthora cinnamomi* Management Plans should be available in the District Office record system. The District Manager is accountable for ensuring that copies are forwarded to Forest Management Branch for inclusion into the Department’s corporate data base and systems.

SECTION 8 – MANAGEMENT OF INFESTED AREAS AND AREAS THAT ARE NOT 'PROTECTABLE' AREAS

8.1 MANAGEMENT OBJECTIVE

The Department's objective is to establish and maintain a set of protocols, founded on science and logic, which establishes guidelines for identifying areas already infested and those areas that are not 'protectable' from root rot caused by *Phytophthora cinnamomi* and sets priorities among management options for them.

The merit for the restoration of areas that have suffered serious environmental damage through the introduction of *Phytophthora cinnamomi* must be determined. Factors to be considered include the establishment of clear and concise goals for rehabilitated areas, the likelihood of successfully achieving those goals and the anticipated costs and benefits.

In the case of declared rare flora, that is susceptible to and threatened by *Phytophthora cinnamomi,* the Department of Conservation and Land Management has in place programs centrally coordinated through the Western Australian Herbarium for the:

- Collection and cryogenic storage of germ-plasm aimed at maintaining gene pools; and
- Investigation of germination processes, cultural requirements and field establishment methods for the species collected, including site selection protocols to determine the suitability of areas for the reintroduction of a particular species.

8.2 MANAGEMENT STRATEGY

For the infested and areas that are not 'protectable' areas the Department will adopt the following:

1. Develop and maintain a set of protocols, founded on science and logic, which establish guidelines for identifying and managing infested areas and for setting priorities among management options for them.

2. Develop recovery plans that include where appropriate providing protection for threatened declared species, threatened ecological communities and the habitat of threatened native fauna through the application of the protective chemical phosphite, and the collection, storage, germination and re-introduction in the wild of threatened species.

3. Provide appropriate management guidelines and training programs.

8.3 MANAGEMENT GUIDELINES

[To be developed]

SECTION 9 - PROTECTION OF THREATENED FLORA, THREATENED ECOLOGICAL COMMUNITIES & THREATENED FAUNA HABITAT USING PHOSPHITE

9.1 MANAGEMENT OBJECTIVE

As a component of it's broader management program of threatened flora, threatened ecological communities and the habitat of threatened fauna, the Department will develop and implement as appropriate programs for the use of the protective chemical phosphite for their protection.

9.2 MANAGEMENT STRATEGY

1. Develop and maintain a set of protocols founded on science and logic which:-
   a) Guide land managers in identifying of threatened flora, threatened ecological communities and the habitat of threatened fauna that may benefit from protection through phosphite application, and
   b) May be used to establish realistic priorities for use of available resources.

2. Implement and monitor a program using scheduled applications of the protective chemical phosphite for protection of threatened flora, threatened ecological communities and the habitat of threatened fauna.

3. Refine and maintain appropriate management guidelines and training programs.

9.3 PHOSPHITE OPERATIONS GUIDELINE

Strategies for management of the impacts of *Phytophthora cinnamomi* in native ecosystems may be placed in two broad but distinct approaches. The simplest approach and one that has been used in Western Australia for over 20 years directs effort at containing the human vectored spread of the pathogen. The second involves using techniques to reduce the destructive interaction between the pathogen and its hosts. Most of these theoretically available techniques for modifying the host-pathogen interaction are prospective only, are too expensive or are unsuitable for use in native plant communities.

One technique that has reached the operational stage is the application of phosphite to either single plants or whole plant communities to give a degree of protection against root rot disease caused by *Phytophthora cinnamomi*. Since the first trials of phosphite (then called phosphonate) by stem injection into jarrah and *Banksia grandis* were conducted in 1989 by researchers at the Department's Dwellingup office a great deal has been learnt about the methodology of its use in treating native vegetation.

The objectives, strategy, methodology and procedural guidelines for applying phosphite in the protection of native plants in the wild is described in detail in *Volume III - Phosphite Operations Guidelines*.

SECTION 10 - RESEARCH, PUBLIC EDUCATION AND LIAISON

10.1 MANAGEMENT OBJECTIVES

As a component of it's broader programs of research, public education and liaison the Department's objective is to :-

1. Implement programs of interagency research and collaboration,that are closely linked with:
   a) Management requirements, and
   b) Other Western Australian, interstate, federal and international institutions involved in research and management on *Phytophthora.*
2. Encourage community interest and participation particularly through support of the Dieback Consultative Council (DCC) and Regional Coordination Groups.
3. Provide appropriate levels of information to the public on the matters related to *Phytophthora* and disease caused by it.

10.2 MANAGEMENT STRATEGIES

Implement coordinated programs of research and collaboration, which are closely linked to management requirements, and involve other Western Australian, interstate, Commonwealth and international land management and research institutions.

Through interaction with the *Phytophthora* Research Advisory Group establish clear research priorities and agreed allocation of those priorities amongst relevant institutions.

Provide appropriate levels of support to the Dieback Consultative Council, other community coordination and liaison groups and the team responsible for the implementation of the National Threat Abatement Plan for *Phytophthora spp*.

10.3 RESEARCH PRIORITIES

Eighteen of the 33 Recommendations contained in the Western Australian Dieback Review Panel Report endorsed by Government in 1997 are concerned with research. In 1999 the Dieback Consultative Council (DCC) examined the immediate need for research, and the mechanisms that will facilitate research, in order to further enhance the appropriate management of disease caused by *Phytophthora cinnamomi* in the Western Australian flora.

A. PRIORITIES

The DCC has identified 10 areas of priority research (Table 3 *Priority Research Areas*) for the next five years. Seven projects are related to short-term management needs (Targeted research) and three projects can be described as basic research fundamental to the understanding of the behaviour of the pathogen which may lead to break through solutions for the management of problems it causes.

Table 3. *Priority Research Areas*

TARGETED RESEARCH PROJECTS	NON-TARGETED RESEARCH PROJECTS
1. Optimising phosphite application regimes	1. Mode of action of phosphite
2. Reduction in autonomous spread of the pathogen using phosphite	2. Long term ecological impacts of the pathogen
3. Fire - phosphite interactions	3. Variability in phosphite tolerance of the pathogen population
4. Improving the effectiveness of hygiene/quarantine protocols	
5. Ex situ conservation and germplasm storage of *Phytophthora* - susceptible flora	
6. Role of fire in managing susceptible threatened species	
7. Seasonal and geographic variation in rate of pathogen spread and disease expression	

B. METHOD FOR RANKING RESEARCH PROJECTS

The DCC used seven criteria were used to identify the projects listed in Table 1.

1. Does the project have a demonstrated applied focus?
2. Is the project likely to contribute significantly within five years?

3. Does the project build on the results of previous work?
4. Are the objectives of the project measurable?
5. Are the project objectives able to be delivered?
6. Is the project affordable?
7. Does the project contribute to any of the following?
   - Protection of threatened flora, threatened ecological communities and/or the habitat of threatened fauna.
   - Review or improvements to hygiene measures.
   - Operational improvements in both the delivery and the effectiveness of protecting plants using phosphite.
   - Understanding the mode of action of phosphite.

The DCC suggested that the above criteria would be useful in the future ranking of research proposals for funding or other purposes.

SECTION 11 – MANAGEMENT ROLES AND RESPONSIBILITIES

The roles and responsibilities of those involved in the management of *Phytophthora cinnamomi* and diseased caused by it on lands vested in the Conservation Commission are described in this section.

11.1 *PHYTOPHTHORA* MANAGEMENT COORDINATOR

- Assists with policy development and interpretation.
- Develops and maintains management systems and sets standards
- Develops and maintains management guidelines.
- Develops, maintains and delivers accredited training programs.
- Liaises with managers, proponents, agencies and organisations on the problem of *Phytophthora cinnamomi* and disease caused by it.
- Plans and implements a program to protect threatened Declared Rare Flora, threatened ecological communities and the habitat of threatened fauna using phopshite treatments.
- Assists in the development of research priorities.
- Provides executive support for the Dieback Consultative Council
- Develops a strategy for the Department to progressively implement the recommendations of the Western Australian Dieback Review Panel Report.
- Develops and implements an effective communication plan for staff, contractors, agencies and the general public.

11.2 DISTRICT MANAGER

- Interprets the Department's policy and management guidelines and ensures that all management activities within the District comply with them.
- Accountable for the initiation, preparation, approval and effective implementation of *Phytophthora cinnamomi* Management Plans for each uninfested 'protectable' area.
- Responsible for the regular review of *Phytophthora cinnamomi* Management Plans.
- Establishes and maintain effective administration and records systems for of *Phytophthora cinnamomi* Management Plans.
- Ensures staff are nominated and trained as District *Phytophthora* Management Coordinator.

11.3 DISTRICT *PHYTOPHTHORA* MANAGEMENT COORDINATOR

- Coordinates and assists with the preparation, approval and effective implementation of *Phytophthora cinnamomi* Management Plans for ‘‘protectable’’ areas.
- Monitors implementation standards and undertakes reviews of *Phytophthora cinnamomi* Management Plans.
- Administers the records systems for *Phytophthora cinnamomi* Management Plans including any amendments made to the plans.
- Liaises with Forest Management Branch.
- Provides advice on planning and implementation standards, work methods and policy.
- Maintains an up to date copy of the manual of guidelines titled *“Phytophthora cinnamomi* and disease caused by it. *Volume I – Management Guidelines* and destroy all out of date copies.

11.4 DISEASE STANDARDS OFFICER (Forest Management Branch)

- Develops and maintains disease detection, diagnosis and mapping systems and standards.
- Monitors systems and standards and approves *Phytophthora cinnamomi* Occurrence maps.
- Develops and maintains procedures manuals for plant disease Interpreters, including an up to date copy of the manual of guidelines titled *“Phytophthora cinnamomi* and disease caused by it. *Volume II– Detection, Diagnosis and Mapping.”* and destroy all out of date copies
- Develops, maintains and implements training programs for plant disease Interpreters
- Advises on the determination of ‘protectable’ areas and their management boundaries.
- Advises on disease biology and epidemiology and management strategies and measures.
- Conducts workplace assessments and accredits plant disease Interpreters.

11.5 SENIOR INTERPRETER

- Manages plant disease Interpreter training and works programs
- Assists with the development and maintenance of disease detection, diagnosis and mapping systems and standards.
- Assists with the approval of *Phytophthora cinnamomi* Occurrence maps.
- Assists in training and evaluating staff.

- Assists with the development of *Phytophthora cinnamomi* Management Plans for ‘protectable’ areas.
- Advises on the determination of ‘protectable’ areas and their management boundaries.
- Advises on disease biology and epidemiology and management strategies and measures.

11.6 FOREST MANAGEMENT BRANCH

- Provide up to date *Phytophthora cinnamomi* Occurrence maps of a consistent standard.
- Provides *Phytophthora cinnamomi* Management maps.
- Develops and maintains an effective Departmental corporate data base.

11.7 ACTIVITY PROPONENT

- May assist with the preparation of *Phytophthora cinnamomi* Management Plans.
- Complies with the *Phytophthora cinnamomi* Management Plans requirements for ‘protectable’ areas.

11.8 PHOSPHITE OFFICER

- Assists with policy development and standards setting.
- Assists with policy development and interpretation
- Develop and maintain management systems, data-bases and sets standards.
- Develops and maintains management guidelines.
- Develops, maintains and delivers accredited training programs.
- Liaises with managers, proponents, agencies and organisations on the problem of *Phytophthora cinnamomi* and disease caused by it.
- Plans and implements a program to protect threatened Declared Rare Flora, threatened ecological communities and the habitat of threatened fauna using phopshite treatments.
- Assists in the development of research priorities.

SECTION 12 - APPENDICES

12.1 *PHYTOPHTHORA CINNAMOMI* MANAGEMENT PLAN – COPY OF THE FORM

PHYTOPHTHORA CINNAMOMI MANAGEMENT PLAN
DISTRICT:................... PLAN & MAP ID No : ....

OBJECTIVE:

To ensure that approved human activities within the 'protectable' areas of ....Park/Reserve/Block are an inconsequential vector for the establishment of new centres of infestation of *Phytophthora cinnamomi*.

ACTION REQUIRED: **(Circle and complete where appropriate)**

(1) TACTICS FOR THE LONG-TERM LAND MANAGEMENT OF THE AREA. THE DEPARTMENT IS RESPONSIBLE FOR ENSURING:

YES NO	The 'protectable' areas and their boundaries have been established and are identified as P .... on the attached map.
YES NO	....[PRINT NAME] is to close & rehabilitate to the standard specified in the manual of management guidelines the roads within the 'protectable' areas identified at the points marked X .... on the attached map by ..../..../200....
YES NO	Permanent *Phytophthora cinnamomi* management gates/turn around points/cleandown points/signs (see attached sign checklist) are installed by.......................... [PRINT NAME] on the retained roads that enter the 'protectable' areas at the points marked COE ....by ..../..../200.... and effectively maintained.
YES NO	The roads marked .... on the attached map are only used when vehicles and machines will not pick up and move soil along them.
YES NO	Road drainage entering the 'protectable' areas at the points marked D........... on the attached map is to be redirected by .... [PRINT NAME] away from the 'protectable' areas by ..../..../200.....

PLAN & MAP ID No: ………..……..………

(2) TACTICS FOR THE MANAGEMENT OF …………………….. ACTIVITIES

THE PROPONENT ……………………..…… IS RESPONSIBLE FOR ENSURING:

(PRINT NAME)

YES NO	Entry into the 'protectable' areas is via the permanent entry points COE……... and/or temporary entry points to be established by the proponent at COE ………..
YES NO	Temporary *Phytophthora cinnamomi* management gates/turnarounds/cleandown points/ signs are installed and maintained at ……………..……….
YES NO	All the temporary entry points are closed and rehabilitated to the standard specified in the manual of guidelines all at the completion of ………………..………………….. activities.
YES NO	Where work methods involve machines or vehicles working at demarcated management boundaries cross contamination from infested areas into uninfested areas does not occur.
YES NO	Only uninfested basic raw materials are used for all earthworks within the 'protectable' areas and/or in situ BRM in uninterpretable areas.
YES	Vehicles, machines & equipment are clean when entering 'protectable' areas and a written record of inspections and/or cleandowns and their effectiveness is maintained.
YES NO	Completing [Describe works]……………………….………………………………..at HMP…; ………………………………………………………………….…………………..… .at HMP…; & ……………………………………………………………...…………………….. .at HMP.… prior to the commencement of ………………………………… activities.

PREPARED & RECOMMENDED BY: Comments ……………………………………………………….

..………………………………… ……………….………….……….. ..…………....

(PRINT NAME) (SIGNATURE) (DATE)

AGREED BY ACTIVITY PROPONENT: **Copy provided: Yes/No/NA**

..…………………………………… ……………….………….……….. ..…………....

(PRINT NAME) (SIGNATURE) (DATE)

PLAN APPROVED BY:

..………………………………… ……………….………….……….. ..…………....

(PRINT NAME) (SIGNATURE) (DATE)

12.2 *PHYTOPHTHORA CINNAMOMI* MANAGEMENT MAP – LEGEND

12.3 ENVIRONMENTAL STANDARDS CHECKLIST - *PHYTOPHTHORA CINNAMOMI* MANAGEMENT PLAN

ENVIRONMENTAL STANDARDS CHECKLIST
DISTRICT…………………………… PLAN ID No. ……………….……………

REASON FOR CHECK: [CIRCLE] Progress Inspection / Audit / Close Out

DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT RESPONSIBILITIES	***PHYTOPHTHORA CINNAMOMI* MANAGEMENT PLAN** for ……………………………Park/Reserve/Block	Complies	Action Required	Not Applicable
	1. Long-term land management of the area by the Department: 1.1 The 'protectable' areas were clearly identified on the map attached to the plan. 'Protectable' areas have been maximised and effective boundaries have been clearly identified.			
	1.2 The work to close and rehabilitate roads into the "protectable" was completed to the standard specified in the manual of guidelines by the nominated target date by the nominated District staff and/or proponent.			
	1.3 *Phytophthora cinnamomi* management gates/signs/turn around points/cleandown points were installed on the roads entering the 'protectable' areas by the nominated target date.			
	1.4 Records cited that confirm that roads, leading to and/or within the 'protectable' areas that were identified for use only when soil will not be picked up and moved along them, were only used under the correct conditions			
	1.5 Works to redirect drainage entering the 'protectable' areas was completed by the target date.			

PLAN ID No. …………………………………

		Complies	Action Required	Not Applicable
PROPONENT RESPONSIBILITIES	**2. <u>Management of</u>…………………....…….<u>activities by the proponent</u>:** 2.1 Entry into 'protectable' areas has only been via approved entry points			
	2.2 Only approved temporary entry points have been established by the proponent and gates/turnarounds/cleandown points/ signs of the standard specified in the manual of guidelines installed as specified in the plan.			
	2.3 Entry points into the 'protectable' areas identified for the proponent to close and rehabilitate were clearly nominated and the works completed to the standard specified in the manual of guidelines by the nominated target date.			
	2.4 Where work methods involve machines or vehicles working at demarcated management boundaries cross contamination from infested areas into uninfested areas has not occurred.			
	2.5 Only uninfested basic raw materials were used within the 'protectable' areas.			
	2.6 Records cited that confirm: Vehicles, machines & equipment were clean when entering 'protectable' areas The required number of checks of inspections/cleandowns have been completed.			
	2.7 Proponent completed the works required described at the HMP(s) by the nominated target date			
	3. <u>Field Cleandown Points</u>: Required in the plan? Yes/No. If yes they: 3.1 Provide physical separation between the object being cleaned: ▪ The effluent being produced; and ▪ Any infested soil and plants.			
	3.2 Allow the effluent to fall directly onto infested soil or be captured for transport & correct disposal (Effluent collected has been deposited at an infested site).			
	3.3 Allow cleaned objects can enter 'protectable' areas without becoming re-infested.			
	3.4 Are easy and safe to use: ▪ When positioning an object to be cleaned, and ▪ When conducting an inspection/cleaning.			

PLAN ID No. ……..…………..……………

CORRECTIVE ACTIONS

ITEM No.	DESCRIBE ACTIONS TO BE TAKEN	ACTION BY (NAME)	DATE ACTION REQUIRED	INITIALS & DATE COMPLETED

CLOSE OUT

1. Check conducted by: ......……............. …......……....... …............

(PRINT NAME) (SIGNATURE) (DATE)

2. District Manager provided with a copy of the completed checklist: **YES** **NO**

3. Contractor/Operator/……………...…given a copy of completed checklist: **YES** **NO**

(PRINT NAME)

4. District Manager's acknowledgement: ....……................. ....……… ....

(PRINT NAME) (SIGNATURE) (DATE)

12.4 STANDARD SIGN WORDING

Standard versions of the commonly used signs are provided below. See also http://calmweb.calm.wa.gov.au/drb/rptd/vis/studio/dieback/dieback.htm

Sign Type 1

Control and Eradication of Forest Diseases
Forest Management Regulations

NO UNAUTHORISED ENTRY

All vehicles and machines
MUST BE FREE OF SOIL
before passing this point

DEPARTMENT OF Conservation AND LAND MANAGEMENT
Conserving the nature of WA

600 x 350mm – Black lettering on white background

Sign Type 2

Control and Eradication of Forest Diseases
Forest Management Regulations

NO UNAUTHORISED ENTRY

All vehicles and machines
MUST BE FREE OF SOIL
before passing this point

Enter only when vehicles and machines
will not pick up and move soil

DEPARTMENT OF Conservation AND LAND MANAGEMENT
Conserving the nature of WA

600 x 450mm – Black lettering on white background

Sign Type 3

Control and Eradication of Forest Diseases
Forest Management Regulations

ROAD
CLOSED

DEPARTMENT OF Conservation AND LAND MANAGEMENT
Conserving the nature of WA

600 x 350mm – Black lettering on white background

Sign Type 4

Control and Eradication of Forest Diseases
Forest Management Regulations

CLEANDOWN
POINT

DEPARTMENT OF Conservation AND LAND MANAGEMENT
Conserving the nature of WA

600 x 450mm – Black lettering on white background

Sign Type 5

Control and Eradication of Forest Diseases
Forest Management Regulations

DISEASE RISK AREA

NO ENTRY WITHOUT
AWRITTEN AUTHORITY

600 x 350mm – Black lettering on white background

12.5 SIGN MANAGEMENT CHECKLIST

SIGN MANAGEMENT CHECKLIST

REQUIREMENTS FOR .... BLOCK

1. Sign Type/Name of Sign **Number Required**

S1 Clean on Entry

S2 Clean on Entry. Do not pick up and move soil.

S3 Road Closed - Control and Eradication of Forest Diseases

S4 Cleandown Point

S5 Disease Risk Area

S6 Other - Specify

2. SIGN ORDERING

To be ordered by .... by ....

(Print name) (Date)

3. FIELD DETAILS (Sketch details of sign field placements; add pages as required)

4. SIGN PLACEMENT AND REMOVAL CHECKLIST

SIGN ID	ERECTED BY	DATE	REMOVAL Yes/No & When	REMOVED BY	DATE

12.6 CLOSURE - METHODS AND STANDARDS

The recommended method and standards for permanently closing and rehabilitating unwanted roads and walk trails are described below.

TYPE ONE

Place one non-utilizable log (preferably with a minimum diameter of 400mm) across the road/track.

TYPE TWO

Place three non-utilizable logs (preferably with a minimum diameter of 400mm) on the road/track, one at the entrance and two within sight from the entrance.

TYPE THREE

Rip wheel tracks for a distance of 100 metres from entrance.
Place three non-utilizable logs (preferably with a minimum diameter of 400mm) on the road/track, one at the entrance and two within sight from the entrance.

TYPE FOUR

Place four non-utilizable logs (preferably with a minimum diameter of 400mm) on the road/track, one at the entrance and three within sight from the entrance.

TYPE FIVE

Rip wheel tracks for 100 metres from the entrance and rip the wheel tracks in the turnaround.
Place three non-utilizable logs (preferably with a minimum diameter of 400mm) on road/track, one at the entrance and two within sight from the entrance.

TYPE SIX

Place three non-utilizable logs (preferably with a minimum diameter of 400mm) on road/track, one at the entrance and two within sight from the entrance, prior to commencement of activities.
Debris to be left on the track / shunt.

TYPE SEVEN

Debris to be left on road/track.

12.7 RECORD OF ENTRY INTO A 'PROTECTABLE' AREA

RECORD OF ENTRY INTO A 'PROTECTABLE' AREA

I agree to implement the *Phytophthora cinnamomi* management measures applicable to the activities I manage within the 'protectable' areas described in this plan.

1.Activity …………………………………………………………………...

Print name ….………………….. Signed ……………….……………….… Date : …..………..

2.Activity …………………………………………………………………….

Print name ….………………..……Signed.……………….……………….… Date : …..……...

3. Activity ……………………………………………………………………..

Print name ….………………..……Signed.……………….……………… Date : …..…….

4. Activity ……………………………………………………………………..

Print name ….………………..……Signed.…………………..……………… Date : ……..….

5. Activity ……………………………………………………………………..

Print name ….………………..……Signed.……………….……………… Date : ……..….

6. Activity ……………………………………………………………………..

Print name ….………………..……Signed.……………….……………… Date : ……..….

12.8 BACKGROUND TO THE REVISION OF DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT POLICY STATEMENT No. 3 "MANAGEMENT OF *PHYTOPHTHORA* AND DISEASE CAUSED BY IT"

HISTORICAL BACKGROUND

Since 1921 it has been evident that an increasing number of patches of formerly healthy jarrah forest has become afflicted with a lethal disease now known as "jarrah dieback" ('JDB').

Until 1964, the cause of this malady had been the subject of contending speculation. In that year proof of the role of the plant pathogen *Phytophthora cinnamomi* as the cause of 'JDB' was established. At the same time, it was recognised that this exotic microbe was also intimately associated with similar damage in other plant communities of sclerophyllous natives, whether jarrah was dominant, a minor component only, or not present at all. The period of intensive research which followed is ongoing and has resulted in revised perceptions of the nature of the pathogen and of the diseases which result from its interactions with the enormously diverse native vegetation of southwester Australia.

Phytophthora cinnamomi is a soil-borne micro-organism of foreign origins. It almost certainly entered Western Australia for the first time on soil around the roots of cultivated plants, shortly after European settlement in 1827. Until the effective implementation by Australia of quarantine of import of exotic soil and plant products there must have been innumerable introductions at many points of entry around the continent and its redistribution within the country over a period of some 150 years.

Phytophthora cinnamomi has now extended its largely unfettered colonisation of the southwest by both human movement of infested soils and autonomous spread, the latter largely by growth of the pathogen in the root systems of highly susceptible native plants. This epidemic of colonisation, which has produced a complex mosaic of infested and uninfested areas, is now well on its way toward the middle stages of its ultimate potential to occupy all of those sites which are environmentally suited to its establishment, survival and multiplication. Such sites are very widely distributed over some 20% or more of the natural vegetation in areas throughout that part of the Southwest Land Division which receives mean annual rainfall in excess of 800mm and occur sporadically at lower rainfall.

Within the 600-800mm rainfall zone the occurrence of *Phytophthora cinnamomi* is also widespread but much less extensive. In this zone severe damage to native vegetation is largely confined to water-gaining sites or to years of abnormally high summer rains. In these circumstances localised patches of the vegetation may periodically suffer severe damage with intervals of recovery during dryer periods.

In areas receiving <600mm dieback due to *Phytophthora cinnamomi* is restricted to circumstances where localised hydrological effects, such as the shed from granite bosses or rising ground water tables associated with upslope land clearance in the catchment, cause effective rainfall to substantially exceed the regional patterns.

There is no record of *Phytophthora cinnamomi* in regions receiving <400mm.

NATURE OF THE EFFECT OF THE PATHOGEN ON CONSERVATION AND COMMERCIAL VALUES

The effect of *Phytophthora cinnamomi* upon the health of plant communities, and upon the species in them, varies greatly. In many places, lethal root-disease destroys the structure of many native communities, reduces their floristic diversity, decimates their primary productivity and destroys habitat for much dependant native fauna, particularly its value as protection against feral predators. In some places the pathogen causes little damage at all. Unfortunately the extent of susceptible communities in vulnerable environments is much greater than that of communities which occur in environments which are inherently unfavourable to the pathogen.

No simple or single relationships exist between the presence of *Phytophthora cinnamomi* and the development of disease because of :-

a) the considerable variability which exists within and between native plant species in their responses to the presence of *Phytophthora cinnamomi*,
b) the differential influence of temporal and spatial variation in environmental forces,

However, within the spectrum of variable disease, response of numerous hosts to particular environmental circumstance, at least four specific nodes can be recognised. These are due to either distinct processes or to different stages in the development of disease which occur upon and after the arrival of the pathogen and its persistence in previously uninfested areas. Each of these circumstances presents a different problem which require separate sets of management response. It is now evident that among the variety of plant communities which occur within that part of the South West Land Division which receives more than 800mm mean annual rainfall the four sets of distinctive consequences are:-

1. No apparent disease at all: this applies *inter alia* to those areas of karri and wandoo forest which contain no floristic elements of the dry sclerophyll (jarrah) forest type and to plant communities on the Spearwood Dune System of the Swan Coastal Plain and pedogenically related landscapes.

2. An extremely destructive epidemic of root rot: this applies within the highly susceptible understorey elements of the dry sclerophyll forest, in *Banksia*

3. woodland and in heathland on podsols, podsolic and lateritic landform. It is characterised by:-
   a) devastation soon after the first arrival of the wave front of infestation,
   b) steady extension of epidemic disease soon after arrival of the pathogen,
   c) complete or near complete elimination of important structural elements of the plant community.
   d) a relative insensitivity of the degree of damage to variation in soil characteristics.

3. A much more variable epidemic occurs within the dominant jarrah tree component of the jarrah forest. - this is characterised by :

   a) a much more erratic and often protracted onset of mortality ranging from early localised onset of mass collapse (similar to type above) through delayed and patchy mortality to no apparent effect at all on health of the jarrah overstorey.
   b) high sensitivity to subtle differences in soils characteristics particularly those effecting drainage.

All variants in the response of jarrah are coincident with, or preceded by, mass deaths in susceptible elements of the understorey. In jarrah, their behaviour varies from that characteristic of epidemics of disease due to invasion by an exotic organism to which the vegetation has not been previously exposed to that typical of long established endemic disease.

4. Where *Phytophthora cinnamomi* has been long established (some 50 years or more) in sites formerly dominated by jarrah/banksia forest and has been very heavily impacted *Phytophthora cinnamomi* behaves in a manner characteristic of endemic pathogen. The forest is often replaced by an 0pen woodland of marri/parrot bush. Periodic outbreaks of mortality in parrot bush (*Dryandra sessilis)* follow, with subsequent regeneration by seed. At this late stage, *Phytophthora cinnamomi* causes more muted disease than at the wave front.

RATIONALE OF THE NEED FOR A REVISION OF POLICY.

Statements of policy , protocols for management, and manuals of practice first developed in the early 1970's have been periodically revised to take account of advances in knowledge and wider managerial experience.

Prior to the present document the most recent statement of policy was encapsulated in the Department's Policy Statement No. 3. "*Phytophthora* Dieback" of January 1991.

The objective of that statement read :-

"To **prevent the introduction, spread or intensification** of the plant diseases caused by *Phytophthora* species **throughout the state**, with particular emphasis on the southwest... (and to monitor for *Phytophthora*)....activity in the remainder of the state, **especially in tropical areas**."

In 1996 an independent review [the WA Dieback Review (Podger *et al*)] was conducted for the government, a process of public input completed, and an appraisal of the recommendations of the review panel completed by the Department.

The Department has now accepted that eradication and prevention of the establishment of new centres of infection is not a realisable objective, even were it both a socially acceptable strategy of denial of human access for any purpose and involved an eradication program of native animals which vector the pathogen. Similarly insurmountable problems of scale and cost would attend efforts to map and treat the thousands of kilometers of invasion front now established within 17 million ha of remnant native vegetation in the Southwest Land Division.

Further, despite intensive research and extensive field tests over three decades, the delivery of ameliorative treatments (which might favourably modify those environmental influences responsible for destructive interaction between plant species which are susceptible to the pathogen) though biologically well founded has so far proved to be impracticable.

Earlier concerns that other species of *Phytophthora* might cause similarly severe and extensive damage are largely unsubstantiated. *P. citricola* and *P. drechsleri* are known to cause very minor damage despite their widespread distribution. Several taxa within each of the species complexes usually assigned to *P. megasperma* or *P. cryptogea* are generally restricted to seasonally inundated sites. Records of *P. nicotianae* are few and derived almost entirely to native plants in cultivation. Whereas research to clarify the role of *P. cryptogea* and *P. megasperma* is on-going, the current revision of policies is focussed on *Phytophthora cinnamomi.*
A further question, of now reduced concern, is the extent to which species of *Phytophthora* might threaten native vegetation in tropical latitudes. Nowhere on earth has any species of *Phytophthora* proved to be a serious pathogen of undisturbed native vegetation in the wet-dry tropics (eg. the Kimberley and Northern Territory) or in the arid zone (eg. Hamersley and McDonnell Ranges.). There are no records of *Phytophthora* species from any source other than irrigated crop culture in these climatic regions within W.A. and none at all of *P. cinnamomi*. This assessment does not however preclude effort to diagnose the cause of any unusual disease in naturally occurring native plant ecosystems that might occur in the future in these regions.

As a result of these processes it is now accepted that Policy No 3 of 1991 is founded on outdated concepts and is both unaffordable and unattainable and should be revised.

CHOICE AMONG POLICY ALTERNATIVES

Three alternative strategies, other than to retain the existing and extremely optimistic policy No 3 of June 1991, are available.

a. **The first alternative**

"Acceptance of the inevitability of defeat and liquidation of material assets"

is argued by very few and is extremely unlikely to be socially acceptable.

b. **A second alternative**

"Prohibition of all human access"

is expected to be attractive to a very small minority. Apart from its impracticality it has serious adverse socio-economic consequences.

c. **The third alternative**

"Adoption of attainable objectives within a framework of socially affordable cost"

will of necessity prove less optimistic than the present policy and will require improved methods of priority setting and greater operational efficiencies including the removal of unnecessary constraints on access and a simplification of operational guidelines.

ESSENTIAL ELEMENTS OF A NEW POLICY.

1. Focus effort principally on *Phytophthora cinnamomi* ?

Whereas it is now recognised that at least eight distinct species of P*hytophthora (P. boehmeriae, Phytophthora cinnamomi, P. citricola, P. cryptogea, P. drechsleri, P. gonapodyides, P. megasperma & P. sojae)* occur at various places in native plant communities of Western Australia (and that the potential importance of several of them still require some further elucidation). *Phytophthora cinnamomi* represents by far the greatest ongoing threat to conservation and other benefits to society which native plant communities provide. This policy should concentrate therefore on *Phytophthora cinnamomi*.

2. A uniform policy across the State ?

The policy should apply uniformly across the South West Land Division only. There is no problem to address in the Eremaea or the wet/dry tropics. Furthermore the distinction in Policy

No 3 between lands north and south of the Preston River should be abandoned together with guidelines based upon it. The scientific basis for that distinction has never been apparent and there is little evidence that it has been beneficial.

CLARITY OF CONCEPTS AND TERMINOLOGY

1. The existing confusion in the use of terms and their conceptual basis needs urgent address. This includes tautological and counter-intuitive usage and extends to an entrenched lexicon which inhibits rather than promotes understanding of underlying principles and processes.

2. Use of the term '7 way test' implies some form of mathematical calculation and encourages a false sense of prescriptive rigour. It is in fact no more than a checklist based on flawed concepts and terminology. It would be better to refer to a set of guidelines for consideration of factors that should normally be taken into account in planning operations.

3. Much of the classification for hygiene purposes is now seen to be superfluous. A particular example is the confusion of risk and hazard. The former is a vital consideration for planning hygienic access. The latter refers only to a forecast of the probable level of damage should *Phytophthora cinnamomi* establish in an area not yet colonised by it. Hazard is determined by both site factors and host susceptibility. Even in the same place it differs depending upon the plant species under consideration. Hazard for jarrah for example may vary greatly over an area which is of uniformly high hazard for species of *Banksia*. Furthermore it has been clearly demonstrated that it is unreasonable to expect that even trained and experienced interpreters should be able to diagnose hazard with any degree of reliability at all. Its use should be abandoned.

4. The matter of reform of terminology will not be simple due to more than 20 years of indoctrination and recital. An organised program of retraining is required.

12.9 WRITTEN AUTHORISATION TO TAKE A POTENTIAL CARRIER INTO A RISK AREA OR DISEASE RISK AREA

12.9.1 Card example

FRONT OF CARD

AUTHORITY NO: ………….

AUTHORISATION

TO TAKE A POTENTIAL CARRIER OF A FOREST DISEASE

INTO A PROCLAIMED RISK AREA OR TO POSSESS, USE OR MOVE A POTENTIAL

CARRIER OF A FOREST DISEASE

WITHIN A PROCLAIMED RISK AREA

[See other side]

BACK OF CARD

In accordance with Regulation 106 of the *Forest Management Regulations 1993*

[Type in Full Name]

may take a potential carrier(s) of a forest disease into a proclaimed risk area or possess, use or move a potential carrier of a forest disease within a proclaimed risk areas subject to compliance with the requirements of any relevant *Phytophthora cinnamomi* Management Plan(s) or in the absence of such a plan(s) after ensuring the potential carrier(s) is clean prior to entry to, and that it will not pick up and move soil while within, a proclaimed risk area.

WARNING: The regulations provide penalties for failure to comply with this authorisation.

……………………………….	……………………………….
[Name of Issuing Officer]	**[Signature of Issuing Officer]**
……………………………….	……………………………….
[Date issued]	**[Expiry date]**

12.9.2 Paper document example

<u>Authorisation to Take a Potential Carrier into a Risk Area or Disease Risk Area</u>

In accordance with regulation 106 of the *Forest Management Regulations 1993*, the potential carriers (vehicles) and drivers listed below may enter a proclaimed risk area or disease risk area subject to the conditions contained in this document.

Authority Number: **Issued at:**

Period during which the authority to enter may be used:

Start Date : **Expiry Date:**

Authority to Enter:

Holders Name:……………………………………

Address:……………………………………………………………………

Suburb:……………………………………….Postcode………………….

Phone Number……………………………………………

Reason for Reason for Entry :

………………………………………………………………………………………..
……………………………………………………………………………………….

Potential Carriers Authorised to be used:

Registration Number	Make	Colour

Authorised Access Route(s) (Map must be attached):

No soil Movement :
……………………………………………………………………………………….
……
……
Soil Movement :
………………………………………………………………………………………

<u>Hygiene Requirements:</u>

- Are access conditions, requirements and other activities in accordance with the approved *Phytophthora* Management Plan | Yes | No |

For No Soil Movement:

- All vehicles, plant and equipment must be free of soil and root material prior to entering and whilst in the restricted access areas.
- No soil or root material may be moved at any time.
- After a rain event, the authority holder must obtain specific endorsement from an authorised person in the district from which the authority to enter was issued prior to entering the forest.

Rainfall Endorsement
Date:………………………………..
Officer:………………………………………………….

For Soil Conditions:

- All access and other activities must be in accordance with the approved *Phytophthora cinnamomi* Management Plan access routes.
- Soil movement may not occur in any areas not specifically approved as soil movement.

General Requirements:

- The authority holder must be able to interpret a Departmental map and be able to navigate the designated route(s)
- The authority holder is only authorised to travel the roads and tracks as specifically authorised in the authority to enter.
- Vehicles and plant may only enter or remain in the restricted access areas with a valid authority to enter.
- All conditions and information contained in written approvals, sign posts and gates must be adhered to.
- All operations must be undertaken in accordance with the *Conservation and Land Management Act 1984*, *Conservation and Land Management Regulations 2002, Forest Management Regulations 1993*, *Wildlife Conservation Act 1950*.

Authority to Enter Approved:

Officers Name:…………………………………………………….

Officer's Signature:……………………………………………….

Date……………………..

I have read and understood the above authority to enter and I agree to observe the conditions of this authority to enter and regulations made under the *Conservation and Land Management Act 1984*.

12.10 LIST OF OTHER RELEVANT MANUALS AND REPORTS

W.A Dieback Review Panel Report 1996

Appendix J: Licence to Take Water

Ve etation nit Inde

Symbols	Vegetation Units
Ac	*Acacia cochlearus* Closed Heath to Open Heath
AcOaMs	*Acacia cochlearus – Oleria axillaris – Melaleuca systena* Open Heath
Ar	*Acacia rostellifera* Heaths (Q)
Ar	*Acacia rostellifera* Closed Scrub to Shrubland (S)
ArMs	*Acacia rostellifera – Melaleuca systena* Open Low Heath
As	*Acacia saligna* Scrubs to Heaths
AsJf	*Acacia saligna* and *Jacksonia furcellata* Open Scrub to Open Tall Shrubland
AsMs	*Acacia saligna – Melaleuca systena* Shrubland
Ba	*Banksia attenuate* Low Woodland to Open Low Woodland
Ba / AsMs	*Banksia attenuate* Low Woodland and Acacia saligna – melaleuca systena Shrubland
Ba / C	*Banksia attenuate* Low Woodland to Open Low Woodland and Scattered and Cleared of native vegetation
Ba / X	*Banksia attenuate* Low Woodland to Open Low Woodland and *Xanthorrhoea preissii* Shrubland to Low Shrubland
Bam	*Banksia attenuate* – B. Menziesii Low Woodland
BamEt	*Banksia attenuate* – B. Menziesii – *Eucalyptus todtiana* Low Woodland to Open Low Woodland
C	Cleared of native vegetation; very few, if any, native plants
Ds	*Dryandra sessilis* Open Heath to Closed Heath (Q)
Ds	*Dryandra sessilis* Open to Closed Heath to Scrubs (S)
Ds / Ba	*Dryandra sessilis* Open Heath and Banksia attenuate Low Open Woodland to Scattered Open Heath
DsCqAp	*Dryandra sessilis – Calothamnus quadrifidus – Acacia pulchella* Closed Heath
DsMhAt	*Dryandra sessilis* Closed Heath with Melaleuca huegelii and / or Acacia truncata
DsMs	*Dryandra sessilis – Melaleuca systena* Open Heath to open Low Heath
Eg	*Eucalyptus gomphocephala* individual trees to small stands of forest (Q)
Eg	*Eucalyptus gomphocephala* (Tuart) individual low trees, or tree mallee (S)
EgMs	*Eucalyptus gomphocephala* Woodland to Scattered over *Melaleuca systena* Open Heath to Shrubland
EMsLm	*Eucalyptus gomphocephala* Open Woodland to Scattered over *Melaleuca systena* Open Low Heath and *Lomandra maritima* Herbland
Fp	*Frankenia pauciflora* Very Low to Low Shrubland
Hh	*Hibbertia hypericoides* Open Low Heath, with *Calothamnus quadrifidus*
Lg	*Lepidosperma gladiatum* Sedgeland
McDs	*Melaleuca cardiophylla – Dryandra sessilis* Closed Heath (with M. Huegelii)
Mch	*Melaleuca cardiophylla – M. huegelii* Low Shrubland to Open Low Heath
MhAt	Melaleuca huegelii – Acacia truncata – Trymalium ledifolium Open Low Heath
Mhcs	*Melaleuca huegelii – M. cardiophylia – M. systena* Closed Heath
MhDs	*Melaleuca huegelii – Dryandra sessilis* (over *Melaleuca systena – Acacia truncate*) Open Low Heath [formerly 'MhsAt (Q)]
Mhs	*Melaleuca huegelii – M. systena [-Dryandra sessilis*] Low Shrubland to Open Low Heath, with Acacia truncate (Q) [formerly 'Mh']
Mhs	*Melaleuca huegelii – M. systena* Closed Heath (S)
MhsAt	*Melaleuca huegelii – M. systena – Acacia truncate* Open low Heath
MhsDs	*Melaleuca huegelii – M. systena – Dryandra sessilis* Open heath to Low Shrubland
Ms	*Melaleuca systena* Low Shrubland to Shrubland
MsDsAt	*Melaleuca systena – Dryandra sessilis – Acacia truncata* Closed Low Heath (with *Melaleuca cardiophylla*) [formerly 'McDsAt]
Ms / MsLm	*Melaleuca systena* Low Shrubland to Shrubland and *Melaleuca systena* – Open Low Heath over *Lomandra maritima* herbland
MsLm	*Melaleuca systena* Open Low Heath over *Lomandra maritima* herbland
MsLm/Hh	*M. systena* open Low Heath over *Lomandra maritima* Herbland and Hibbertia hypericoides Open Low Heath
MsOaLm	*Melaleuca systena – Olearia axillaris* Open Low Heath over *Lomandra maritima* herbland
Nf	*Nuytsia floribunda* Closed Low Heath and Open Low Woodland, with 5 trees (in Site B only)
Nf	*Nuytsia floribunda* Open Low Forest to Low Woodland (not in Site B)
SgSc	*Spyridium globulosum – Scaevola crassifolia* Closed Low Heath to Shrubland
X	*Xanthorrhoea preissii* Shrubland to Low Shrubland (Q)
X	*Xanthorrhoea preissii* Shrubland to Low Shrubland (S)

Appendix K: Vegetation Community Index

Vegetation Unit Index

Symbols	Vegetation Units
Ac	*Acacia cochlearus* Closed Heath to Open Heath
AcOaMs	*Acacia cochlearus – Oleria axillaris – Melaleuca systena* Open Heath
Ar	*Acacia rostellifera* Heaths (Q)
Ar	*Acacia rostellifera* Closed Scrub to Shrubland (S)
ArMs	*Acacia rostellifera – Melaleuca systena* Open Low Heath
As	*Acacia saligna* Scrubs to Heaths
AsJf	*Acacia saligna* and *Jacksonia furcellata* Open Scrub to Open Tall Shrubland
AsMs	*Acacia saligna – Melaleuca systena* Shrubland
Ba	*Banksia attenuate* Low Woodland to Open Low Woodland
Ba / AsMs	*Banksia attenuate* Low Woodland and Acacia saligna – melaleuca systena Shrubland
Ba / C	*Banksia attenuate* Low Woodland to Open Low Woodland and Scattered and Cleared of native vegetation
Ba / X	*Banksia attenuate* Low Woodland to Open Low Woodland and *Xanthorrhoea preissii* Shrubland to Low Shrubland
Bam	*Banksia attenuate* – B. Menziesii Low Woodland
BamEt	*Banksia attenuate* – B. Menziesii – *Eucalyptus todtiana* Low Woodland to Open Low Woodland
C	Cleared of native vegetation; very few, if any, native plants
Ds	*Dryandra sessilis* Open Heath to Closed Heath (Q)
Ds	*Dryandra sessilis* Open to Closed Heath to Scrubs (S)
Ds / Ba	*Dryandra sessilis* Open Heath and Banksia attenuate Low Open Woodland to Scattered Open Heath
DsCqAp	*Dryandra sessilis – Calothamnus quadrifidus – Acacia pulchella* Closed Heath
DsMhAt	*Dryandra sessilis* Closed Heath with Melaleuca huegelii and / or Acacia truncata
DsMs	*Dryandra sessilis – Melaleuca systena* Open Heath to open Low Heath
Eg	*Eucalyptus gomphocephala* individual trees to small stands of forest (Q)
Eg	*Eucalyptus gomphocephala* (Tuart) individual low trees, or tree mallee (S)
EgMs	*Eucalyptus gomphocephala* Woodland to Scattered over *Melaleuca systena* Open Heath to Shrubland
EMsLm	*Eucalyptus gomphocephala* Open Woodland to Scattered over *Melaleuca systena* Open Low Heath and *Lomandra maritima* Herbland
Fp	*Frankenia pauciflora* Very Low to Low Shrubland
Hh	*Hibbertia hypericoides* Open Low Heath, with *Calothamnus quadrifidus*
Lg	*Lepidosperma gladiatum* Sedgeland
McDs	*Melaleuca cardiophylla – Dryandra sessilis* Closed Heath (with M. Huegelii)
Mch	*Melaleuca cardiophylla – M. huegelii* Low Shrubland to Open Low Heath
MhAt	Melaleuca huegelii – Acacia truncata – Trymalium ledifolium Open Low Heath
Mhcs	*Melaleuca huegelii – M. cardiophylia – M. systena* Closed Heath
MhDs	*Melaleuca huegelii – Dryandra sessilis* (over *Melaleuca systena – Acacia truncate*) Open Low Heath [formerly 'MhsAt (Q)]
Mhs	*Melaleuca huegelii – M. systena [-Dryandra sessilis*] Low Shrubland to Open Low Heath, with Acacia truncate (Q) [formerly 'Mh']
Mhs	*Melaleuca huegelii – M. systena* Closed Heath (S)
MhsAt	*Melaleuca huegelii – M. systena – Acacia truncate* Open low Heath
MhsDs	*Melaleuca huegelii – M. systena – Dryandra sessilis* Open heath to Low Shrubland
Ms	*Melaleuca systena* Low Shrubland to Shrubland
MsDsAt	*Melaleuca systena – Dryandra sessilis – Acacia truncata* Closed Low Heath (with *Melaleuca cardiophylla*) [formerly 'McDsAt]
Ms / MsLm	*Melaleuca systena* Low Shrubland to Shrubland and *Melaleuca systena* – Open Low Heath over *Lomandra maritima* herbland
MsLm	*Melaleuca systena* Open Low Heath over *Lomandra maritima* herbland
MsLm/Hh	*M. systena* open Low Heath over *Lomandra maritima* Herbland and Hibbertia hypericoides Open Low Heath
MsOaLm	*Melaleuca systena – Olearia axillaris* Open Low Heath over *Lomandra maritima* herbland
Nf	*Nuytsia floribunda* Closed Low Heath and Open Low Woodland, with 5 trees (in Site B only)
Nf	*Nuytsia floribunda* Open Low Forest to Low Woodland (not in Site B)
SgSc	*Spyridium globulosum – Scaevola crassifolia* Closed Low Heath to Shrubland
X	*Xanthorrhoea preissii* Shrubland to Low Shrubland (Q)
X	*Xanthorrhoea preissii* Shrubland to Low Shrubland (S)