

# Gravel Pit Revegetation Plan for the East Road Gravel Pit, Kent

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Prepared for the Shire of Kent  
March 2019



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## Statement of limitations

### Reliance on data

In the preparation of this report, Ecoedge has relied on data, surveys, analyses, designs, plans and other information provided by the Client and other individuals and organisations, most of which are referred to in the report. Unless stated otherwise in the report, Ecoedge has not verified the accuracy or completeness of the data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in the report are based in whole or in part on the data, those conclusions are contingent upon the accuracy and completeness of the data. Ecoedge will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, unavailable, misrepresented or otherwise not fully disclosed to Ecoedge.

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# 1 Introduction

## 1.1 Purpose of the plan

The Shire of Kent (the Shire) propose to undertake an extension to a gravel pit located on the south side of East Road approximately 2.3 kilometres east of the Newdegate-Pingrup Road intersection. These works will require the clearing of approximately 1.6 hectares (ha) of native vegetation and are required in order to provide for the future ongoing road maintenance works within the Shire.

Ecoedge was engaged by the Shire in September 2018 to prepare a revegetation plan for the rehabilitation of the 1.6 ha of cleared land to mitigate the impact of the clearing activities (the Project Area) (**Figure 1**).

This revegetation plan aligns with State guidelines for the preparation of a revegetation plan for Clearing Permits (Department of Water and Environment Regulation, 2018).

## 1.2 Impact mitigation

The proposed revegetation activities will mitigate impacts of clearing in the following ways.

The revegetation activities mean that the proposed clearing will not result in a permanent loss of vegetation at site and that there will be no net loss of vegetated areas.

The revegetated area will restore the overall functioning of the ecological linkage/corridor for the migration of fauna and flora.

Revegetation processes will mitigate potential impacts to infiltration and drainage caused by extraction activities. The exposed clay layer will be ripped and covered with overburden, topsoil and mulch. This will slow water flow and facilitate localised water infiltration.

Restored vegetation and proposed weed control activities will impede potential recolonisation of cleared areas by weeds.

Site restoration efforts will promote positive community attitudes in the local and broader community about responsible custodianship of the environment.

### 1.3 Plan preparation details

Clearing Permit number: To be confirmed

Revegetation Plan

Author: Colin Spencer (B.Sc. (Hons)), Botanist, Debbie Brace (B.Sc (Hons in mine site rehabilitation) Ecoedge Director.

Experience: Colin Spencer

- Ecoedge Botanist, 2018 to present
- Local Government Environmental Officer, 10 years (City of Bunbury)
- Local Government Bushland Regenerator, 3 years (City of Melville)
- Catchment Management Group Bushland Regenerator and Environmental Education officer, 3 years (Bayswater Integrated Catchment Management Group)



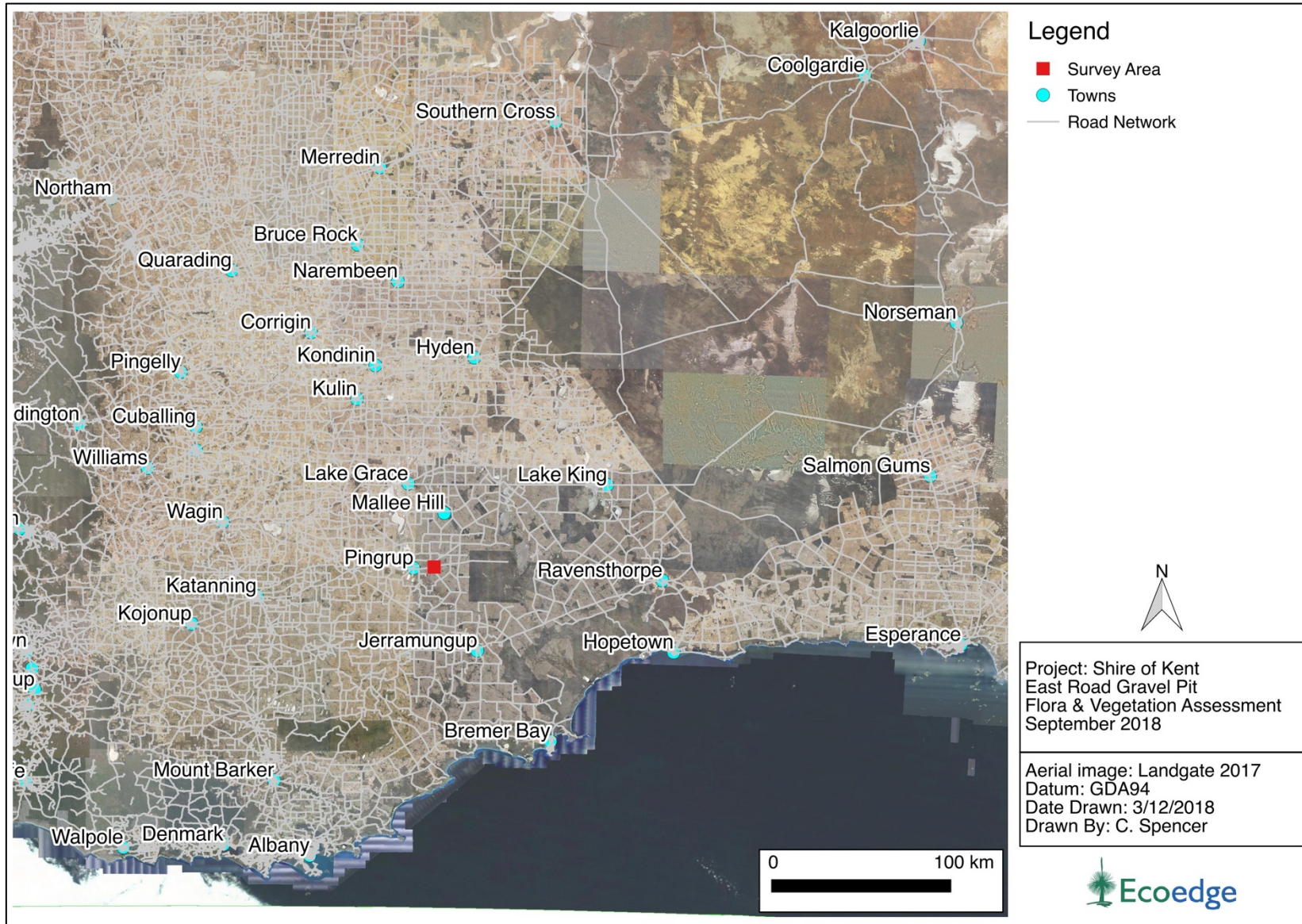


Figure 1. Aerial photograph showing the location of the Project Area.

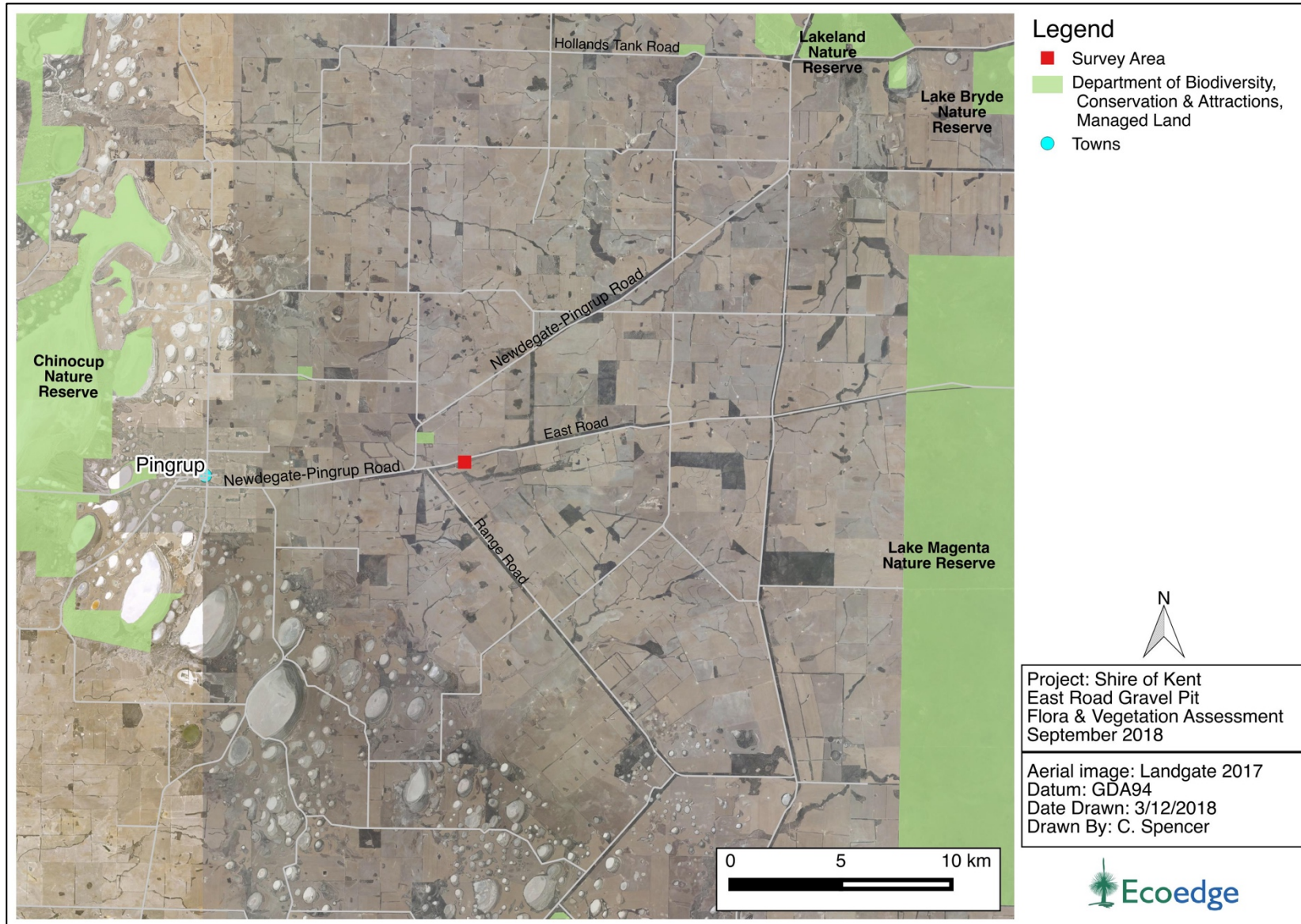


Figure 2. The Project Area in context of surrounding land uses.

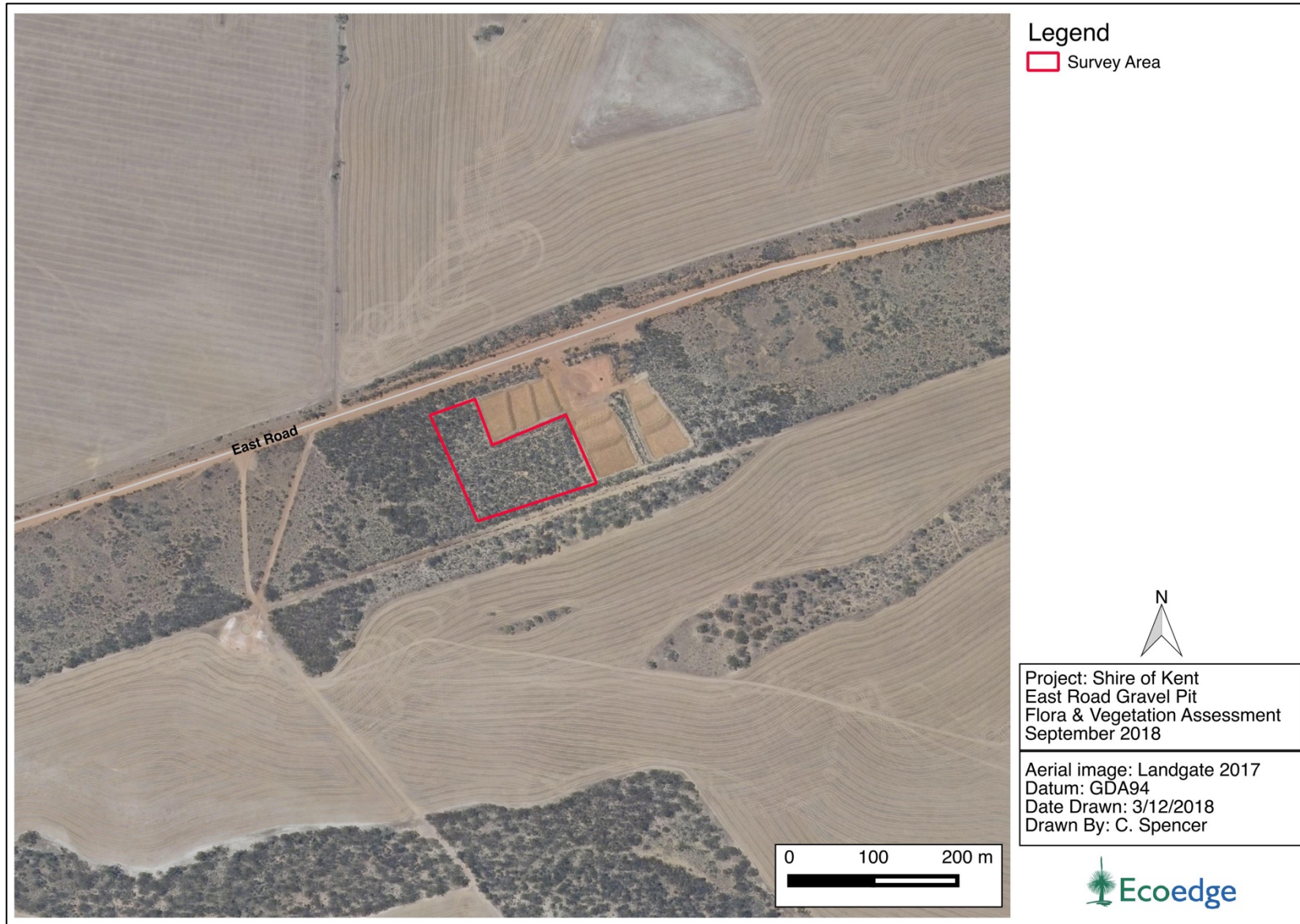


Figure 3. The Project Area approximate clearing and subsequent revegetation boundary.

## 2 Background of revegetation site

### 2.1 Planning considerations

- Area: 1.6 hectares
- Tenure: Crown Land
- Management arrangement: Shire of Kent
- Zoning: Road Reserve

### 2.2 Conservation security

The site will be managed for road reserve purposes – consistent with its reservation – on an ongoing basis. The use of the land for conservation/revegetation activities is consistent with the area’s reservation and will not be an impediment for ongoing use of this site for this purpose.

### 2.3 Site location and description

The Survey Area is situated within the Western Mallee (MAL2) sub-region of the Mallee biogeographic region, as defined in the Interim Biogeographical Regionalisation for Australia (IBRA) (Commonwealth of Australia, 2016).

The Survey Area occurs within the South Eastern Zone of Ancient Drainage (SEZAD) which has a zone mapping unit 250. The SEZAD generally comprises a smooth to irregularly undulating plain dominated by salt lake chains in the main valleys with duplex and lateritic soils on the uplands.

The Survey Area occurs within a corridor of vegetation approximately 200 m wide that runs east and west along East Road for a total of about 14.5 kilometres. This corridor is locally significant as it provides a key linkage for many isolated patches of bushland that are located in the near vicinity north and south of it in an otherwise cleared landscape (**Figure 2** and **Figure 3**).

## 3 Climate

The Project Area experiences a Mediterranean climate with cool wet winters and warm dry summers. The annual average rainfall is 357.7 mm per year.

Monthly average rainfall and temperature data for the Project Area is presented in **Table 1**.

Table 1. Average rainfall and temperature data for the Project Area

Month	Rainfall <sup>1</sup>	Temp max <sup>2</sup>	Temp min <sup>2</sup>
Jan	16.4	28.7	13.9
Feb	18	27.9	14.3
Mar	21.8	26	13.2
Apr	22.6	22.8	11.2
May	43	18.9	8.6
Jun	51.7	16.1	6.7
Jul	48.1	15	5.8
Aug	40.6	15.8	5.9
Sep	32.8	17.9	6.5
Oct	25.4	21.3	8.2
Nov	20.4	24.5	10.5
Dec	15.5	27.2	12.4
Annual	<b>357.7</b>		

1. based on climate data for Pingrup Weather Station, Station No. 10627 (Bureau of Meteorology, 2019).
2. based on climate data for Ongerup Weather Station, Station No. 10622 (Bureau of Meteorology, 2019).

### 3.1 Vegetation

A Reconnaissance and Targeted flora and vegetation survey of the project area was conducted by Ecoedge on 13 September 2018 in accordance with State and Commonwealth requirements for the bioregion and species and communities present, and the Environmental Protection Authority's 'Technical Guidance' (EPA, 2016a) (Ecoedge, 2019a).

Fifty seven (57) species of vascular flora were identified in the Survey Area (**Table 2**), two of which are classified as Priority flora.

### 3.2 Environmental weeds and declared pest plants

No environmental weeds or Declared pest plants were found within the Survey Area.

#### 3.2.1 Vegetation units

Two vegetation units were identified and mapped in the Survey Area: '*Eucalyptus eremophila* Mallee Woodland' and '*Eucalyptus pleurocarpa* Mallee Woodland'.

#### *Eucalyptus eremophila* Mallee Woodland

Mallee woodland of *Eucalyptus eremophila* over *Melaleuca pungens* tall shrubs over *Austrostipa elegantissima* scattered grass and clay loam in a drainage line (**Figure 4**).

Area: 0.05 ha

*Eucalyptus pleurocarpa* Mallee Woodland

Mallee woodland of *Eucalyptus pleurocarpa* over variable shrubland that includes *Adenanthos flavidiflorus*, *Banksia armata*, *B. cirsioides*, *B. meisneri* subsp. *meisneri*, *Bossiaea preissii*, *Lysinema pentapetalum* and *Xanthorrhoea nana* on yellow sand (**Figure 5**).

Area: 1.5 ha

Neither of these vegetation units resemble a Threatened or Priority ecological community.



Figure 4. *Eucalyptus eremophila* Mallee Woodland



Figure 5. *Eucalyptus pleurocarpa* Mallee Woodland

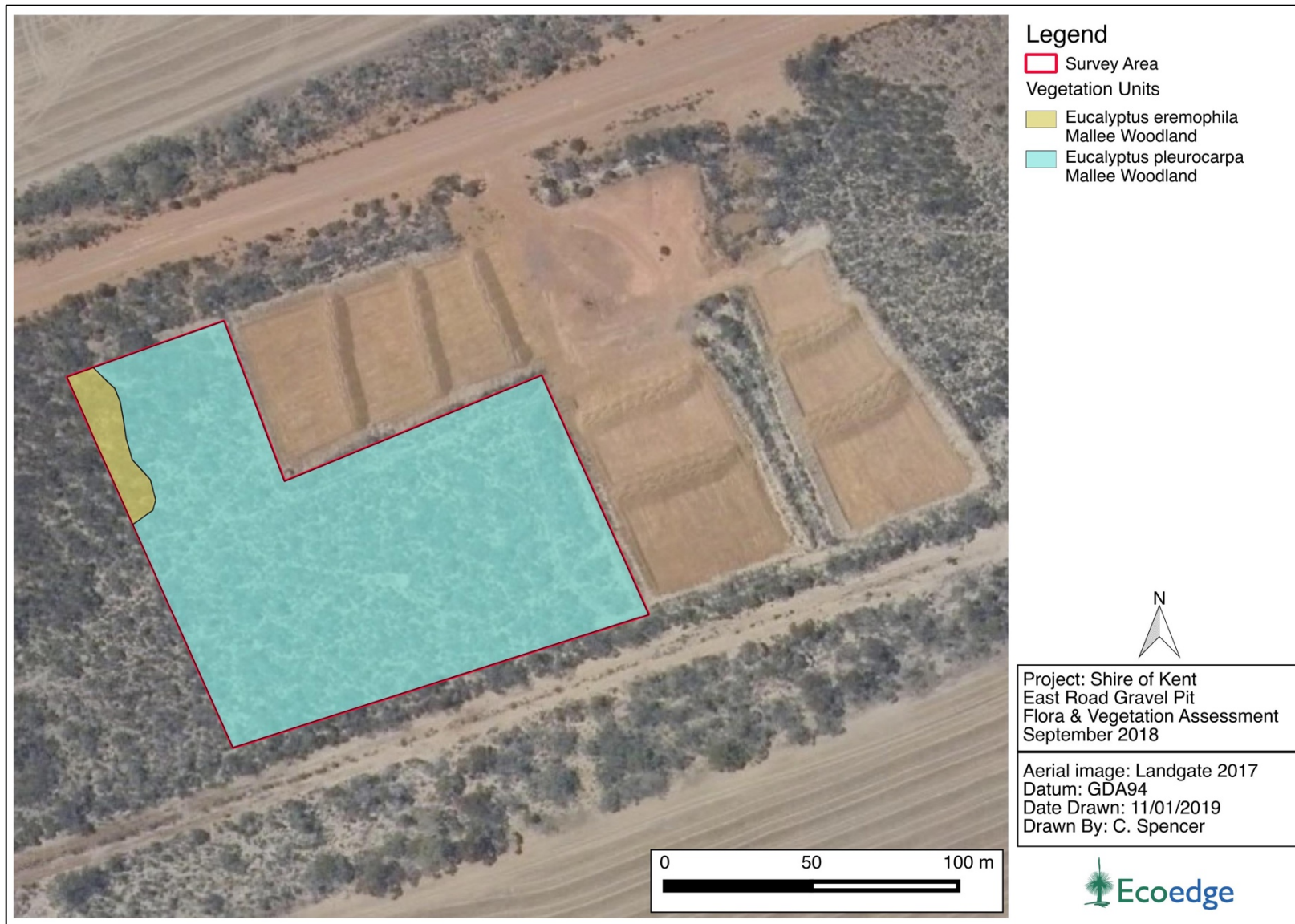


Figure 6. Vegetation units mapped for the Survey Area.

### 3.2.2 Vegetation condition

Virtually all vegetation in the Survey Area was in Excellent condition (**Figure 7**). There was some sign of previous physical disturbance in the form of tracks, and several small areas had been cleared for gravel extraction previously.

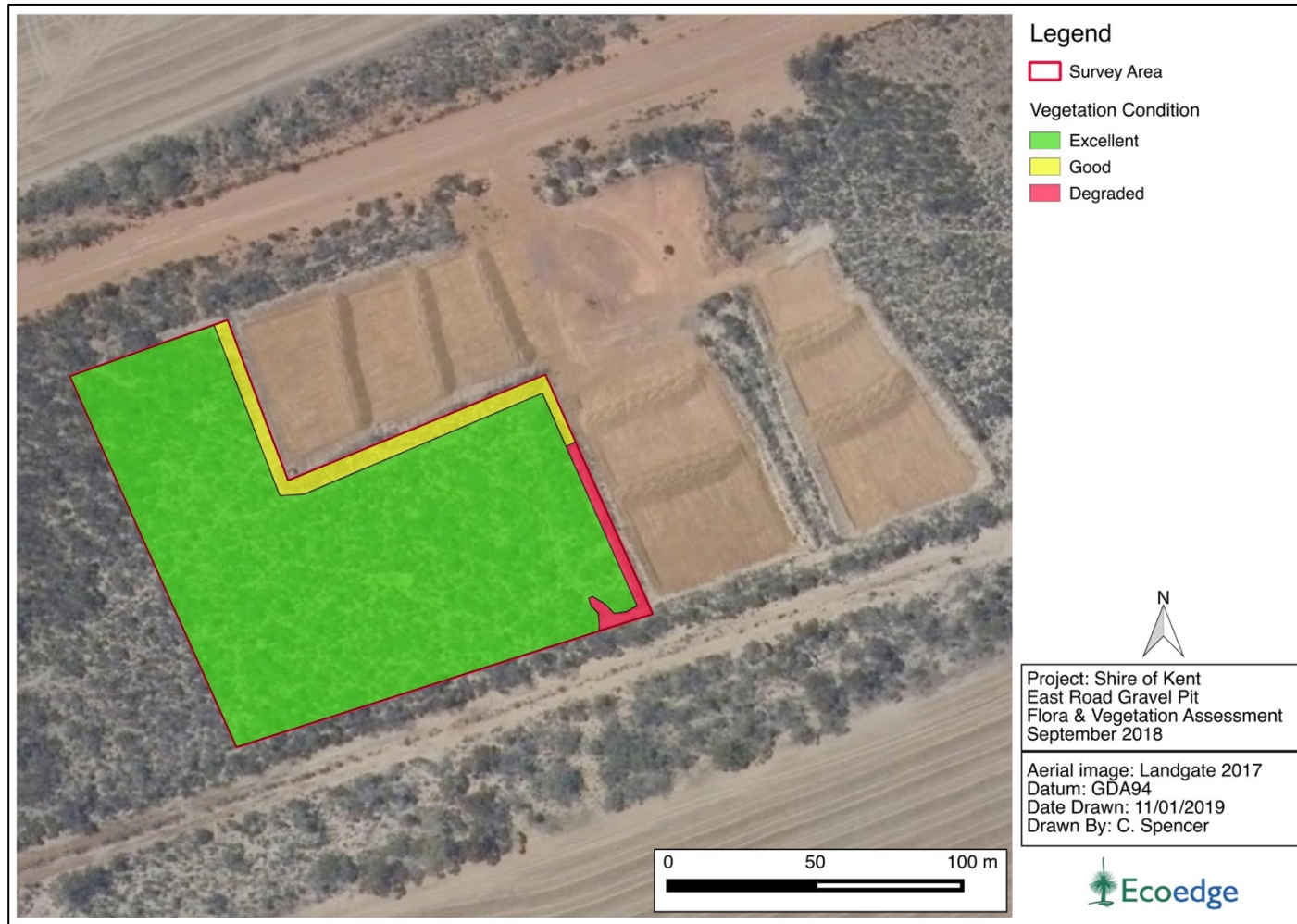


Figure 7. Condition of vegetation within the Survey Area.



## 4 Fauna

A Level 1 Fauna survey and a targeted search for Carnaby's black cockatoo habitat/site use was conducted on the 3 October 2018 (Ecoedge 2019a). The surveys were conducted in accordance with Technical Guidance - Terrestrial Fauna Surveys (EPA 2016b) and Technical Guidance – Sampling Methods for Terrestrial Vertebrate Fauna (EPA 2016c).

The fauna assessment determined that it was unlikely that any fauna species of conservation significance would be significantly impacted on by the proposed clearing. No specific revegetation measures are therefore required to meet the potential need of these species.

## 5 Current disturbance and threats

### 5.1.1 Historical disturbance

The Project Area is located adjacent to an existing gravel pit. Portions of it have been historically disturbed from previous gravel extraction activities, but for the most part the site has been free of historical disturbance.

### 5.1.2 Existing land use disturbances

The Project Areas is relatively free of conflicting lawful e.g. grazing, or unauthorised landuse disturbances e.g. unauthorised 4wd use and rubbish dumping, that could lead to deterioration of the condition of the bushland within the Project Area.

### 5.1.3 Physical site factors

Impeded infiltration and drainage: Gravel extraction will likely expose the underlying clay. This clay layer may impede drainage and alter surface and subsurface water flows. The dense clay may impede root development and uptake of the water and oxygen by plants leading to poor establishment and ongoing development of plants at site.

Erosion: The cleared area may be exposed to water and wind erosion; however this is unlikely to be an issue based on experience in adjacent cleared gravel areas which have a similar profile and level of exposure to the weather. The low annual rainfall together with the presence of large expanses of intact vegetation around the Project Area provide a lower risk of strong erosive forces.

Cleared edges adjacent to roads and previously cleared areas: Vegetation located adjacent to cleared areas are likely be subject to increased soil temperatures, evaporation and transpiration due to increased wind and solar exposure. This will favour some plant species e.g. colonising species such as those of the Fabaceae family but may compromise establishment and growth of other species.

Weather: The main potential impact to revegetation is from long hot dry seasons. A drier than average winter together with higher than average summer temperatures could have a significant impact on the establishment of vegetation.

Vandalism: Vandalism, rubbish dumping etc is a potential impact to revegetation works, however this may not be a problem due to the pits isolation

#### 5.1.4 Existing Biological Site Conditions:

Weeds: No weeds were recorded within the Project Area during the flora survey (Ecoedge, 2019a). The Project Area's isolated location within an intact tract of native vegetation is likely to be a primary reason for the site remaining relatively free of weeds.

Plant disease: Observation of the flora at site showed no obvious and significant visual signs of vegetation decline due to disease. The plant pathogen *Phytophthora cinnamomi* is not considered to be a threat in the area due to the average annual rainfall being lower than 400 mm.

Feral animals: There are known foxes and rabbits in the area, however local knowledge suggests these will not be a problem. If rabbits or other pest animals become a problem, predated on the seedlings, then mitigation measures will be required.

## 6 Revegetation commitments

### 6.1 Vision

Vegetation at the site is self-sustaining and broadly representative of the pre-clearing vegetation units represented at site within five years of the completion of revegetation.

### 6.2 Objectives

1. Enhance establishment of the pre-cleared vegetation unit through spreading topsoil, targeted direct seeding and planting of seedlings to establish dominant plant species, where possible.
2. Facilitate natural establishment of native flora through careful post-extraction pit profiling, effective breakup of exposed clay and optimum use of topsoil, overburden and debris.
3. Minimise threats to establishment of natural plants and seedlings by managing weeds and physical disturbance at the site.

### 6.3 Reference site floristic data collection

Site observations during the 2018 spring survey was used to generate the completion targets and criteria for the revegetation project (**Section 3.2.1**). The key reference data for the project is presented below:

#### Project Area

- Area:1.55 ha
- Estimated species richness: 57 species
- Estimated species density: 7500 stems/ hectare (s/ha)
- Weed cover: Nil

#### *Eucalyptus eremophila* Mallee Woodland

- Area:0.05 ha
- Estimated species richness: 13 species
- Estimated species density: 2500 stems/ hectare (s/ha)
- Estimated tree density: 200 s/ha
- Weed cover: Nil

#### *Eucalyptus pleurocarpa* Mallee Woodland

- Area: 1.5 ha
- Estimated species richness: 55 species
- Estimated species density: 5000 Species
- Weed cover: Nil

### 6.4 Species list compilation

The Project Area species list together with their respective availability of seedlings and seeds is provided in **Table 2**. This information provides the basis for the establishment of revegetation targets associated with the planting of seedlings.

Table 2. Project Area species list and commercial availability.

No	Family Name	Species Name	Is Category	Plant type	<i>Eucalyptus eremophila</i> Mallee Woodland	<i>Eucalyptus pleurocarpa</i> Mallee Woodland	Seedlings currently commercially available (Yes/No)	Seed commercially available (Yes/No)	Ease of propagation for field planting <sup>1,2,3</sup>
1	Poaceae	<i>Austrostipa elegantissima</i>		Grass	x	x	No	Yes	Ok
2	Boryaceae	<i>Borya constricta</i>		Herb		x	No	No	Challenging
3	Fabaceae	<i>Chorizema aciculare</i>		Herb		x	No	Yes	May be Ok
4	Polygalaceae	<i>Comesperma volubile</i>		Herb		x	No	No	Challenging
5	Goodeniaceae	<i>Dampiera juncea</i>		Herb	x	x	No	No	Challenging
6	Asteraceae	<i>Millotia tenuifolia</i> var. <i>tenuifolia</i>		Herb	x	x	No	No	Challenging
7	Asteraceae	<i>Podotheca angustifolia</i>		Herb		x	No	Yes	Challenging
8	Asteraceae	<i>Rhodanthe rubella</i>		Herb		x	No	No	Challenging
9	Hemerocallidaceae	<i>Stypandra glauca</i>		Herb	x	x	No	No	Challenging
10	Myrtaceae	<i>Verticordia coronata</i>	P3	Herb		x	No	No	Challenging
11	Restionaceae	<i>Chordifex sphacelatus</i>		Sedge	x	x	No	No	Challenging
12	Cyperaceae	<i>Lepidosperma</i> sp. ' <i>broadleaf</i> '		Sedge	x	x	No	No	Challenging
13	Cyperaceae	<i>Lepidosperma</i> sp. ' <i>terete</i> '		Sedge	x	x	No	No	Challenging
14	Cyperaceae	<i>Mesomelaena preissii</i>		Sedge	x	x	No	No	Challenging
15	Fabaceae	<i>Acacia acutata</i>		Shrub		x	No	No	May be Ok
16	Fabaceae	<i>Acacia chrysocephala</i>		Shrub		x	No	No	May be Ok
17	Fabaceae	<i>Acacia obesa</i>	P3	Shrub		x	No	No	May be Ok
18	Fabaceae	<i>Acacia pulchella</i>		Shrub		x	Yes	Yes	Ok
19	Proteaceae	<i>Adenanthos flavidiflorus</i>		Shrub		x	No	No	Challenging
20	Proteaceae	<i>Banksia armata</i>		Shrub		x	Yes	Yes	Ok
21	Proteaceae	<i>Banksia blechnifolia</i>		Shrub		x	No	Yes	May be Ok

No	Family Name	Species Name		Plant type	<i>Eucalyptus eremophila</i> Mallee Woodland	<i>Eucalyptus pleurocarpa</i> Mallee Woodland	Seedlings currently commercially available (Yes/No)	Seed commercially available (Yes/No)	Ease of propagation for field planting <sup>1,2,3</sup>
22	Proteaceae	<i>Banksia cirsioides</i>		Shrub		x	No	No	May be Ok
23	Proteaceae	<i>Banksia meisneri</i> subsp. <i>meisneri</i>		Shrub		x	No	Yes	May be Ok
24	Proteaceae	<i>Banksia nivea</i> subsp. <i>nivea</i>		Shrub		x	Yes	Yes	Ok
25	Proteaceae	<i>Banksia sessilis</i>		Shrub		x	Yes	Yes	Ok
26	Fabaceae	<i>Bossiaea preissii</i>		Shrub		x	No	No	May be Ok
27	Dasygogonaceae	<i>Calectasia valida</i>		Shrub		x	No	No	Challenging
28	Cupressaceae	<i>Callitris roei</i>		Shrub		x	No	Yes	May be Ok
29	Myrtaceae	<i>Calothamnus quadrifidus</i>		Shrub		x	Yes	Yes	Ok
30	Myrtaceae	<i>Calytrix leschenaultii</i>		Shrub		x	No	No	Challenging
31	Myrtaceae	<i>Chamelaucium ciliatum</i>		Shrub		x	No	No	May be Ok
32	Myrtaceae	<i>Chamelaucium megalopetalum</i>		Shrub		x	No	No	May be Ok
33	Polygalaceae	<i>Comesperma scoparium</i>		Shrub		x	No	No	Challenging
34	Proteaceae	<i>Conospermum croniniae</i>		Shrub		x	No	No	Challenging
35	Rhamnaceae	<i>Cryptandra nutans</i>		Shrub		x	No	No	Challenging
36	Fabaceae	<i>Daviesia cardiophylla</i> qm		Shrub		x	No	No	May be Ok
37	Fabaceae	<i>Daviesia incrassata</i>		Shrub		x	No	Yes	May be Ok
38	Fabaceae	<i>Daviesia incrassata</i> subsp. <i>teres</i>		Shrub		x	No	No	May be Ok
39	Fabaceae	<i>Gastrolobium reticulatum</i>		Shrub		x	No	No	May be Ok
40	Proteaceae	<i>Grevillea teretifolia</i>		Shrub		x	No	Yes	May be Ok
41	Proteaceae	<i>Hakea cygna</i> subsp. <i>cygna</i>		Shrub	x	x	No	Yes	Ok
42	Proteaceae	<i>Hakea pandanica</i> subsp. <i>crassifolia</i>		Shrub		x	No	No	May be Ok
43	Proteaceae	<i>Hakea prostrata</i>		Shrub		x	Yes	Yes	Ok

No	Family Name	Species Name	ns Category	Plant type	<i>Eucalyptus eremophila</i> Mallee Woodland	<i>Eucalyptus pleurocarpa</i> Mallee Woodland	Seedlings currently commercially available (Yes/No)	Seed commercially available (Yes/No)	Ease of propagation for field planting <sup>1,2,3</sup>
44	Dilleniaceae	<i>Hibbertia gracilipes</i>		Shrub		x	No	No	Challenging
45	Lamiaceae	<i>Lachnostachys verbascifolia</i>		Shrub		x	No	No	May be Ok
46	Ericaceae	<i>Lysinema pentapetalum</i>		Shrub		x	No	No	Challenging
47	Myrtaceae	<i>Melaleuca pungens</i>		Shrub	x	x	No	Yes	Ok
48	Myrtaceae	<i>Melaleuca sp</i> photo 442		Shrub		x	No	No	May be Ok
49	Proteaceae	<i>Petrophile glauca</i>		Shrub		x	No	No	Challenging
50	Proteaceae	<i>Petrophile rigida</i>		Shrub		x	No	No	Challenging
51	Proteaceae	<i>Petrophile squamata</i>		Shrub		x	No	No	Challenging
52	Amaranthaceae	<i>Ptilotus polystachyus</i>		Shrub	x		No	Yes	May be Ok
53	Fabaceae	<i>Pultenaea indira</i> subsp. <i>indira</i>		Shrub		x	No	No	May be Ok
54	Proteaceae	<i>Synaphea spinulosa</i> subsp. <i>major</i>		Shrub		x	No	Np	Challenging
55	Xanthorrhoeaceae	<i>Xanthorrhoea nana</i>		Shrub	x	x	No	No	May be Ok
56	Proteaceae	<i>Banksia obovata</i>		Shrub		x	No	No	May be Ok
57	Myrtaceae	<i>Eucalyptus eremophila</i>		Tree	x		No	Yes	Ok
58	Myrtaceae	<i>Eucalyptus pleurocarpa</i>		Tree		x	No	Yes	Ok
<b>Totals</b>					<b>13</b>	<b>55</b>	5 (Yes)	10 (Yes)	23 (Maybe Ok)
									10(Ok)

1. Young J.A. (2006). Hakeas of Western Australia a Field and Identification Guide
2. Nicolle D. (2013). Native Eucalypts of South Australia,
3. Brophy J.B., Lyndley A.C. and Doran J.C. (2013) Melaleucas, their Botany, Essential Oils and Uses

## 6.5 Targets and completion criteria

Species richness targets have been determined by an assessment of commercially available seedlings and the ease of which plants may be propagated (**Table 2**). Plants which were classified as Challenging in the table are regarded as unlikely to be available in commercial quantities for the revegetation project.

It is considered that broadly representative pre-clearing vegetation will be achieved across the project area through attention to the revegetation criteria presented in **Table 3**. The completion criteria for these targets is provided in **Table 4**.

Density targets have been determined by what is deemed fiscally reasonable for the Shire to achieve over five years following all techniques of revegetation including, use of topsoil, direct seeding and planting of seedlings.

Table 3. Completion criteria measures.

Criterion		Measure	Units	Comments
A	Species richness	Species richness (site)	Species count	Measure based on Survey of Project Area
B	Species density	Tree density	Stems / ha (s/ha)	Measure based on assessment of random quadrats
		Other plant density (grass, sedge, shrubs etc)		
C	Weed cover	Minor non-competitive species and major competitive species	% cover	Measure based on Survey of Project Area
		Declared pest plants	Individual plants	Measure based on Survey of Project Area

Table 4. Project Area completion criteria.

Criterion	Baseline floristic data (Table 6)	Five year completion targets	Five year completion criteria	Comments
A	Total species richness <ul style="list-style-type: none"> <li>58 species</li> <li>10 most likely to be commercially available</li> </ul>	Minimum Project Area species richness is 50% of commercially available species	A minimum of 5 species occurring within the Project Area.	This level of species richness is considered achievable based on current availability of seedlings, seed and general ease of propagation ( <b>Table 2</b> ). This fraction is the only part for which the Shire has any control over.
C(i)	Percentage cover environmental weeds both minor and major competitive species <ul style="list-style-type: none"> <li>&lt;1%</li> </ul>	Total combined weed cover should not exceed 10% baseline data.	The revegetation site should have no more than 10% cover of either minor and major environmental weeds	It is possible that there will be some colonisation of the site by environmental weeds following site works due to the high level of disturbance. The 10% cover target is applied to this criterion as it may be hard to guarantee complete control of all weeds, especially if they cannot be controlled by selective herbicides.
C(ii)	Declared Pest Plants <ul style="list-style-type: none"> <li>Nil</li> </ul>	Total number of Declared Pest plants should not exceed baseline data.	No Declared Pest plants recorded across the Project Area.	A list of Declared Pest plants in the Shire of Kent is available on the Department of Primary Industries and Regional Development website.

Table 5. *Eucalyptus eremophila* Mallee Woodland vegetation unit completion criteria.

Criterion	Baseline floristic data (Table 6)	Five year completion targets	Five year completion criteria	Comments
A	<i>E eremophila</i> Mallee Woodland tree species richness <ul style="list-style-type: none"> <li>1 species</li> <li>1 commercially available</li> </ul>	Tree species richness is 100% of total tree species richness.	One tree species occurring within the vegetation unit.	A 100% tree species richness is considered achievable. The species is considered commercially available as seedling based on assessment of their current availability of seedlings, seed and general ease of propagation. These can be planted by the Shire as seedlings.
B(i)	Tree density 400 stems/ha	Minimum plant density (s/ha) is 50% of commercially available tree density.	A minimum of 200 s/ha per commercially available tree species established per hectare. $0.05 * 200 = 10$ stems	A 50% tree density target is considered achievable. Extraction activities are likely to impact on long-term successful regeneration of eucalypt species. The altered substrate may be both lower in nutrients and shallower making it more suited to development of shrubs.



Criterion	Baseline floristic data (Table 6)	Five year completion targets	Five year completion criteria	Comments
B(ii)	Other plant density (grass, sedge, shrubs etc) 2500 stems/ha	Minimum other plant density (p/ha) is 40 % of baseline data.	A minimum of 1250 native plant stems established per hectare. $0.05 \text{ ha} \times 1250 = 62.5(63) \text{ stems}$	A 50% target is considered achievable. The low rainfall combined with long hot summers make the success of planted seedlings hard to predict. The sites isolation makes watering of seedlings impractical.

Table 6. *Eucalyptus pleurocarpa* Mallee Woodland vegetation unit completion criteria.

Criterion	Baseline floristic data (Table 6)	Five year completion targets	Five year completion criteria	Comments
A	<i>E pleurocarpa</i> Mallee Woodland tree species richness <ul style="list-style-type: none"> <li>1 species</li> <li>1 commercially available</li> </ul>	Tree species richness is 100% of total tree species richness.	One tree species occurring within the vegetation unit.	A 100% tree species richness is considered achievable. The species is considered commercially available as seedling based on assessment of their current availability of seedlings, seed and general ease of propagation. These can be planted by the Shire as seedlings.
B(i)	Tree density 400 stems/ha	Minimum plant density (s/ha) is 50% of commercially available tree density.	A minimum of 200 s/ha per commercially available tree species established per hectare. $1.5 \times 200 = 250 \text{ stems}$	A 50% tree density target is considered achievable. Extraction activities are likely to impact on long-term successful regeneration of eucalypt species. The altered substrate may be both lower in nutrients and shallower making it more suited to development of shrubs.
B(ii)	Other plant density (grass, sedge, shrubs etc) <ul style="list-style-type: none"> <li>5000 p/ha</li> </ul>	Minimum plant density (p/ha) is 20 % of baseline data.	A minimum of 1000 native plant stems established per hectare. $(1.5 * 1000 = 1500 \text{ stems})$	A 20% target is considered achievable for the Shire. The low rainfall combined with long hot summers make the success of planted seedlings hard to predict. The sites isolation makes watering of seedlings impractical.

## 7 Revegetation techniques

Recommended techniques for the revegetation of cleared areas within the gravel pit are provided below.

These techniques are to be applied for the rehabilitation of the two vegetation units identified within the Survey Area (**Figure 6**).

### 7.1 Pit establishment

#### 7.1.1 Clearing

The project clearing area must be clearly defined in the field prior to commencement of clearing operations.

The scrub and small trees should be pushed over, crushed and broken up by a bulldozer. This broken up vegetation will be scraped up and removed like the topsoil, **Section 7.1.2**. The broken-up vegetation debris will be a source of organic matter, nutrients, seed and habitat that will enhance revegetation outcomes.

Larger and more unmanageable trees can be collected and set aside with a rake bucket, these can be reapplied as habitat following final application of topsoil.

Where possible seed should be collected from the preclearing vegetation prior to clearing operations this seed can be used for direct seeding and supply of seedlings, see **Section 7.3.1**.

#### 7.1.2 Topsoil and overburden removal and stockpiling

##### Topsoil

The topsoil is of critical importance; it is rich in seed, organic material and beneficial microbes that will support the natural colonization of native plants. It is the only effective means of re-establishing a diverse plant community following clearing operations. The removal of topsoil should therefore be carefully managed as follows:

- Within the limits of on-ground practicality, topsoil (the top 100 mm to 150 mm, if possible) should be removed and stockpiled separately at a predetermined site.
- Topsoil less than 12 months old will provide the best revegetation results as viability to generate seedlings decreases after this period. Research by Alcoa has shown that stockpiling can result in losses of up to 80-90% of potential germination (GoA, 2006). Increased depth of topsoil excavation is unnecessary and not beneficially to revegetation outcomes. Studies show that most seed is stored within the top 10 cm of soil and that increased depth of topsoil stripping correlated to significantly decreased recruitment of native seedlings following reuse of topsoil. Increased removal of topsoil dilutes seed

quantities and leads to over burying of seed (Rockich, *etal* 2000, Government of Australia (GoA), 2006). To this end, mixing topsoil with underlying material during the stockpiling and stripping process should be avoided, where possible.

- It is ideal if the topsoil can be used immediately but if stockpiled it should be used within one year as its viability to generate seedlings decreases after this period. Research by Alcoa has shown that stockpiling can result in losses of up to 80-90% of potential germination (GoA, 2006).
- Topsoil should be stored in piles or wind rows between two and three meters in height, the lower the better (GoA, 2006). Decreased regeneration may be attributed to decomposition of seed when exposed to elevated temperatures and moisture conditions within a stock pile, which is more prevalent in larger stockpiles.
- Topsoil should be removed when the soil is dry, ideally in late summer or early autumn after the native plants have dropped their seeds and before the onset of winter rains.
- Topsoil stockpiles should be located so that they can be practically and easily re-spread.

### Overburden

Any overburden, if present, should also be carefully removed and stockpiled separately to topsoil. This should be applied evenly to the entire cleared area to increase the depth of soil under the revegetation area.

#### 7.1.3 Gravel extraction

It is recommended that, where possible, the pit is not worked to the clay layer, but that a 100 mm – 200 mm layer of friable material is left across the base of the pit to assist with the establishment and long-term growth of vegetation. Observations of long-term success of gravel pit restorations correlate with increased depth and quality of soil to the impervious clay layer (GoA, 2006, P White 2019, pers comm, 21 January Operations Officer (Lake Bryde) Wheatbelt Region, DBCA)).

Some gravel should also be set aside for the creation of batters and pit profiling.

## 7.2 Pit reinstatement

### 7.2.1 Site profiling

The Project Area should be shaped to generally approximate the pre-extraction profile, with the understanding that finished levels will generally be lower than the original setting. The sides and floors of the pit shall be formed to a flowing finish where reasonably practical. It is recommended that pit batters are between a 1:4 and 1:6 gradient (Main Roads Western Australia (MRWA), 2009; Department of Environment and Conservation (DEC), 2008).

It is also important that the pit profile does not result in un-natural ponding of water and that any potential drainage is directed away. This will as best as practically possible allow for the replication of similar pre-clearing habitats and drainage patterns.

Where possible spoil/surplus soil from other areas in the vicinity can be imported to site and used to assist with reprofiling (e.g. from road widening projects). The importation and use of these products can introduce weeds to site, especially if sourced from adjacent to agricultural areas. Where this material is used it should be buried as deep in the profile as possible and covered with overburden and topsoil. Special attention should be paid to the monitoring and management of weeds in these areas.

### 7.2.2 Ripping

Ripping of the subsurface clay will increase the potential depth of available soil and improve drainage resulting in better revegetation outcomes.

The Project Area should be ripped as much as is practically possible with the aim to creating as much friable subsurface soil as can be achieved. The amount of ripping required will depend on the nature of the clay, however as a minimum the following is recommended:

Ripping across the contours to a minimum depth of 500 mm (more is better) at no more than 1000 mm spacings (less is better) followed by ripping along the contour at the same depth and spacing.

### 7.2.3 Topsoil and overburden application

Overburden, if available, should be spread evenly over all bare areas of the revegetation area prior to the application of topsoil.

Topsoil should then be evenly spread across clearly marked revegetation areas within the Project Area. *Eucalyptus pleurocarpa* Mallee unit topsoil to the *Eucalyptus pleurocarpa* Mallee unit revegetation area and the *Eucalyptus eremophila* Mallee unit topsoil to the *Eucalyptus eremophila* Mallee unit revegetation area.

This should ideally be done in Autumn when the soil is dry, prior to the onset of winter rains to optimise germination of stored seeds. Research shows that seed persists better when moved when the soil is dry (GoA, 2006).

### 7.2.4 Replacement of cleared vegetation

Larger logs (and boulders) set aside in the clearing process should be replaced across the revegetation site for habitat purposes.

Plant material bearing seed from future extraction areas can be applied to the Project Area to supplement seed stock.

## 7.3 Revegetation

### 7.3.1 Direct seeding

Direct seeding is known to compliment/support revegetation outcomes of revegetation. It is recommended that seed used for direct seeding is collected from the same provenance and preferably from the proposed clearing area and adjacent bushland prior to site clearing activities. Seed collected can be also used for the propagation of seedlings for the project (**Section 7.3.2**).

#### Obtaining seed

Seed can be purchased off the shelf from seed merchants but this material will generally not be collected from anywhere close to the Project Area. It is generally preferred that seed is harvested locally as seedlings grown from local seed are better adapted to local conditions.

Seed collection generally occurs over summer and early autumn following spring flowering. Optimum diversity of seed is generally collected over two or more seasons owing to variability in seed set. This could be included in the long-term plan for the Shire.

Typical target quantity of seed for revegetation projects is between 2.5 – 5 kg per hectare depending on desired revegetation outcomes, but guaranteeing even the lowest target may be both fiscally and practically challenging given the potential unavailability of seed, staggered seed set and general isolation of the site.

Instead of setting collection quantities it is recommended that seed is collected by a reputable seed collector on a schedule of rates basis over a set period of time. For example five days are allocated over one season to harvest as much seed as practically possible, firstly from all vegetation within the proposed clearing areas and then as time allows from the same species within a provenance boundary of about 20km. This should achieve a reasonable value for money outcome.

#### Seed pre-treatment

Seed will be supplied bagged and 'clean' if source from a professional seed collector. Some species need to be pre-treated prior to application. Pre-treatment methods including scarification, heat treatment and exposure to smoke to break seed dormancy and enhance germination. Pre-treatment can be undertaken by seed suppliers. The organisation of pre-treatment may be a condition of the supply of seed by either the seed merchant or collector.

### Spreading seed

Seed is to be apportioned to respective vegetation units, with some seed also apportioned for the propagation of seedlings.

Seed is to be spread evenly spread across the entire site, paying attention to demarcated vegetation unit boundaries, after the application of the topsoil. If possible the area should be lightly harrowed or chained to incorporate the seed into the topsoil horizon.

### 7.3.2 Planting seedlings

#### Obtaining seedlings

Planting of seedlings is perhaps the surest way of ensuring a successful revegetation outcome because it is not reliant solely on nature and variables associated with plant establishment can be managed to a degree. For this reason, desired revegetation targets of plant species richness and plant densities have been set so that they can realistically attained via planting of seedlings only (**Section 6.5**). It is expected that natural regeneration from topsoil will occur and that the desired targets may be exceeded, especially where fresh topsoil and good pit reinstatement practices are undertaken.

An important limitation to be considered is the commercial availability of seedlings. Many plant species are not available from nurseries either due to a lack of demand for the species, or because they are either difficult to propagate, or cannot be propagated. Of the 34 species in **Table 2** only three are readily available, and 16 of these likely to be available based on an assessment of their relative ease of propagation.

Sufficient lead times need to be factored in to ensuring plant availability, especially where seedlings have to be propagated from locally collected propagation material (i.e. of a local provenance). A minimum of 18 months is required to supply local provenance seedlings where local provenance seed material is not available (the seeds are collected in summer and propagated in following summer ready for planting in winter). A minimum of six months is required where seeds are available.

Nurseries specialising in the supply of native plants will be able to advise on desired quantities of seed to be supplied for propagation purposes. Bearing in mind that sufficient seed will need to be set aside for any remedial or infill planting required over the life of the project. There should be ample quantities for this from the direct seed collecting activities (**Section 7.3.1**).

#### Seedling quality

It is imperative that seedlings are supplied in a good condition with optimum chances of survival. Seedlings should be purchased from a nursery accredited under the Nursery Industry Accreditation Scheme Australia.

The following basic seedling quality standards are recommended.

Seedlings should:

- be weed and disease free
- have a well-developed root system, that is not compacted or spiralling
- have a good root depth to plant height ratio – maximum height of seedlings 250 mm
- be hardened off prior to supply

For further advice on seedling quality refer to Mullan, G. D. and White, P. J. (2001). *Seedling Quality: Making informed choices*. Bushcare and the Department of Conservation and Land Management, available at <https://www.dpaw.wa.gov.au/images/documents/conservation-management/salinity/seedlingqual22-10-02.pdf>

### 7.3.3 Planting seedlings

Seedlings will need to be installed following the application of topsoil and direct seed.

Plants are to be mixed and evenly distributed across the site according to respective vegetation units. Plants should be installed adjacent to, or into rip lines, where possible, to maximise their access to any subsurface water.

It is recommended that seedlings are installed in the second year of gravel pit restoration following an assessment of the outcomes of topsoil and direct seeding initiatives. Seedling quantities should then be calculated to achieve the desired revegetation targets.

A planting list with quantities recommended for the first planting season is provided in **Table 7**. The first column shows an amount to achieve the desired species richness and density targets. The second column includes an additional 50% to account for possible attrition. It is recommended that more plants are planted at the start of the project to account for attrition.

Table 7. Recommended first season planting species list and quantities

No.	Commercially available species	Plant type	<i>Eucalyptus eremophila</i> Mallee Woodland	<i>Eucalyptus eremophila</i> Mallee + 50%	<i>Eucalyptus pleurocarpa</i> Mallee Woodland	<i>Eucalyptus pleurocarpa</i> Mallee + 50%	Totals
1	<i>Acacia pulchella</i>	Shrub	20	30	162	243	273
2	<i>Banksia armata</i>	Shrub		0	162	243	243
3	<i>Banksia nivea subsp. nivea</i>	Shrub	20	30	81	121	151
4	<i>Banksia sessilis</i>	Shrub		0	162	243	243
5	<i>Calothamnus quadrifidus</i>	Shrub	20	30	162	243	273
6	<i>Hakea cygna subsp. cygna</i>	Shrub	20	30	324	486	516
7	<i>Hakea prostrata</i>	Shrub	20	30			30
8	<i>Melaleuca pungens</i>	Shrub			324	486	486
9	<i>Eucalyptus eremophila</i>	Tree	81	121.			121
10	<i>Eucalyptus pleurocarpa</i>	Tree			243	364	364
<b>Totals</b>			<b>181</b>	<b>271.5</b>	<b>1620</b>	<b>2429</b>	<b>2700</b>



### 7.3.4 Staging

The revegetation of the gravel pit can be approached in a number of ways, especially as the already cleared area provides opportunities for immediate reuse of topsoil. A conceptual diagram showing an incremental and one stage revegetation operation are provided in **Figure 8**. Some advantages and disadvantages of these options are presented in **Table 8** to assist the Shire in determine its preferred course of action. The schedule and budget in **Section 10** provides an indication of financial and timeline implications for a one stage operation.

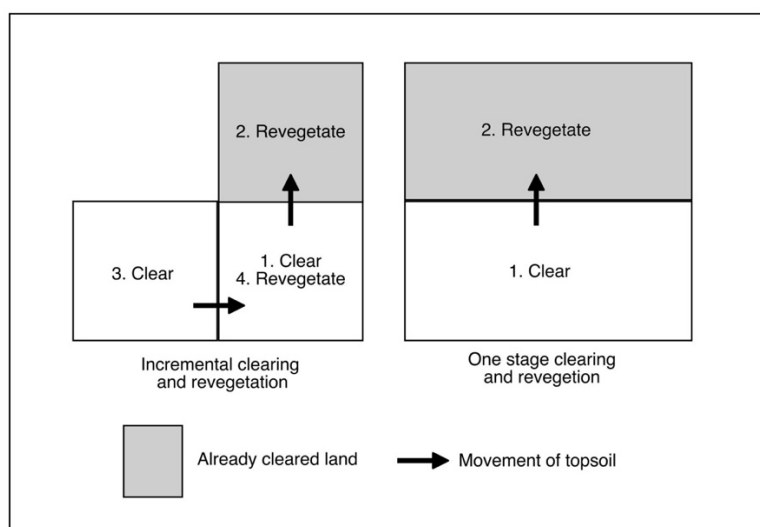


Figure 8. Possible staging options for the clearing and use of topsoil

Table 8. Possible staging options for the revegetation project.

Incremental clearing and revegetation	One stage clearing and revegetation
<p><b>Advantages:</b>            Allows for improvements to be implanted along the way            Has less vegetation cleared at one time.</p>	<p><b>Advantages:</b>            Plant and machinery mobilised once.            The project has best chance to be fully completed within a 5 year timeframe.</p>
<p><b>Disadvantages:</b>            More mobilisation of plant and equipment            May prolong the project more than five years.</p>	<p><b>Disadvantages:</b>            More vegetation cleared at once time, interrupting the vegetated corridor.</p>

## 8 Maintenance and contingency measures

The aim of the maintenance and contingency measures are to ensure as best as possible successful outcomes of revegetation activities and that the revegetation targets are successfully achieved. The health of plants within the revegetation area can be impacted by a range of factors as identified in **Section 5**. Maintenance and contingency measures to mitigate against the significant potential impacts are provided in **Table 9**, below.

Table 9. Possible revegetation program maintenance and contingency measures.

Threat and Consequence	Maintenance measures	Trigger	Contingency measures
Drought - Plant death, poor plant health	Sound planting and pit establishment and reinstatement practices.	Observed death of plants such that revegetation targets will not be met.	Undertake remedial planting to offset shortfall in plant species as soon as possible.
Weeds - Plant death, poor plant health	Practice good hygiene to prevent weed infestation. Develop and implement work practices for contractors and staff to ensure weeds are not introduced to site: Ensure seedlings are purchased from a nursery accredited under the Nursery Industry Accreditation Scheme Australia. Ensure all vehicles and machinery are clean prior to entry at site. Shire staff undertakes quarterly site weed inspections and implements control as necessary. Consider installation of a sign akin to the following: Gravel Pit Restoration Area Please keep the area weed & disease free Vehicles and machinery must be clean on entry. Shire of Kent	Significant weeds including all Declared Pest Plants in the Shire of Kent are identified within and adjacent to the Project Area.	Weeds occurring within the Project Area and in project buffer area are treated within two weeks of reported observation.
Vandalism - Damaged and dead plants	Undertake quarterly inspection of gravel pit that site is free from vandalism. Consider placement of gravel bunds /logs to limit access to revegetation areas.	Site shows evidence of vandalism such that revegetation targets will not be met.	Install gravel bunds to limit access to the revegetation area.
Rabbits - plant death	Shire officers undertake quarterly inspection of the Project Area and surrounding areas for evidence of rabbits, especially prior to the onset of the wet growing season.	Rabbits are identified as primary cause of plant death such that revegetation targets will not be met.	Undertake emergency measures to reduce local rabbit population for example via the use of pindone or targeted release of Rabbit Haemorrhagic Disease Virus (RHDV) by appropriately authorised persons.

Threat and Consequence	Maintenance measures	Trigger	Contingency measures
Fire -- plant death	Ensure obligations consistent with fire hazard warning categories are implemented. Ensure vehicles are fitted with appropriate fire extinguishing devices.	Fire causes damage to revegetation area such that revegetation targets will not be met.	Assess outcomes of damage – initiate remedial planting of seedlings, application of brush and direct seed as necessary. Advise DWER on damage and proposed remedial actions.

## 9 Monitoring and analysis

Monitoring and reporting measures to demonstrate attainment of revegetation outcomes are provided below **Table 10**.

Table 10. Possible revegetation program monitoring and reporting measures.

Measure	Monitoring type	measure	Frequency
Plant species richness	Flora and Vegetation surveillance survey over Project Area and each vegetation unit	Total number of plant species recorded across the survey area and respective vegetation unit.	Annually during spring.
Plant density	Installation of one random and one permanent 10 x 10 m quadrats within each vegetation type in the Project Area	Average density of target plant species in quadrats as indication of overall site density per species or structural element. Overall plant density estimated by quadrats	Annually during spring.
Vegetation health	Assessment of planted seeding health within permanent and random quadrats.	Average assessed health of all planted seedlings within quadrats as either: excellent, moderate, or poor. Estimated seedling age, given that the survivorship of seedlings is assumed to increase with age. <ul style="list-style-type: none"> <li>• &lt;1 yr</li> <li>• 1-2 years</li> <li>• &gt;2 years</li> </ul>	Annually during spring.
Vegetation health	Photo monitoring of permanent quadrats.	Visual observation of plant health	Annually during spring
Weed cover	Weed mapping	Percentage cover	Annually during spring

## 10 Schedule and Budget

A schedule has been prepared to base a quotation on the clearing and revegetation of a (1ha or less) gravel pit. This is presented in **Tables 11-16** below. This should only be used as a general guide to schedule. No costs have been allocated as it will depend on Shire budget each year.

Table 11. Possible 2019 year 1 schedule and budget

Action	J	F	M	A	M	J	J	A	S	O	N	D	Unit cost	Total cost \$ ex GST	Responsibility
	<b>2019</b>														
Submit clearing permit application			x	x									\$ 200.00	\$200.00	Shire
Receive clearing permit application					x	x									Shire/consultant
Appoint seed collection contract								x	x						Shire
Appoint seedling supply contract								x	x						Shire
Appoint earth moving contracts								x	x						Shire
Seed collection												x			Contractor
Unforeseen costs															
													<b>Total Cost</b>	<b>\$</b>	

Table 12. 2020 year 2 schedule and budget for quotation requirements

Action	J	F	M	A	M	J	J	A	S	O	N	D	Unit cost	Total cost \$ ex GST	Responsibility
	2020														
Seed Collection	x	x	x											\$	Contractor
Seed processing														\$	Contractor
Project Area monitoring - rabbits, vandalism, weeds		x		x				x			x				Shire
Contingency works, repairs pest control, weed control etc	x	x	x	x	x	x	x	x	x	x	x	x			Shire / Contractor
Submit 1st annual compliance assessment report to DWER					x										Shire
Vegetation Clearing			x	x									\$ X/ hectare		Contractor
Removing and stockpiling topsoil and overburden			x	x									\$ x / hour		Contractor
Site profiling cleared area			x	x									\$ x / hour		Contractor
Ripping of Project Area			x	x									\$ x / hour		Contractor
Application of overburden and topsoil			x	x									\$ x / hour		Contractor
Direct seeding / chaining and harrowing				x	x								\$ x / hour		Seed contractor Shire/Contractor

Action	J	F	M	A	M	J	J	A	S	O	N	D	Unit cost	Total cost \$ ex GST	Responsibility
	2020														
Return habitat logs				x	x								\$ x / hour		Shire/Contractor
Revegetation monitoring and report										x			Quotation		Consultant
Order seedlings for remedial plantings											x	x	Quotation		Shire
Unforeseen cost															
													<b>Total Cost</b>	<b>\$</b>	

Table 13. 2021 year 3 schedule and budget for quotation.

Action	J	F	M	A	M	J	J	A	S	O	N	D	Unit cost	Total cost \$ ex GST	Responsibility	
	2021															
Project Area monitoring - rabbits, vandalism, weeds		x		x				x			x					Shire
Contingency works, repairs pest control, weed control etc	x	x	x	x	x	x	x	x	x	x	x	x				Shire / Contractor
Submit 2 <sup>nd</sup> annual compliance assessment report to DWER					x											Shire/consultant
Install seedlings					x	x										Shire/contractor
Revegetation monitoring and report										x						Consultant
Order remedial seedlings											x	x				Shire
Unforeseen cost																
													<b>Total Cost</b>			

Table 14. 2022 year 4 schedule and budget for quotation purposes.

Action	J	F	M	A	M	J	J	A	S	O	N	D	Unit cost	Total cost \$ ex GST	Responsibility	
	2021															
Project Area monitoring - rabbits, vandalism, weeds		x		x				x			x					Shire
Contingency works, repairs pest control, weed control etc	x	x	x	x	x	x	x	x	x	x	x	x				Shire/contractor
Submit 3rd annual compliance assessment report to DWER					x											Shire/consultant
Install seedlings					x	x										Shire/contractor
Revegetation monitoring and report										x						Consultant
Order remedial seedlings											x	x				
Unforeseen cost																
													<b>Total Cost</b>	<b>\$</b>		Quotation required



Table 15. 2023 year 5 schedule and budget for quotation purposes.

Action	J	F	M	A	M	J	J	A	S	O	N	D	Unit cost	Total cost \$ ex GST	Responsibility	
	2021															
Project Area monitoring - rabbits, vandalism, weeds		x		x				x				x				Shire
Contingency works, repairs pest control, weed control etc	x	x	x	x	x	x	x	x	x	x	x	x			\$2,000	Shire/Contractor
Submit 4 <sup>th</sup> annual compliance assessment report to DWER					x											Shire/consultant
Install seedlings					x	x							\$2 per seedling x 250	\$500		
Final revegetation monitoring and report										x			Site and quadrat survey		Shire/consultant	
Unforeseen cost																
													<b>Total Cost</b>	<b>\$</b>		

Table 16. 2024 year 6 schedule and budget for quotation purposes.

Action	J	F	M	A	M	J	J	A	S	O	N	D	Unit cost	Total cost \$ ex GST	Responsibility
	2021														
Project Area monitoring Rabbits, Vandalism		x		x											Shire
Contingency works, repairs pest control, weed control etc	x	x	x	x	x										Shire/contractor
Submit final annual compliance assessment report to DWER					x										Shire/consultant
Receive closure on project from DWER						x	x	x							
Unforeseen cost															
													<b>Total Cost</b>	<b>\$</b>	

## 11 References

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