Cardno
Shaping the Future

Rehabilitation and Revegetation Plan

Maralla Road Sand Mine

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Executive Summary

Cardno Pty Ltd (Cardno) was engaged by Urban Resources to produce a Rehabilitation and Revegetation Plan (RRP) for a Silica Sand Mine at Lot 5892 Maralla Road, Bullsbrook (subject site) (**Figure 1**). This RRP has been produced to satisfy Condition 5 of the Development Approval (DA) No. 121010 by the Western Australian Planning Commission (WAPC) and the City of Swan (CoS).

The subject site is proposed to be mined by Urban Resources for silica sand and other construction sands, incorporating mining tenement M70/326 for a period of 10 to 12 years. The following RRP is designed to minimize open areas and rehabilitate the site in a progressive manner with a view to establishing permanent vegetation cover that is representative of the existing vegetation at the subject site.

The subject site is proposed to be mined and then rehabilitated in 23 stages throughout the life of the project. This work will involve the following:

- Clearing of any vegetation (only as required for the immediate sand extraction operation);
- Stockpiling of vegetation brush, trash and logs (dieback and usefulness dependant);
- Stripping of topsoil to approximately 10cm deep to be returned directly to future rehabilitation areas where possible, or stored in short term stockpiles;
- Stripping of overburden and stockpiling (resource separation and utilisation);
- Excavation of white/grey silica sand and underlying fill or concrete sand (within the buffer limits set for the groundwater protection area);
- Processing and transportation of white/grey silica and underlying fill or concrete sand on and offsite;
- Stabilisation, rehabilitation and regeneration of mined areas; and
- Installation and relocation of processing plant and associated infrastructure. (Cardno 2008a)

The rehabilitation program will involve the stripping and re-spreading of topsoil over newly mined areas along with ripping and spreading extra local provenance seed. If rehabilitation areas are not ready for topsoil spreading then this topsoil will be stockpiled in windrows on the subject site of no higher than 2m. The rehabilitation areas will be monitored for weed invasion.

A rehabilitation maintenance program will be implemented after the initial works have been completed on the rehabilitation areas. This program will address aspects of the rehabilitation program that may affect the completion of the rehabilitation criteria stated in this document. The rehabilitation program will be monitored for a period of three years after completion of rehabilitation works with the aim of assessing the success of the program of meeting the completion criteria. The completion criteria of the rehabilitation program for each stage are stated as follows:

- At least 70% of the species spread as seed are represented;
- The average density of plants is 3 per m^2 or greater;
- Weed presence is minimal and not inhibiting native plant survival and growth; and
- Erosion is minimal and not inhibiting native plant survival and growth.

By meeting these completion criteria and following techniques in this RRP for the rehabilitation of each stage of the mining operation, the objective of re-establishing functioning *Banksia* woodland on the subject site will be achieved.

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1 Introduction

1.1 Background

Cardno Pty Ltd (Cardno) was engaged in March 2011 by Urban Resources to produce a Rehabilitation and Revegetation Plan (RRP) for a Silica Sand Mine at Lot 5892 Maralla Road, Bullsbrook (subject site) (**Figure 1**).

This RRP has been produced to satisfy Condition 5 of the development approval No. 121010 by the Western Australian Planning Commission (WAPC) and the City of Swan (CoS). Condition 5 states that "Prior to the commencement of excavation works, a rehabilitation and revegetation plan is to be prepared to the specification of the City of Swan (CoS) on advice of the Department of Environment and Conservation (DEC). The rehabilitation and revegetation plan is to address but not limited to:

- Stabilisation of surface sands against erosion;
- Minimisation of disturbance to the hydrological balance within the proposed lease area and adjacent land;
- Establishment of a diverse, effective and permanent vegetation cover capable of plant succession and regeneration to suit the present priority land use of water production;
- Establishing trials incorporating the use of fine tailings materials in surface soils to assess suitability for rehabilitation;
- Ensuring that areas affected by mining are left in an environmentally acceptable condition in the event of early closure of the operations; and
- Final gradients to accommodate possible future land uses".

The following RRP is designed to minimize open areas and rehabilitate the site in a progressive manner with a view to establishing permanent vegetation cover that is representative of the existing vegetation at the subject site.

2 Vision and Objectives

The overarching vision of this RRP is to produce an ecologically diverse, self-sustaining and functional *Banksia* woodland ecosystem comprised of local provenance species that reflect the vegetation communities present on the subject site before clearing of the site for sand mining.

The objective of the RRP is to re-establish functioning *Banksia* woodland through the staged rehabilitation of the mining areas on the subject site through undertaking the following activities:

- Stabilisation of the soil profile after mining activities have been completed to prevent significant erosion;
- Stripping, storage and re-spreading of topsoil from the various mining stages in the subject site on the rehabilitation areas to promote germination of the seedbank;
- Collection, treatment and spreading of local provenance seed on rehabilitation areas which will add to the topsoil seedbank;
- Provide achievable and suitable rehabilitation completion criteria and monitoring methods that can be recorded and assessed over time in order to gauge the long term success of the rehabilitation program;
- Provide a schedule for rehabilitation works and staging plan for mining and rehabilitation works in the subject site; and
- Provide a reporting schedule on the rehabilitation works and monitoring results for the subject site.

3 Existing Environment

3.1 Climate

The Swan Coastal Plain (SCP) has a Mediterranean climate with hot dry summers and mild wet winters. Winter precipitation varies between 600-1000mm per year with five to six dry months per year (Beard 1990). Climate information obtained from the Pearce weather station (the nearest reporting station), has recorded an average rainfall of 695 mm per year (1940 to 2007), with about 56 rain days per year. Mean maximum temperatures range from 17.8 °C in July to 33.3 °C in January. Mean minimum temperatures range from 8.2 °C in August to 17.4 °C in February (Bureau of Meteorology 2011).

3.2 Landforms, Soils and Vegetation

The Swan Coastal Plain is generally flat, approximately 20 – 30 kms wide and consists of two sedimentary belts of different origin. On the eastern side of the SCP, the Pinjarra Plain has been formed from the deposition of alluvial material whilst the three dune systems (Quindalup, Spearwood and Bassendean) that form the western part of the SCP are of aeolian origin (Seddon 2004). The dune systems represent differing ages of deposition with soils at different stages of leaching and formation. The coastal plain itself is low lying, often swampy with sandhills and therefore the soils predominantly consist of recent sands or swampy deposits (Beard 1990).

The subject site occurs within the Bassendean Dune System, which represents an accumulation of beach sands on an ancient coastline. The sands have been leached of much of their calcium carbonate and are quite infertile (Seddon 2004). The landform consists of low hills and swamps in the swales. The vegetation of the Bassendean sands is quite diverse, consisting in the main of *Banksia* low woodlands with a diverse understorey.

Landform and soil mapping by Churchwood and McArthur (1980) place a majority of the subject site within the Bassendean Complex - North, which is comprised of sandplains with low dunes and occasional swamps. The vegetation of the Bassendean Complex - North (south of the Moore River) consists of a low open forest and low woodland of *Banksia* spp*. Eucalyptus todtiana* to low woodland of *Melaleuca* spp., and sedgelands which occupy the moister sites (Heddle *et al.* 1980).

3.3 Wetlands

One wetland has been identified as occurring within the subject site. Each wetland listed within the DEC's Geomorphic Wetland Dataset is given a Unique Feature Identifier (UFI) number and the mapped wetland in the northwest portion of the subject site has been assigned UFI 8907. The wetland is described as a dampland and is classified as a Conservation Category Wetland (CCW). This wetland will be excluded from mining operations and protected by a 50 m vegetation buffer zone.

The Groundwater Monitoring Program will indicate if there is any detrimental impact on the hydrological balance however this is unlikely due to the groundwater separation distance, benign operations to be undertaken and no storage of hydrocarbons on the subject site.

3.4 Flora and Vegetation

Cardno undertook a level 1 flora and vegetation assessment of the subject site in 2007. A total of 148 plant taxa (including subspecies and varieties) from 105 genera and 40 families were recorded within the subject site. The dominant families were Myrtaceae (17 taxa), Papilionaceae (14 taxa) and

Proteaceae (12 taxa). Twenty introduced (weed and cultivated) taxa were recorded on the site. The most common weeds were daisies such as **Hypochaeris glabra* and **Ursinia anthemoides* whilst the grass **Briza maxima* was also common (Cardno 2008).

Three plant communities were identified within the subject site (**Figure 2**), consisting of two woodland communities and a low shrubland community. A description of each plant community on the subject site is provided below:

- Community B1: Woodland of *Banksia attenuata* and *Banksia menziesii* with *Banksia ilicifolia* over *Xanthorrhoea brunonis* over *Dasypogon bromeliifolius* and *Patersonia occidentalis* on grey/white sands of flats and lower slopes;
- Community B2: Woodland of *Banksia attenuata* and *Banksia menziesii* over *Eremaea pauciflora var. pauciflora* and *Scholtzia involucrata* over *Lyginia barbata*, *Hibbertia subvaginata* and *Hibbertia hypericoides* on grey/white sands of slopes and ridges; and
- Community B3: Low shrubland of *Xanthorrhoea brunonis* and *Eremaea pauciflora var. pauciflora* with emergent *Banksia littoralis*, *Banksia attenuata* and *Banksia menziesii* on grey sands of broad flats (Cardno 2008).

Community B1 covers the majority of the subject site and mining envelope. A small population of Priority taxa, *Stachystemon axillaris* (P4), was recorded from one site in Community B2, near the southwestern boundary of the subject site. The majority of the subject site is in 'Excellent' condition with little disturbance and a minimal presence of weeds.

4 Proposed Mining Program

4.1 Mining Activities

The subject site is proposed to be mined for silica sand and other construction sands, incorporating mining tenement M70/326 for a period of 10 to 12 years. This work will involve the following:

- Clearing of any vegetation (only as required for the immediate sand extraction operation);
- Stockpiling of vegetation brush, trash and logs (dieback and usefulness dependant);
- Stripping of topsoil to approximately 100m deep to be returned directly to future rehabilitation areas where possible, or stored in short term stockpiles;
- Stripping of overburden and stockpiling (resource separation and utilisation);
- Excavation of white/grey silica sand and underlying fill or concrete sand (within the buffer limits set for the groundwater protection area);
- Processing and transportation of white/grey silica and underlying fill or concrete sand on and offsite;
- Stabilisation, rehabilitation and regeneration of mined areas; and
- Installation and relocation of processing plant and associated infrastructure (Cardno 2008a).

4.2 Land Use

The subject site is currently zoned rural and in the absence of a defined end use it is a requirement of the planning approval process that it be rehabilitated back to natural woodland ecosystem. The subject site may be suitable for a variety of end land uses including, but not limited to, urban development, industrial development or intensive agriculture. In the event that a defined end land use for the site is approved which is not compatible with this approach a revised proposal may be submitted in the future to the CoS.

4.3 Groundwater

Groundwater abstraction from the site is not initially proposed with the only requirement for water being for dust control. Urban Resources intends to use scheme water in the short term to manage dust control.

It is intended to utilize ground water from the site in the future, particularly when the washing plant is utilized for processing of the silica sand. Abstraction rates required are not high as the water used is constantly recycled in the process. It is estimated that the abstraction requirement for the site would be less than 80,000 kl per annum. A water license for future use is currently being sought.

5 Rehabilitation and Revegetation Program

5.1 Rehabilitation Staging Plan

The original staging plan submitted with the DA showed 12 stages of mining for the project of approximately 4 to15 ha each. This staging proposed areas of similar volume, as the DA has restricted initial sales of product to 150,000 tonnes per annum. It was considered appropriate to revise the staging to create smaller areas more suited to this volume of extraction and provide the opportunity to begin to achieve progressive rehabilitation as quickly as possible. The revised staging plan now consists of 23 stages with stages 2, 3, 4, 5 and 6 being split into stages A and B to increase efficiency of mining and support the progressive rehabilitation works. The revised staging plan is provided in **Figure 3**.

The current staging plan may alter in subsequent years depending on material quality and demand. In the lower areas of the site, larger stages have been planned as the volume of sand able to be extracted is substantially less than areas with deeper excavation design.

Key objectives of this revised staging plan are as follows:

- Gain entry to the site to set up infrastructure and initial areas with minimal clearing and earthworks;
- Retain as much vegetation buffer around the boundaries of the site as possible in the early stages of mining to create substantial barriers to any possible issues with noise or dust;
- Gain access to the deeper areas of mining as soon as possible which reduces the annual clearing rate by way of increasing sand available per ha; and
- Enable progressive rehabilitation to commence as soon as possible.

Stage 1 will involve the clearing of a total of 4 ha to enable the set up of infrastructure in a relatively low area of the site. Clearing and topsoil from this area will be stockpiled within the Stage 1 as it is not planned for progressive rehabilitation. The topsoil from stage 1 will eventually be used in the final decommissioning of the site or gradually blended with direct transferred topsoil from subsequent stages. Approximately half of Stage 1 will be utilized for initial and future infrastructure needs. The northern part of Stage 1 will be used for topsoil and vegetation storage.

Stage 2A will involve the clearing of 2 ha with the topsoil from this area to be stockpiled on Stage 1 for future use. The remaining 2 ha will be cleared after mining in Stage 2A is complete. The topsoil will be transferred to Stage 2A to commence progressive rehabilitation. This will allow for working areas to be maintained whilst managing the rehabilitation.

An initial 2 ha will be cleared with the topsoil from 3A to be transferred to Stage 2B. Progressive rehabilitation will now be undertaken at every stage.

The remaining stages will continue with the same methodology across the subject site. Each stage will be cleared in two sections to enable the progressive re-spreading of topsoil to continue in an orderly manner.

A total of 4 ha will remain permanently open through the life of the project to allow for necessary site infrastructure and topsoil stockpiling. The maximum open area at any time will be 10 ha and as rehabilitation commences this area will be reduced progressively to approximately 8 ha.

To enable the progressive removal of the material, access roads will be established throughout the site. The main access road will run along the boundaries of Stages 3, 4, 5 and 6. This access road will not be rehabilitated until mining has been completed. The remaining topsoil from the last stage and from Stage 1 and 2A will be utilized to achieve the final land closure.

The progressive nature of the rehabilitation means that in the case of early closure a relatively small open area will remain. Existing faces would be battered to a suitable slope and remaining topsoil would be used to stabilise the site and enable it to be left in an acceptable condition should early closure occur.

5.2 Site Preparation

5.2.1 Topsoil Management

Banksia woodland topsoil provides a rich and useful source of seeds for rehabilitation of Banksia woodland communities in the southwest of Western Australia. Topsoil collected from the newly cleared areas is proposed to be stripped and transferred immediately to a stage ready for rehabilitation (known as a direct return). If this is unable to be achieved then the topsoil would need to be stockpiled onsite for future use in the rehabilitation areas.

It is preferable that the stripping of topsoil for newly cleared areas be undertaken in autumn when the soil profile is driest. This will aid in the stockpiling of the topsoil as a wet or damp soil profile may result in exacerbated seed germination and decomposition of the soil which could kill parts of the seedbank (Meney et al. 1994) (Rokich et al, 2000).

The topsoil is to be stripped from the newly cleared areas to a maximum depth of 10cm which is proven to be an ideal depth of topsoil in rehabilitation sites in order to increase the germination of the contained seedbank (Rokich et al, 2000). The topsoil will be stockpiled (if required) on cleared sites in windrows no more than two metres high. This design enables the soil profile of this stockpile to dry out and reduce composting due to increased heat and moisture.

The topsoil is to be re-spread on the new rehabilitation sites to the same depth as it was collected (max of 10cm). This increases the diversity and abundance of seed species that can germinate within the seedbank contained in the topsoil. If this respreading is not completed as a direct return then the topsoil will be applied in autumn before the breaking rains. This enables the topsoil profile to settle on the rehabilitation area and provides a longer timeframe for establishment of seedling over the winter and spring period.

5.2.2 Ripping

Areas that have been subject to compaction (the majority of the mined site) will be ripped in order to break up the soil media which is aimed at increasing the seed germination (Koch et al. 1996) and improved growth of seedlings through adequate root development into the subsoils. The ripping will occur after the spreading of topsoil, using a winged ripping tyne mounted on a bulldozer. The ripping would be undertaken in autumn (before breaking rains) when the soil profile is at its driest to ensure significant fracturing of any compaction layers present.

5.2.3 Dune Re-Contouring and Re-Nourishment

Figure 3 details the proposed final mining levels and was submitted with the Development Application (DA) approved by the CoS (Cardno 2008a). The final contours have been designed to accommodate the range of potential end land uses with only minor changes to levels required and to interface with the existing levels of the surrounding properties. Therefore, these levels will be adopted at the commencement of mining with the understanding that the contours may alter slightly to accommodate the final development requirements. The final contours will allow for a minimum of 2m of soil above the highest recorded groundwater level, with the majority of the site to establish greater than 2m separation distance to enable the contours to interface with surrounding topography.

5.2.4 Use of fine tailings for rehabilitation

Research carried out in previous years on ML 70/238 has indicated that fine tailings materials are not suitable for rehabilitation. The fine tailings are inert and will be managed by blending with lower grade products for sale from the site.

5.3 Erosion Control

Soil erosion will be controlled during sand mining operations by the following management techniques and operational processes:

- Clearing will only be undertaken in stages as required for mine operations and will not be conducted in adverse and extreme weather conditions (e.g. excessive windy and dry conditions);
- Areas affected by erosion (especially wind erosion in summer) will be treated immediately with stabilising hydro-mulch;
- Any mulch layers will be broken up by scarification before topsoil application and ripping is undertaken for rehabilitation works;
- Regular monitoring of erosion problems will be undertaken by the site supervisor and reported to erosion control contractor;
- Gradual, slightly sloping contours will be maintained during mining operations to reduce water and wind erosion on steep sand batters; and
- Large logs (remaining following vegetation clearing) will be placed throughout the rehabilitation sites to decrease the potential for erosion and vehicle movement as well as providing future habitat for insects and fauna species.

No mulch layers are to be used during the rehabilitation of the site due to all mulching techniques resulting in significant reduction in seed germination and recruitment (Rokich and Dixon, 2007). The use of cereal rye cover crops may be considered in areas which are deemed highly prone to wind erosion as the rye helps to bind the soil and reduce ground wind speed on the site. The cereal rye is sterile and does not cause problems with introducing weed species to the subject site. The large tree logs taken from the clearing the vegetation of the subject site, are proposed to be placed on the rehabilitation area to reduce wind erosion effects and in the short and long term habitat for insects fauna species. This work should be carried out following the application of topsoil and the ripping of the soil profile.

5.4 Seed Collection and Installation

The viability of the seedbank contained within topsoil stripped from newly cleared *Banksia* woodlands, progressively declines over time due to germination of seeds and heat created from compositing of the soil which kill seeds. While the use of the topsoil seedbank can contribute to the majority of seedling recruitment in post-mined sites within *Banksia* woodland, there are many species that store their seeds in persistent fruits held in the vegetation canopy (serotiny) (Rokich and Dixon, n,d). The seeds from species such as *Banksias* and *Hakeas* are only usually released from their pods following a fire event which also contributes to breaking seed dormancy of other species which require smoke (water) to germinate.

5.4.1 Seed Collection

Due to the factors described above, extra seed requires spreading on the topsoil during the revegetation period to increase the germination and density of species to satisfy the rehabilitation completion criteria for the subject site. A seed collection program will be undertaken to source local provenance seed (within 30km of the subject site) from the surrounding similar plant community types.

An experienced revegetation contractor will be engaged at least 1 year prior to revegetation works on the subject site in order for all species specified to be spread as seed collected over the summer to autumn period. Seed species with germination barriers will be treated shortly before being spread on the rehabilitation areas. Germination barriers such as thick/hard seed coats (i.e. *Acacia, Hardenbergia)* can be treated through the use of scarification or boiling water which would break/crack this coat and enable moisture to enter the seed (required for germination). Smoke treatment will also be used to break seed dormancy on many species such as those in the Proteaceae family (i.e. *Banksia, Grevillia, Hakea*) which require specific chemicals present in burnt material to germinate. This is an adaptation of species to germinate after fire when high amounts of nutrients are release into the soil and new opportunities created for seedlings due to lesser competition for light, nutrients and moisture.

5.4.2 Seed Installation

Seed installation will be undertaken following site preparation works (in autumn) during the months of May to July after significant rainfall has wet the soil profile. Seed is to be spread on all revegetation areas at a rate of 4 kg per ha, which would provide a significant cover of seedlings to satisfy with the completion criteria. A full list of seed species required for the project is shown in **Appendix A** which also shows the percentage ratio for each species and grams/ha. The ratio of seed species has been developed from information on current plant densities recorded in the flora and vegetation survey report (Cardno 2008). These ratios may vary throughout the life of the rehabilitation program due to availability of seed species collected before and during the program.

The seed will be spread by hand using a damp bulking agent (i.e. sawdust or sand) which will spread all seed species in an even pattern. The bulking agent prevents light seeds from blowing away in the wind when being spread and also helps bind seeds to the soil to reduce movement around the site by the wind.

After the spreading of seeds, raking of the topsoil would occur by dragging a light rake (eg. building mesh in large scale rehabilitation or household rake in small) over the surface to slightly bury the seeds on the surface of the sand. This burying of seed by raking has been shown to significantly increase the germination of spread seed in Banksia woodland rehabilitation sites by reducing temperature exposure, greater anchorage of the seed in the profile and greater consistency of soil moisture availability (Rokich and Dixon, 2007).

5.5 Weed Control

The biggest issue facing rehabilitation programs are the control of problem weeds which have the potential to outcompete native species for light, nutrients and moisture. The rehabilitation areas are predicted to be relatively free of weeds due to the low presence of weeds in the existing vegetation (therefore low amounts of seed in the topsoil) and surrounding native bushland and the fact that the site will be bare white sand following mining. There is however a risk of infestation of weeds into the revegetation site from through wind dispersal from surrounding areas and vehicles transporting seeds in tyres and attached soil. **Table 1** displays the weed species which were identified on the subject site in the flora and vegetation report (Cardno, 2008).

Table 1: Weed species present on the subject site.

Weed Species	
Aira caryophyllea	*Isolepis marginata*
Anagallis arvensis	*Lotus subbiflorus*
Arctotheca calendula	*Lupinus cosentinii*
Avena barbata	*Moraea flaccida*
Briza maxima	*Ornithopus pinnatus*
Carpobrotus edulis	*Pinus pinaster*
Ehrharta calycina	*Solanum nigrum*
Ehrharta longiflora	*Sonchus oleraceus*
Gladiolus caryophyllaceus	*Ursinia anthemoides*
Hypochaeris glabra	*Wahlenbergia capensis*

Each stage will be treated for weeds in a similar way. An initial assessment will be undertaken for the specific rehabilitation site before application of topsoil and ripping of the soil profile. This assessment will determine if there is a need to remove or spray any weed species present which could infect the soil profile. If required, weed control work will be carried out for the specific weeds before topsoil spreading and ripping.

A second assessment will be undertaken approximately two to four weeks before seed spreading (April – June) to determine if any significant outbreaks of weeds are present on the rehabilitation site following the application of topsoil, ripping and significant breaking rains. This assessment will again determine if any weed control work is required to be undertaken before the spreading of seed. If required, this work will be undertaken two weeks prior to seed spreading if chemical applications are proposed to ensure all chemical residues have been broken down in the soil.

Following the spreading of seed on the rehabilitation area, an assessment will be undertaken in spring to ascertain the germination of weed species in the rehabilitation areas. If weeds have germinated, chemical applications using Glyphosate will only be undertaken using a spot spraying technique, while Fusillade can be blanket sprayed over grass infestations without significantly affecting the germinating native plant species.

Further weed assessment after this period should be undertaken every two to three months particularly during spring and after the breaking rains in autumn. During the maintenance and monitoring period for the rehabilitation sites, weed control work will be planned (if necessary) for each season to target specific weeds deemed a threat to the health of the revegetation. As the rehabilitation sites are direct seeded, it is difficult to identify seedling to avoid when traversing through the site and care will be taken during any weed control program implementation.

5.6 Rehabilitation Research

Rehabilitation at the site will be managed in a similar fashion to the methodology developed by Kings Park Board and Rocla in the nearby mining tenement ML 70/238. Stephen Elliott, now from Urban Resources, was the state manager of Rocla for 18 years and initiated and supported the research required to establish this rehabilitation regime. Urban Resources is negotiating with Kingsley Dixon from the Botanic Gardens and Parks Authority to conduct further research into the rehabilitation methods being used with a view to continuing to improve the standard and end results that can be achieved. The methodology now adopted has produced excellent results but Urban Resources aim is to constantly improve the standard of rehabilitation that is achieved.

6 Rehabilitation Monitoring

The aim of a monitoring program is to measure the progress and relative success of rehabilitation operations. Irrespective of the completion criteria, the rehabilitation contract should be based on routine maintenance (i.e. repairs, weed management, reseeding, etc.). If at any time it is likely that the completion criteria may not be met, the rehabilitation contractor should undertake remedial action (in the required time of year depending on the actions) in consultation with Urban Resources.

All monitoring activities and site assessments will be conducted by the revegetation contractor or rehabilitation consultant, with reports and regular monthly feedback to be provided to Urban Resources. The monitoring will be conducted twice yearly in autumn and spring for 3 years (for each stage of rehabilitation) after the initial revegetation work has been completed (usually at the end of winter). At the end of the three year monitoring period all of the rehabilitation completion criteria must be met by the program. If aspects of these criteria are not met then the contractor may also provide feedback to the Urban Resources regarding site specific problems and proposed maintenance work.

6.1 Monitoring Methods

The rehabilitation monitoring program will be based around setting up 2 x 2m monitoring quadrats in the newly rehabilitated areas. These quadrats would be installed to monitor the seed germination over approximately 0.2% of the rehabilitation area which would equate to approximately 5 quadrats/ha. The quadrats will be pegged at each corner, with the photo point to be located on the north west corner of the quadrat. Observational recordings will also be made in and around the quadrats into other aspects involving rehabilitation success such as erosion, weed invasion/growth, access disturbance and fauna predation.

Information recorded for each quadrat is as follows:

- Date;
- Transect number;
- GPS location;
- Photo and photo number;
- Surveyor initials;
- Quadrat number; and
- General comments on weed infestation, erosion/disturbance and pest predation.

Seed germination data recorded for the quadrats includes:

- Species name of seedlings present;
- Count per species present; and
- Count per species present from topsoil germination (those species that were not installed as seed).

6.2 Completion Criteria

The following rehabilitation completion criteria are proposed as an average for each stage:

- At least 70% of the species spread as seed are represented;
- The average density of plants is 3 per m^2 or greater;
- Weed presence is minimal and not inhibiting native plant survival and growth; and
- Erosion is minimal and not inhibiting native plant survival and growth.

These criteria are considered practical and realistic based on other rehabilitation works in the area and the direct seeding rates provided. These expectations are for a period of average weather conditions.

6.3 Reporting

Monitoring reports will be produced after each of the rehabilitation monitoring periods which will describe the methods used, the analysis of data collected and recommendations for maintenance of rehabilitation. These reports are to be produced by the rehabilitation contractor/consultant responsible for monitoring and provided to Urban Resources and rehabilitation contractor, no more than three months after data collection. This will ensure any recommendations proposed for maintenance are current and can be enacted in a timely fashion. A total of six reports will be produced in the three years of the monitoring program with the final report to be provided to the CoS to prove final completion criteria has been met.

7 Rehabilitation Maintenance

The rehabilitation maintenance program is aimed at providing a framework for additional rehabilitation works to be undertaken in the rehabilitation areas after the initial period of works. These works will be undertaken if various aspects of the rehabilitation program are performing poorly (as identified in site assessments and/or monitoring program) and require further inputs. These inputs could be extra seed spreading, additional weed management, fencing repairs and access control.

7.1 Re-seeding

Re-seeding of the rehabilitation areas could be required is seed germination from the previous year/s seed spreading has shown poor results. This re-seeding could be tailored at a single or group of species. The entire species list could also be re-seeded in areas that are performing poorly overall resulting from problems such as shallow topsoil, erosion, weed invasion competition or access disturbance. These recommendations can be provided in the monitoring report or communicated to the Urban Resources by the rehabilitation contractor/consultant. The re-seeding program would be undertaken at the same time of year but would not require any site preparation works such as ripping and raking.

7.2 Weed Management

Weed management is the most controllable factor that will ultimately determine the success of the rehabilitation plan. It is essential that weeds are monitored and controlled at all times to ensure their impact is minimised. Weeds have the greatest impact during the first few years of native seedling development through competition with seedlings for nutrients, light and soil moisture. Once native plant species have developed a significant root structure and canopy they out-compete weeds and hence the impact is reduced.

8 Rehabilitation, Monitoring and Maintenance Schedule

Table 2: Rehabilitation schedule per rehabilitation stage

Timing	Works Type	Works program	Responsible agency
Oct – April **Year 1**	Revegetation Program	Collection of local provenance seed for rehabilitation program.	Rehabilitation or seed collection contractor.
April – May	Weed Control Program	Initial assessment of the finished mining area for invading weed species.	Weed control contractor
April – May	Weed Control Program	Control of weed species using manual or chemical controls (if required).	Weed control contractor
April – May	Site Preparation	Spread topsoil over finished mining areas ready for rehabilitation.	Mining contractor
April – May	Site Preparation	Ripping of soil profile.	Mining contractor
May – June	Weed control	Assessment of rehabilitation site for weed germination	Weed control contractor
May – June	Weed Control Program	Control of weed species using manual or chemical controls (if required).	Weed control contractor
May – June	Revegetation Program	Treatment of seed species which require the breaking of seed dormancy for germination.	Rehabilitation or seed collection contractor.
May – June	Site Preparation	Placement of large tree logs on rehabilitation area sourced from cleared vegetation.	Mining or Rehabilitation contractor.
May – July	Revegetation program	Spreading of seed on rehabilitation areas using bulking agent.	Rehabilitation contractor
May – July	Revegetation program	Raking of rehabilitation area after seeding.	Rehabilitation contractor
Sept - Oct	Weed Control Program	Assessment of rehabilitation site for weed germination	Weed control contractor
Sept - Oct	Weed Control Program	Control of weed species (if required) using manual methods, spot chemical controls with glyphosate (broadleaf species) or blanket chemical spray with Fusillade (grass species).	Weed control contractor
Sept – Oct	Monitoring	Set up monitoring quadrats and photo points and undertake initial assessment of seed germination and take photos.	Rehabilitation contractor/consultant.

Timing	Works Type	Works program	Responsible agency
Nov – Jan **Year 2**	Monitoring	Produce first monitoring report for rehabilitation program	Rehabilitation contractor/consultant.
April – May	Weed Control Program	Assessment of the rehabilitation area for germination of weed species.	Weed control contractor
April – May	Weed Control Program	Control of weed species (if required) using manual methods, spot chemical controls with glyphosate (broadleaf species) or blanket chemical spray with Fusillade (grass species).	Weed control contractor
April – May	Monitoring	Second monitoring of quadrats and take photos from points.	Rehabilitation contractor/consultant.
June – Aug	Monitoring	Produce second monitoring report for rehabilitation program.	Rehabilitation contractor/consultant.
May – July	Revegetation Maintenance	Re-seed poorly performing rehabilitation areas and repair any damaged fencing (if required).	Revegetation contractor
Aug - Oct	Weed Control Program	Assessment of the rehabilitation area for germination of weed species.	Weed control contractor
Aug - Oct	Weed Control Program	Control of weed species (if required) using manual methods, spot chemical controls with glyphosate (broadleaf species) or blanket chemical spray with Fusillade (grass species).	Weed control contractor
Sept - Oct	Monitoring	Third monitoring of quadrats and take photos from points.	Rehabilitation contractor/consultant.
Nov – Jan **Year 3**	Monitoring	Produce third monitoring report for rehabilitation program.	Rehabilitation contractor/consultant.
April – May	Weed Control Program	Assessment of the rehabilitation area for germination of weed species.	Weed control contractor
April – May	Weed Control Program	Control of weed species (if required) using manual methods, spot chemical controls with glyphosate (broadleaf species) or blanket chemical spray with Fusillade (grass species).	Weed control contractor
April – May	Monitoring	Fourth monitoring of quadrats and take photos from points.	Rehabilitation contractor/consultant.
June – Aug	Monitoring	Produce fourth monitoring report for rehabilitation program.	Rehabilitation contractor/consultant.
May – July	Revegetation Maintenance	Re-seed poorly performing rehabilitation areas and repair any damaged fencing (if required).	Revegetation contractor

Timing	Works Type	Works program	Responsible agency
Aug - Oct	Weed Control Program	Assessment of the rehabilitation area for germination of weed species.	Weed control contractor
Aug - Oct	Weed Control Program	Control of weed species (if required) using manual methods, spot chemical controls with glyphosate (broadleaf species) or blanket chemical spray with Fusillade (grass species).	Weed control contractor
Sept - Oct	Monitoring	Fifth monitoring of quadrats and take photos from points.	Rehabilitation contractor/consultant.
Nov – Jan **Year 4**	Monitoring	Produce fifth monitoring report for rehabilitation program.	Rehabilitation contractor/consultant.
April – May	Weed Control Program	Assessment of the rehabilitation area for germination of weed species.	Weed control contractor
April – May	Weed Control Program	Control of weed species (if required) using manual methods, spot chemical controls with glyphosate (broadleaf species) or blanket chemical spray with Fusillade (grass species).	Weed control contractor
April – May	Monitoring	Sixth monitoring of quadrats and take photos from points.	Rehabilitation contractor/consultant.
June – Aug	Monitoring	Produce sixth and final monitoring report for rehabilitation program that meet all completion criterion within the RRP.	Rehabilitation contractor/consultant.

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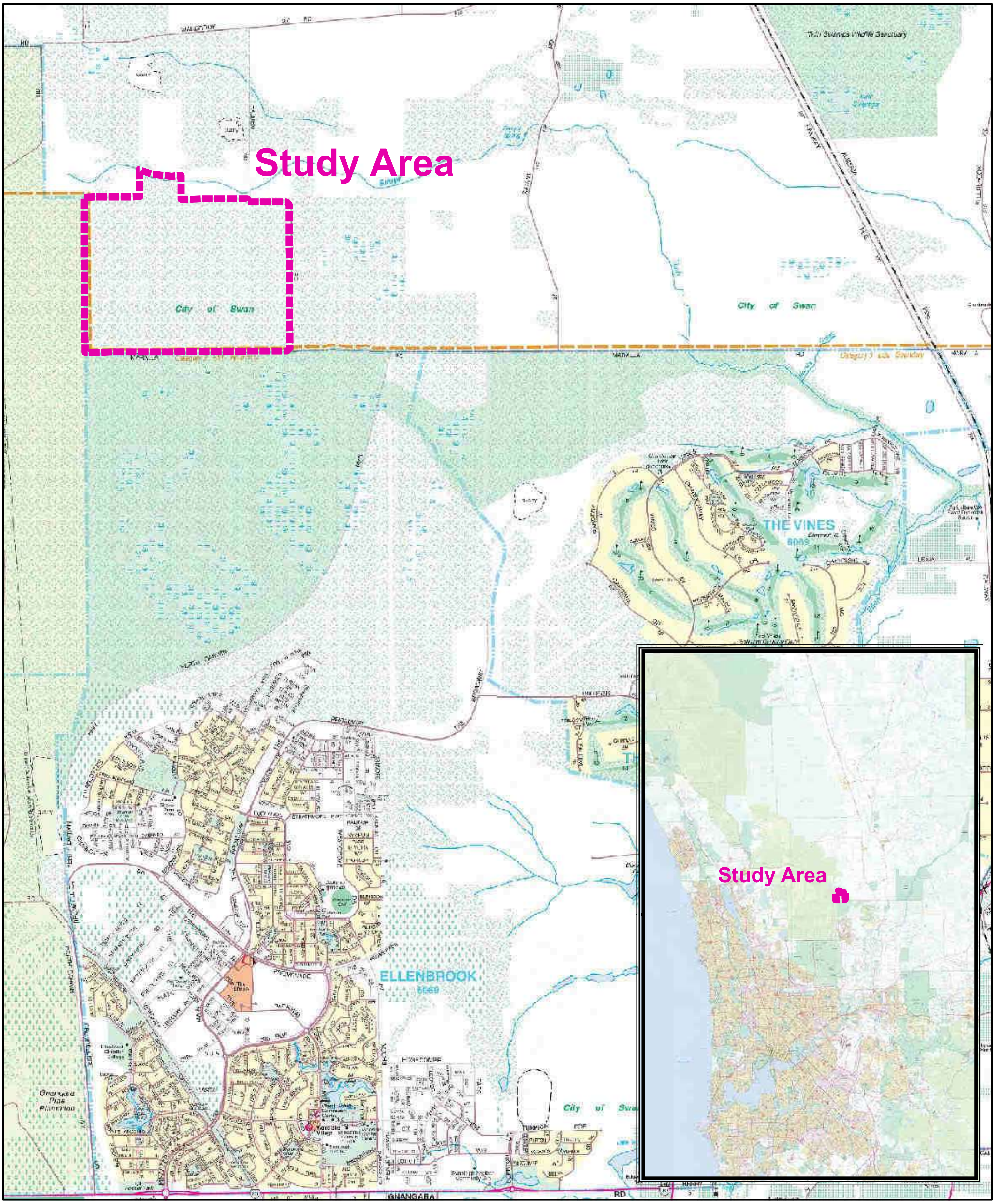
Figures



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Scale: 1:35,000

0 350 700 1,400 2,100 2,800 3,500 Meters

PROJECT Maralla Road Rehabilitation and Revegetation Plan

DRAWING TITLE FIGURE 1 : Locality Plan

PRINCIPAL Urban Resources

Project Number V7054

Original A4

Drawing Number SK01

Revision 00

Designed MF

Checked

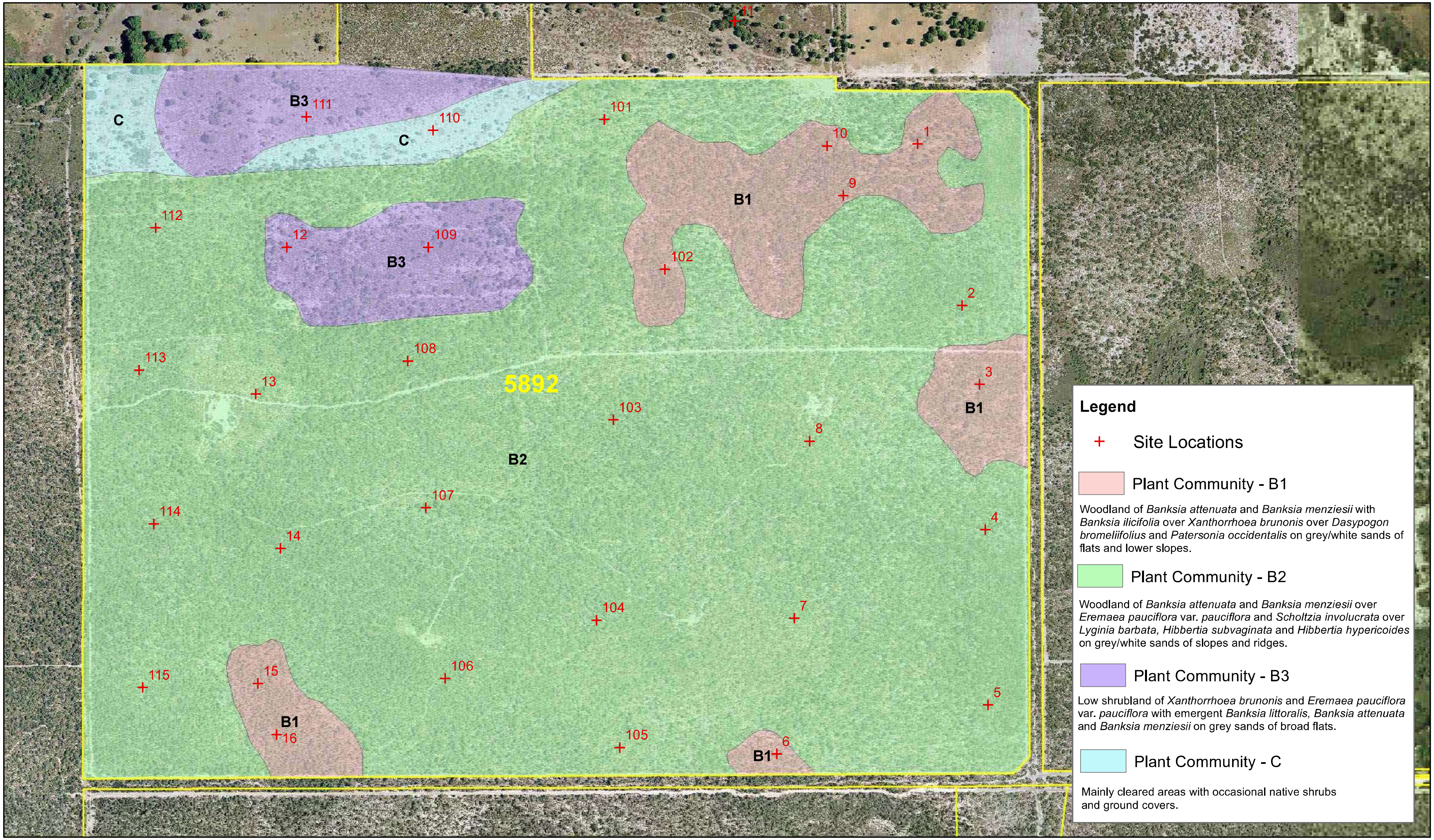
Drawn MGW

Approved

Local Authority Shire of Swan

Sheet 1 of 1

Date 22/03/11



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PROJECT **Maralla Road Rehabilitation and Revegetation Plan**

DRAWING TITLE **FIGURE 2 : Plant Communities**

PRINCIPAL **Urban Resources**

Scale: **1:5,500**

0 75 150 300 450 600 750 Metres

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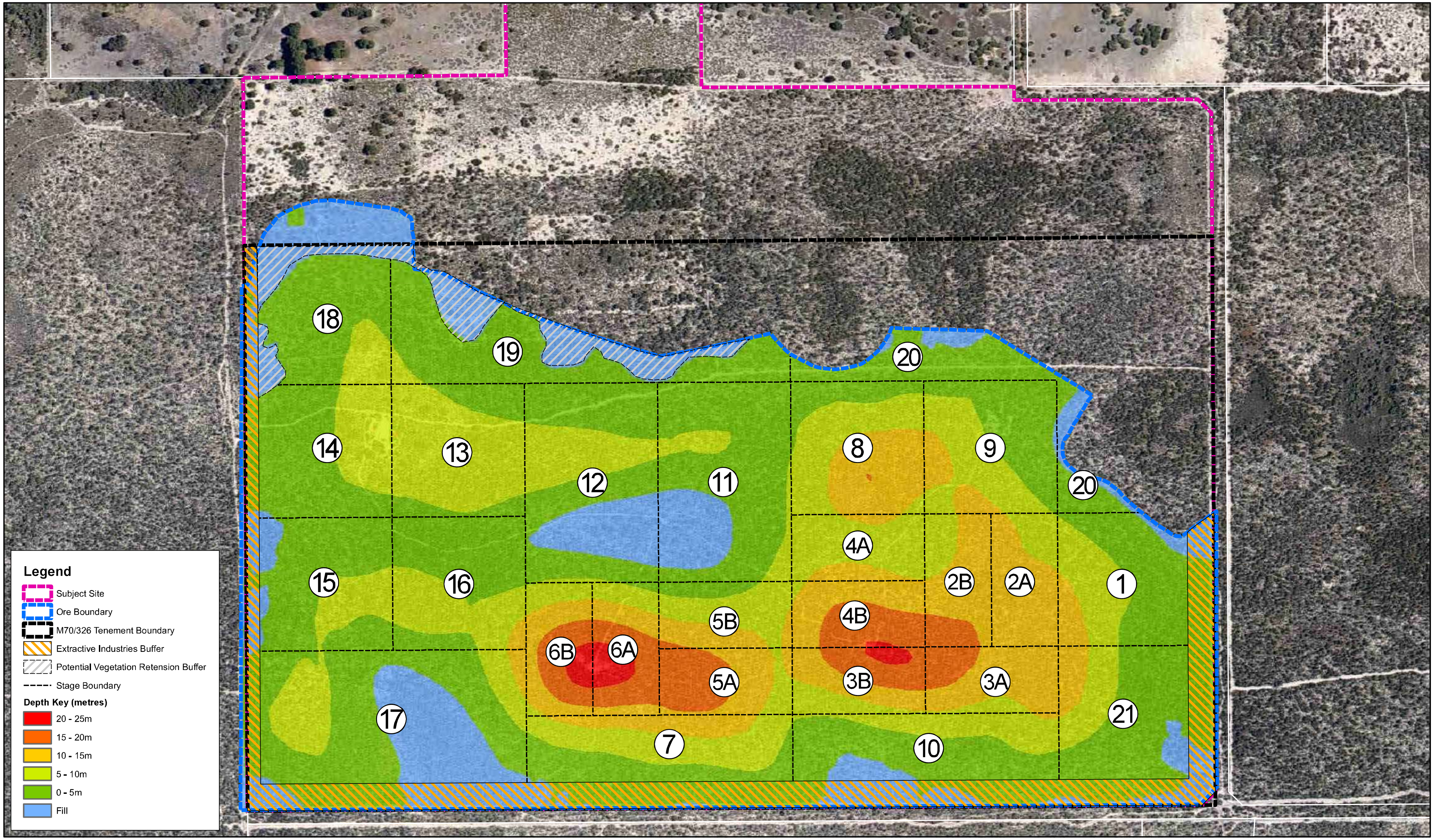
Project Number	Drawing Number	Revision	Original
V7054	SK02	00	A3

Designed	MF	Checked		Date	22/03/11
Drawn	MGW	Approved		Sheet	1 of 1
Local Authority	City of Swan				



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 **Maralla Road Rehabilitation and Revegetation Plan**

DRAWING TITLE **FIGURE 3 : Overall Staging Plan**

PRINCIPAL **Urban Resources Pty Ltd.**

Scale: **1:5,500**

0 50 100 200 300 400 500 600 700 Metres

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V7054	**SK03**	**00**	**A3**

Designed MF
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Date 22/03/11
Sheet 1 of 1

Appendix A

Rehabilitation Species List

Revegetation species list	**Seed Ratio**	**Seed g/ha**
Acacia huegelii	1	40
Acacia pulchella	5	200
Adenanthos cygnorum	10	400
Allocasuarina humilis	1	40
Anigozanthos humilis	0.1	4
Anigozanthos manglesii	0.1	4
Astroloma xerophyllum	5	200
Banksia attenuata	8	320
Banksia menziesii	5	200
Beaufortia elegans	3	120
Bossiaea eriocarpa	0.1	4
Calytrix flavescens	0.1	4
Calytrix fraseri	0.1	4
Conospermum incurvum	0.1	4
Conostephium pendulum	3	120
Conostylis juncea	0.1	4
Conostylis setigera	0.5	20
Dasypogon bromeliifolius	3	120
Daviesia preissii	0.1	4
Eremaea pauciflora var. pauciflora	15	600
Eucalyptus todtiana	5	200
Gastrolobium capitatum	1	40
Gompholobium tomentosum	2	80
Hakea costata	2	80
Hemiandra glabra subsp. glabra ms	0.5	20
Hovea pungens	0.1	4
Jacksonia floribunda	0.5	20
Jacksonia furcellata	3	120
Leptospermum erubescens	0.1	4
Leucopogon polymorphus	0.5	20
Leucopogon squarrosus	0.5	20
Lyginia barbata	8	320
Macrozamia riedlei	0.5	20
Nuytsia floribunda	5	200
Persoonia saccata	0.5	20
Petrophile linearis	1	40
Philotheca spicata	0.1	4
Scholtzia involucrata	5	200
Stirlingia latifolia	0.5	20
Trachymene pilosa	0.1	4
Verticordia drummondii	0.1	4
Verticordia nitens	0.2	8
Xanthorrhoea brunonis	0.5	20
Xanthorrhoea preissii	3	120
Total	**100**	**4000**