Appendix F
Draft Rehabilitation Plan

DRAFT REHABILITATION PLAN

Coburn Mineral Sand Project

Prepared for

Gunson Resources Limited
Level 2, 33 Richardson St
West Perth WA 6872

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URS

Project Manager: ....
Sonia Finucane
Principal Environmental Scientist

Project Director: ....
Ian LeProvost
Senior Principal Environmental Scientist

Author: ....
Blair Hardman
Project Environmental Scientist

URS Australia Pty Ltd
Level 3, The Hyatt Centre
20 Terrace Road
East Perth WA 6004 Australia
Tel: 61 8 9221 1630
Fax: 61 8 9221 1639

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Gunson Resources Limited (Gunson) proposes to develop the Coburn Mineral Sand Project's Amy Zone Operations (the Project) at a site in the Shark Bay district of Western Australia, approximately 250 km north of Geraldton and approximately 84 km south-east of Denham (Figure 1). The proposed operation comprises the excavation of a major low-grade heavy mineral sand deposit known as the Amy Zone and processing to form a heavy mineral concentrate (HMC) that will be transported off-site.

The Amy Zone orebody is approximately 35 km long, up to 3 km wide and between 10 and 40 metres (m) thick. The orebody comprises approximately 620 million tonnes of ore hosted in loose, dunal sand with very low clay content. Based on the average grade of 1.1 % Heavy Mineral (HM), nearly five million tonnes of HMC will be yielded over approximately 20 years. The economic minerals of the Amy Zone include ilmenite, rutile, leucoxene and zircon.

The Project will include:

- ten open-pit mines, of which only two would be operational at any one time;
- two processing plants (concentrators) that will be relocated as mining progresses northwards;
- a borefield;
- haul roads and access corridors;
- offices, workshops and other supporting infrastructure; and
- an accommodation camp.

The mining and processing operations will move forward at an annual rate of one to two kilometres. Rehabilitation will be conducted on a progressive basis to reduce the area of disturbance and facilitate return of native flora and fauna.

The proposed Project is being assessed as a Public Environmental Review (PER). Due to a bilateral agreement between the State and Commonwealth governments, the PER serves as the environmental assessment document under both the State *Environmental Protection Act* 1986 (EP Act) and the *Commonwealth Environmental Protection and Biodiversity Conservation Act* 1999 (EPBC Act).

The WA EPA has expressed concern that the mine will be difficult to rehabilitate and could pose a long-term threat to the adjacent Shark Bay World Heritage Property (SBWHP) if the returned dune sands are not stabilised adequately after completion of mining. In response, the Proponent has undertaken a Benchmarking Study of previously disturbed sites in the region and other mineral sand mining operations located in similar environments elsewhere to determine the factors required for successful revegetation. The findings of the Benchmarking Study have been used to design this Rehabilitation Plan.

This document is a draft Rehabilitation Plan for the Coburn Mineral Sand Project. It has been prepared using the findings of a range of studies including baseline studies of the Project Area, the Benchmarking Study and stakeholder consultation. The plan is appended to the PER to provide regulators, members of the public and other stakeholders with information on how Gunson proposes to rehabilitate areas disturbed by the Project and to receive feedback from these stakeholders. The plan will be finalised with consideration of stakeholder comments and input.

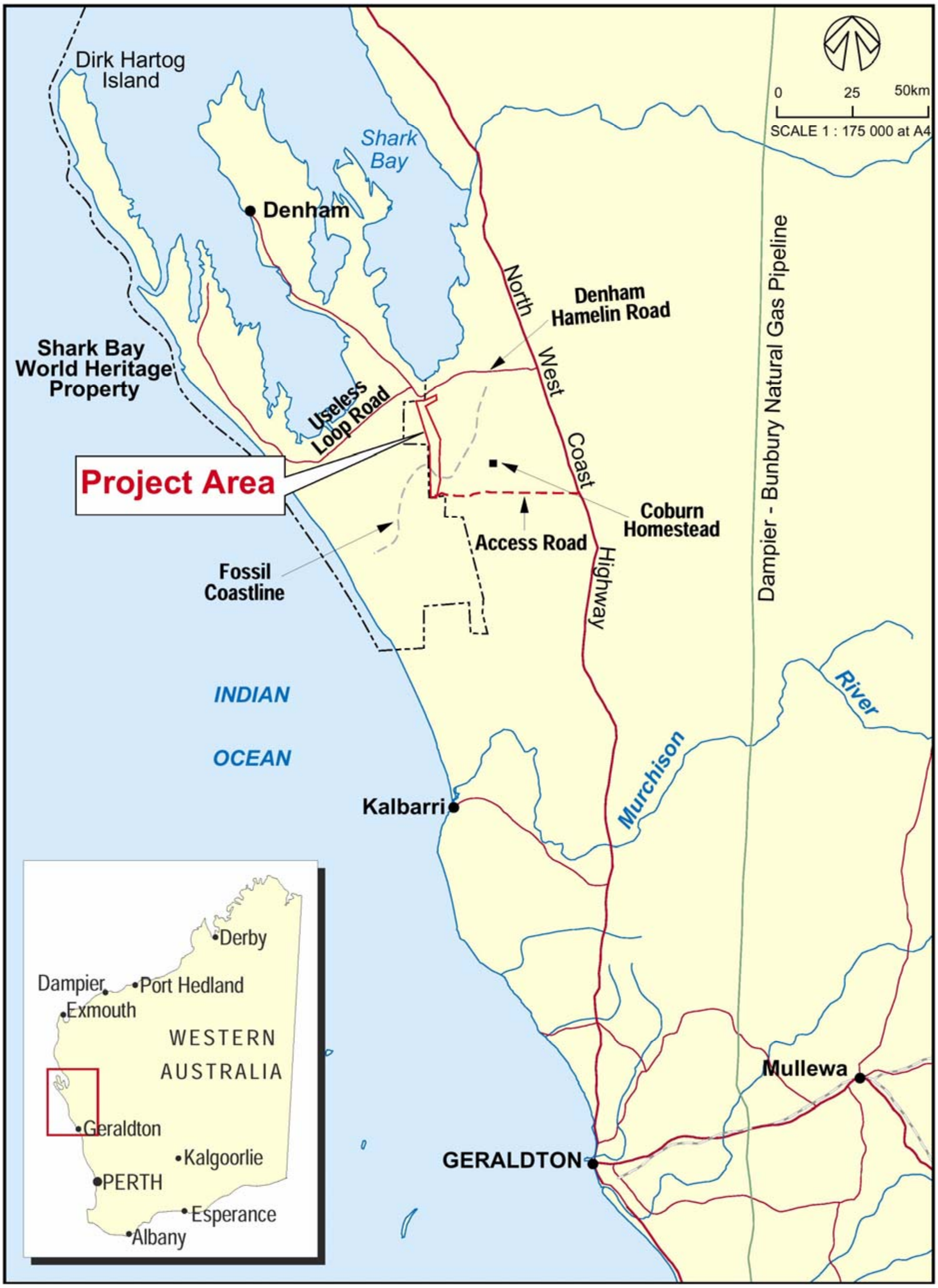

Figure 1 Coburn Mineral Sand Project Area

Objectives

The current land use of the Project Area is pastoral. This Rehabilitation Plan outlines Gunson's strategy for returning the disturbed areas created by mining operations to a pastoral land use. This strategy will be supported by four objectives:

- Minimise the amount of cleared area at any one point in time through progressive rehabilitation of mined out pits.
- Ensure the post-mining surface morphology is visually congruent to the surrounding undisturbed area.
- Stabilise disturbed land as soon as reasonably practicable to control dust and wind erosion.
- Revegetate the stabilised land surface to allow the return of native flora and fauna and sustainable use of the area for pastoral purposes.

These objectives are consistent with those objectives recommended by the Commonwealth Environmental Protection Agency (EPA) Best Practice module *Rehabilitation and Revegetation* guidelines (Ward 1995).

3.1 Environmental Characteristics

Gunson recognises that the EPA and other land management agencies will require reassurance that the proposed mineral sand project can in fact be rehabilitated and will not cause adverse impacts on the adjacent SBWHP. In acknowledgement of this, Gunson has utilised the services of URS Australia Pty Ltd and external contractors to conduct a range of studies in order to provide a detailed description of the existing environment within the Project Area and the likely issues involved with the proposed mining operations.

Further detailed information is provided in the PER. However, a summary of the environmental factors associated with the rehabilitation of the proposed mining operations is provided below:

Climate

Rainfall at the Project Area is extremely variable, with approximately 70% falling between May and August. Rainfall averages 212 mm per annum at Hamelin Pool, although rainfall in the southern half of the Project Area is likely to be around 240 mm per annum (Hamelin Station pastoral lease manager *pers. comm*.). The area is influenced by south-east trade winds, which generate southerly winds for the majority of the year. During summer, southerlies are consistently over 25 km/hr for several days. Cyclones generating wind gusts up to 180 km/hr occur infrequently over summer and autumn (CALM 1998). The expected site conditions of high summer wind speed and temperature, high evaporation, and unpredictable rainfall, are expected to make rapid site rehabilitation difficult. However, additional moisture provided by dew and fog, and permeable soils providing high water infiltration and low water erosion hazard are likely to benefit rehabilitation procedures.

Landform and Soils

The landforms of the Amy Zone comprise a complex dune system with high local relief and lower relief dunes with rolling terrain. The soils are dominated by sands, typically reddish brown (2.5 YR4/8) to dark red (7.5 R3/6) in colour. The soils of the Amy Zone are slightly to strongly alkaline (pH ranging 7.5 – 9.5) with maximum electrical conductivity values (salt content) of 25 mS/m. This reading is rated as “low”, with minimal effect on plant growth (Moore 1998).

The majority of the soil profiles surveyed by D. C. Blandford and Associates (see Appendix C of the PER) had a surface layer of highly mobile sand, varying in thickness from 1.0 cm to 15.0 cm. This indicates that the surface layer is quite unstable and demonstrates a degree of surface instability due to erosion by wind. Under this layer, the majority of the soils displayed development of fabric and coherence at some depth below the surface, where soil fabric is defined as the physical constitution of soil material as expressed by the spatial arrangement of the solid particles and associated voids. However, upon disturbance the soil materials are likely to revert to a single grain fabric, predisposing them to accelerated wind erosion. In addition, the mining process will clear native vegetation and potentially increase soil exposed to wind.

Field evidence indicates the presence of dispersible soil material at depth, which may contaminate surface soils if the two parts of the profile are mixed. Dispersion is defined as the ability of the clay fraction of a soil to move into suspension when wet. This is generally caused by a dominance of sodium ions (Na^+) on the exchange complex but other factors contribute to the process such as the electrolyte content of the percolating water.

The impacts from the dispersion of clays can be quite dramatic. When the clay moves into suspension, the fabric and binding mechanisms of the soil particle are lost and the particle collapses. If the dispersive soil particles are on the surface, this collapse predisposes the soil to accelerated soil erosion. In some instances, the clays will set very hard on drying, creating a hostile environment for seed germination and rainfall infiltration. Under Australian terminology, a soil is said to be sodic when the exchangeable sodium percentage (ESP) is >6%. However, when the ESP passes 15%, the soil is regarded as being prone to tunnel erosion where the formation of tunnels occurs below the surface. The tunnels subsequently collapse creating quite deep and unstable gullying. This process can be quite insidious and may take a number of years before the collapse stage is reached. However, the soils of the Project Area were found to have low clay content (generally < 10 %), which makes the soils less susceptible to structural decline. Regardless, it will be essential for landform and soil profile reconstruction to ensure segregation of dispersive soils.

Part of the soil profile will consist of sand tailings that will be generated by processing sands in a wet concentrator. The wet concentrator uses brackish water (<12 ppt) to separate materials, therefore the tailings are likely to retain slightly elevated salt contents when returned to the soil profile. The presence of salt may impede the rehabilitation process if the salt concentration of the soil is too high to support local vegetation. In addition, the potential loss of up to two-thirds of the fine materials during the sand processing may decrease the moisture retention ability of the lower soil profile.

Hydrogeology

The hydrogeology of the region and the Amy Zone is described in detail in Appendix D of the PER. Groundwater aquifers in the region are mainly confined although some superficial unconfined aquifers also occur in northern parts of the mine. There are five significant aquifers in the Gascoyne Platform area, all of which are mostly confined except for local areas in the eastern recharge area overlying the Ajana Ridge (Refer to Figures 8, 34 and 48 in Appendix D of the PER). Unconfined aquifers in and near the Project Area are limited to a shallow palaeo-drainage and down-gradient areas adjoining Hamelin Pool. Apart from a thin, saturated layer occupying the lower-most part of the superficial sand in the axis of an inferred north to north-west trending palaeo-drainage, the superficial sand deposits in the Project Area are dry, i.e. above the water table.

Surface Hydrology

The Project Area is internally draining and has no surface water features due to low rainfall, high evaporative conditions, and high infiltration rates. It has no defined watercourses, permanent fresh-water bodies or birridas (seasonally inundated saline lakes). There are no known sensitive surface water features within the proposed mining area. Most rainfall quickly evaporates or infiltrates.

Flora and Vegetation

The typical vegetation of this system comprises of “tree heath”, or heath with scattered trees. A total of 18 plant communities, consisting of seven *Eucalyptus* Woodlands, ten Shrublands and one Mosaic community were identified (refer to Appendix J of the PER). None of the plant communities within the Project Area are considered to be Threatened Ecological Communities, although 14 communities were identified as Regionally Significant, and a further 12 communities as Locally Significant.

A total of 231 taxa (including subspecies and varieties) from 132 genera and 51 families were recorded, including 14 introduced (weed) species. No plant taxa gazetted as Declared Rare Flora or Threatened Flora were located, but nine species classified as Priority Flora were recorded. In addition eight species were located outside their previously recorded ranges.

Successful revegetation is likely to be a slow process, and one that relies heavily on the success of the landforming process and a range of other environmental factors. The success of a rehabilitation programme is generally judged on the return of appropriate vegetation density and species richness. However, rehabilitated sites do not generally return to biodiversity values found in undisturbed ecosystems. This is because the conditions created during the land rehabilitation process are unsuitable for some species.

The majority of the vegetation within the Project Area is relatively slow growing. Some species seem capable of colonising disturbed areas, while other species slowly gain dominance over time. Therefore, it is likely that the rehabilitation sites may experience vegetation successions proceeding at different rates. Evidence collected from disturbed areas in the region of the proposed mine suggest that it may take an extended period for some sites to attain a community of similar structure and composition as the undisturbed community (Appendix E of the PER). This finding significantly influences the closure criteria of the Project Area.

Historically, one of the first colonisers of land disturbed by mining operations are introduced weed species. The mining disturbance removes competition from native species, leaving large tracts of open areas that provide an ideal environment for colonisation and growth. The expected increase in weed population may negatively affect the rehabilitation of native species, and may increase weed populations in adjacent undisturbed areas.

Fauna

A total of eight native mammal species, 61 bird species and 45 reptile species were identified in the Project Area (refer to Appendix K of the PER). Three species known to occur within, or in close proximity to the Project Area are listed under EPBC Act (1999). A further two species are likely to occur in the Project Area that are gazetted under the *Wildlife Conservation Act* (1950). In addition, another three vertebrates likely to occur in the Project Area are gazetted under the CALM Priority Fauna List. No stygofauna was recovered from the sampling of seven groundwater bores within the Project Area.

Given the mobility of the fauna species within the Project Area, and their generally widespread distribution, the mining operations are not expected to significantly affect regional fauna populations. This mobility is also likely to allow fauna populations to rapidly return to rehabilitated areas. However, their return is highly correlated with the successful rehabilitation of habitat that is capable of providing the required food sources and protection.

3.2 Regulatory Framework

The legislation with which the Rehabilitation Plan for the Project Area will comply include:

- *Environmental Protection Act* 1986;
- *Environmental Protection and Biodiversity Conservation Act* 1999;
- *Rights in Water and Irrigation Act* 1914;
- *Conservation and Land Management Act* 1984;
- *Soil and Land Conservation Act* 1945;
- *Mines Safety and Inspection Act* 1994 and associated Regulations;
- *Mining Act* 1978*;* and,
- *Mining Regulations* 1981.

Rehabilitation requirements may be imposed through conditions outlined on each mining lease. In addition, conditions associated with the Ministerial statements of approval would apply once the Project achieves environmental approval. Therefore, the Proponent recognises that some elements of the framework outlined in this Rehabilitation Plan are likely to change.

The Project Area is located in the Australian semi-arid zone and is classified as having a semi-desert Mediterranean climate (Beard 1976) dominated by a hot, dry summer. The area is known to be windy and field evidence indicates that the re-mobilisation of sands is a natural process (see Appendix C of the PER). Therefore, as Section 3 suggests, the initial issue for rehabilitation is the stabilisation of the reconstructed landform. There will be several stages in this process, including initial stabilisation against wind, the re-establishment of vegetation as the precursor to habitat restoration, and the continuance of species introduction defined by the post mining land use.

Closely linked to landform stability are the constraints associated with the physical and chemical characteristics of the reconstructed profile. The physical and chemical characteristics of the undisturbed soils are known and the characteristics of the reconstructed profile can be derived. When these characteristics are coupled with climatic constraints imposed by the location, achieving successful rehabilitation becomes a function of working within the limiting factors of landform, soils and climate.

Vegetation in the region is traditionally slow growing, so cannot be relied upon for the rapid surface stabilisation that is required. In addition, little research has been conducted on the vegetation in the area to determine which species are most able to rapidly colonise the disturbed soil.

In order to design a comprehensive Rehabilitation Plan, the Proponent commissioned a range of investigations aimed at assessing the issues influencing rehabilitation success. These studies included:

- Site visits to the Namakwa Sands mineral sands project on the arid west coast of South Africa and the North Stradbroke Island mineral sands mine off the north-east coast of Australia. Information on the rehabilitation occurring as part of these projects, which are influenced by similar environmental conditions, are presented as Case Studies in Appendix E of the PER.

- A field evaluation of ten disturbed sites in the Gascoyne region. An investigation into these rehabilitation sites was conducted in January 2005 to determine which local environmental factors could constrain rehabilitation of the proposed Project Area. Information on these sites is presented as Case Studies in Appendix E of the PER.

- A field assessment to investigate the stability of the dunes within the Project Area. These results were then compared with dune stability from within the adjacent SBWHP.

- Monitoring a back-filled test pit. The area of the bulk sample pit in the southern section of the ore body is currently being used as a preliminary trial site to assess the effects of backfilling and replacement of topsoil and surface brush. It is proposed that further regeneration trials and research into profile/materials performance will also be carried out in the early stages of operations. The species selected for rehabilitation trials will be a function of the requirement to develop an initial rapid vegetative cover followed by the introduction of species suitable for the long process of habitat restoration. The flora and vegetation surveys, and the revegetation strategy, provide the appropriate provenance data for species selection.

Additional expertise was provided by external sources to improve the Rehabilitation Plan. This information was in the form of:

- Revegetation strategy. A revegetation plan has been provided by Mattiske Consulting Pty Ltd. This includes advice on issues such as site seed collection, planting schedules and flora species to be used for revegetation. This advice has been incorporated into the Rehabilitation Plan.
- Peer Review. This Rehabilitation Plan has been peer reviewed by Mr Alan Payne of the Department of Agriculture. Mr Payne also took part in the field evaluation of ten disturbed sites within the Gascoyne region. Mr Doug Blandford has also peer reviewed the Rehabilitation Plan.

A range of information valuable to the design of the Rehabilitation Plan was gained from these investigations, including:

- There is no apparent difference between the soil surface stability of the Project Area and the SBWHP.
- Nearly all of the disturbed Gascoyne Case Study sites visited in January 2005 (Appendix E of the PER) had weak soil surface crusts that were able to confer stability to the sites. No accelerated wind erosion was recorded at any of the sites. Soil crusts are likely to begin forming with the addition of water during winter rainstorms. Therefore, wind erosion is unlikely to be a problem on parts of the rehabilitation area that have crusts. However, it is likely to be a problem in areas that are yet to form a crust.
- The surface crust is likely to remain intact and provide continued surface stability to the site provided traffic and grazing animals do not cause significant disturbance. The protection afforded by the soil crust can also be improved by respreading cleared vegetation (Appendix C of the PER) or chemical stabilisers to decrease the effect of the shear velocity.
- The destruction of soil fabric by the mining process has not affected the initial growth of vegetation at the test pit within the proposed mining area, however the extent of soil coherence is unknown. In addition, the soil disturbance due to mining processes at Namakwa Sands and North Stradbroke Island has not affected the re-establishment of vegetation at rehabilitation sites.
- Re-establishment of vegetation is likely to occur with initial colonizing by introduced annual weeds and native species. Trials within the proposed mining area (test pit) showed that wild turnip (*Brassica tournefortii*) is likely to be the dominant colonizing species. This has a benefit of providing wind protection for the soil and other colonizing species, but potential negative attributes in being competitive with native species for water and nutrients.
- Wild turnip was recorded at most Case Study sites, both disturbed and undisturbed, but in very low abundances. Abundance seemed to decrease as time since disturbance increases, suggesting that as sites become more stable, native species dominate and this weed species becomes reduced in abundance.
- Annual and perennial native colonizers were present in recently disturbed sites. Two species in particular, *Acacia ligulata* and *Stylobasium spathulatum*, were found in a number of disturbed areas.

A. ligulata, in particular, was found to dominate some sites that had been disturbed 8-15 years ago. Due to lack of dominance of *A. ligulata* in rehabilitated sites older than 15 years, it is expected that the slower growing climax vegetation will be re-establishing by this time.

- Colonizing by native or exotic species was not observed at all sites. Some rehabilitation sites that had been previously subject to compaction by vehicles showed low vegetation re-colonisation. The comparison of two sites that had been subject to similar conditions and disturbances suggested that ineffective ripping may have been the cause. This lesson is particularly important for the rehabilitation of haul roads within the Project Area, and suggests that comprehensive compaction relief is required.

- The rate of rehabilitation is likely to be decreased if there is significant loss of vegetation biomass through grazing pressure. Some Case Studies showed that sustained high levels of grazing, usually by exotic herbivores, reduce species diversity and vegetation cover in rehabilitation areas. Very few herbivores were recorded during fauna surveys within the Project Area (Appendix K of the PER), thus high levels of grazing are not likely to be an issue. However, the presence of water in process water dams and elsewhere in the Project Area, as well as the growth of young nutrient-rich vegetation, may attract herbivores to the region. If this occurs, exclusion fencing or some form of exotic species population management may need to be implemented.

5.1 Introduction

The rehabilitation process outlined in this section has been designed on the basis of the findings of the investigations described in the previous section. It presents the basic components of the Rehabilitation Plan. Further components of the Plan will also include some of the additional measures outlined in the following section on Research and Development.

The mine will be developed as a series of dry pits (Figure 2). Pit 1 at the south-eastern end of the mine will be developed first. Prior to commencement of mining, all pits will be topographically surveyed to guide landform development in the rehabilitation phase. In addition, access roads and infrastructure (accommodation camp, workshop etc) will be constructed. Vegetation and topsoil (top 10 cm) cleared from these areas will be stockpiled for future use.

When mining first commences there will be a requirement to stockpile all vegetation, topsoil, subsoil (10-100 cm) and overburden removed above the orebody until such time that a sufficiently large pit has been created to enable direct placement of overburden and tailings back into the pit. Once this occurs (anticipated within 6 months of start-up) the mining and rehabilitation will occur progressively as depicted in Figure 3. The pit rehabilitation process will then proceed as follows:

- Overburden will be stripped from above the orebody and placed directly on the mined out pit floor;
- Sand tailings will be deposited on top of the overburden directly,
- Sand tailings will then be contoured to the final landform shape;
- Subsoil stripped from above the orebody will then be placed on top of the tailings.
- Topsoil having been stripped from above the subsoil will be placed directly onto returned subsoil to recreate the original soil profile in the surface 1 m;
- The topsoil will be levelled and seeded with a mixture of native seeds; and,
- Vegetation will then be spread across the surface to assist in soil stabilisation.

All material mined will be returned to the mining excavation, except for the concentrate produced which will be transported to Geraldton.

The primary aim is for rehabilitation to occur progressively so that landform reconstruction and revegetation occur as soon as possible behind the mining operations. The normal mining operation is expected to maintain an open area of some 40 ha. The replacement of subsoil over contoured tailings will be a continuous operational activity, however the clearing of vegetation and the removal and direct replacement of topsoil will occur periodically. The retention of the upper profile (depth <1 m) has been identified as important for the retention of soil micro-organisms and is the main region of plant root penetration (Appendix C).

When the distance between the in-pit screening module and the wet concentrator reaches the limit of the pumping system, the wet concentrator and associated infrastructure will be moved northwards to the next mining block. This is expected to occur approximately every two years.

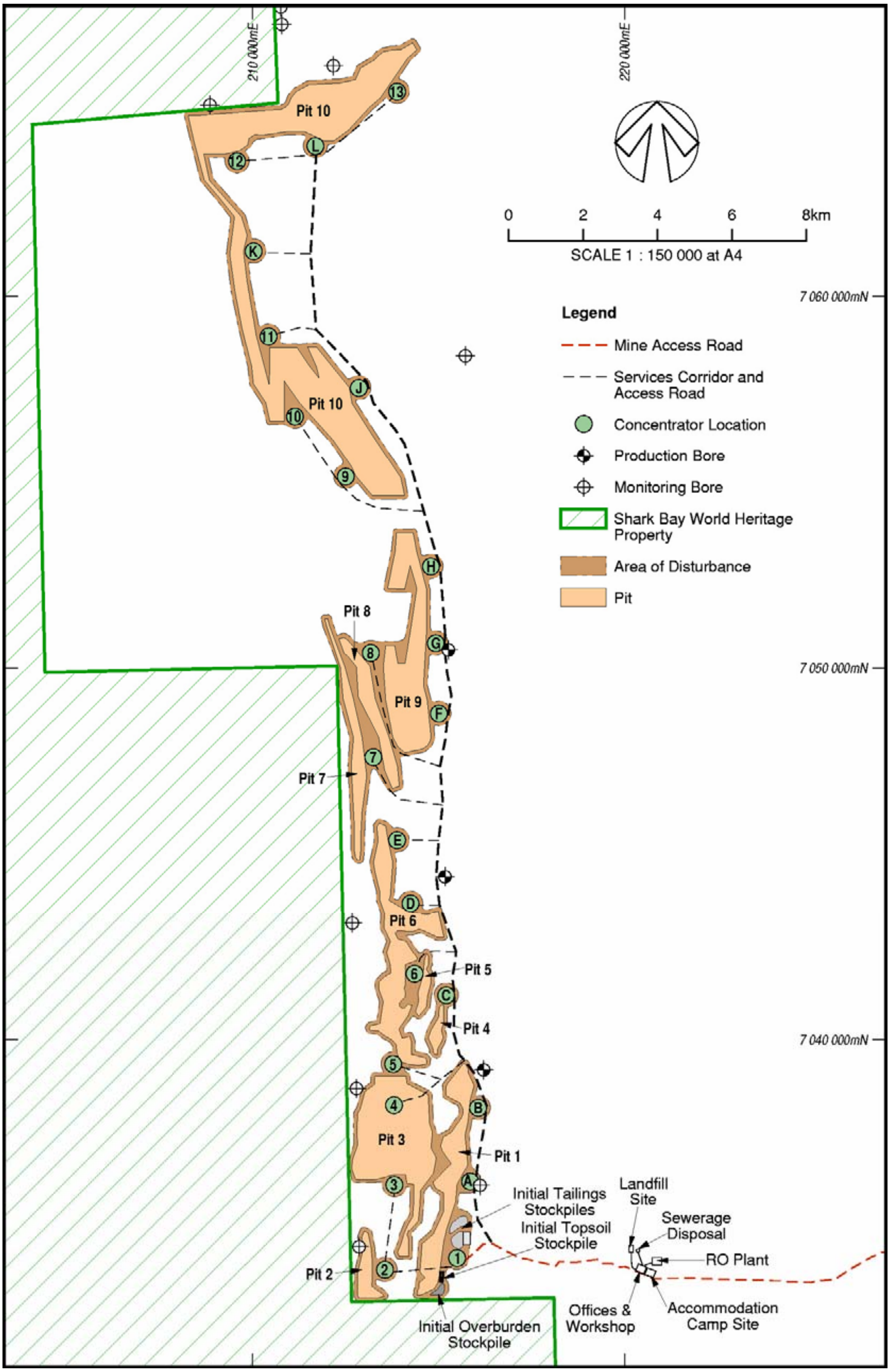

Figure 2 Proposed Layout of Amy Zone Operations

Detail on the proposed rehabilitation tasks is provided in the following sections.

5.2 Details of Rehabilitation Process

5.2.1 Landform Reconstruction

Landform surveying will be conducted prior to clearing. The topography results recorded will guide future landform morphology. Dune intensity currently increases to the south and south-east of the Project Area (van De Graaf et al. 1983). The land surface elevation varies from approximately 20 m AHD in the north of the Project Area to approximately 100 m AHD in the south. Once the soil profile has been reconstructed, the final landform will result in a flatter landscape, compared to that of pre-disturbance, particularly in the southern parts of the Project Area. However, the final landform will retain visual congruency with the original landform.

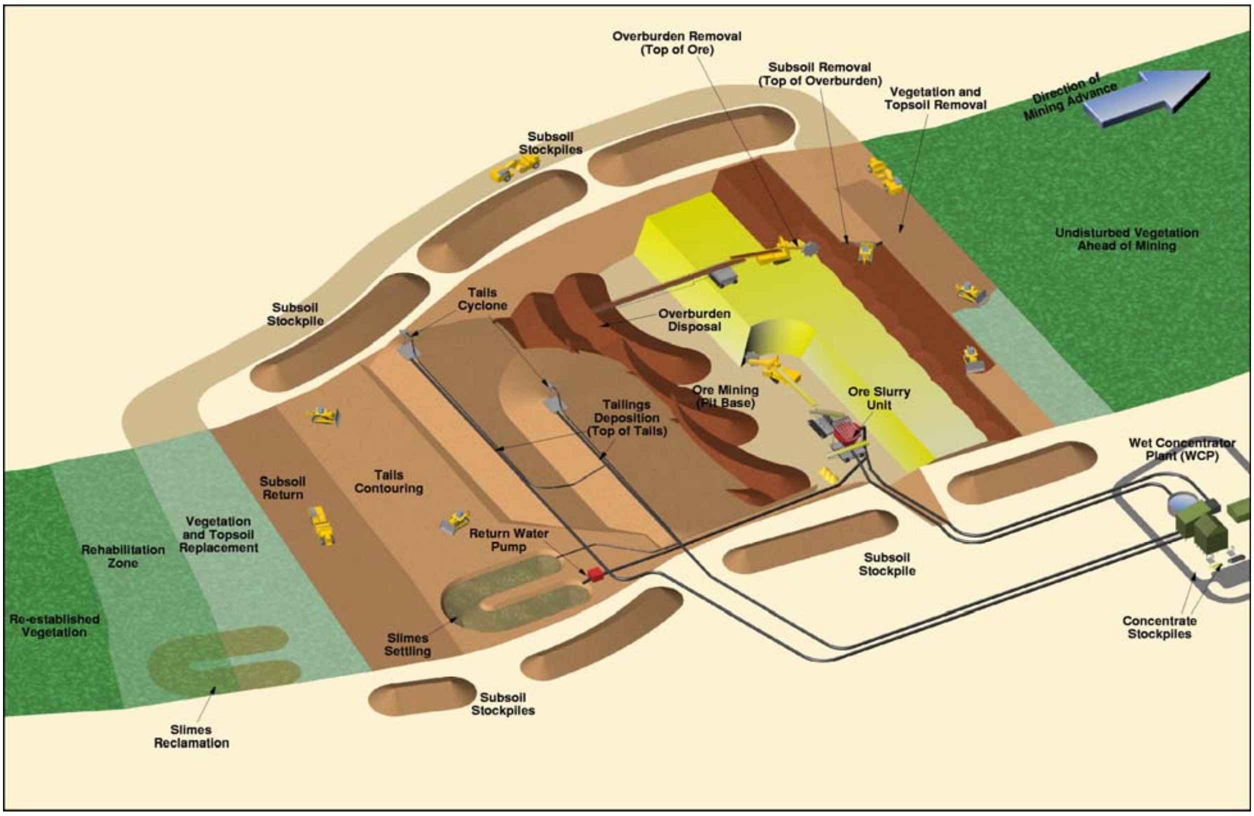

Figure 3 Conceptual Pit Layout

5.2.2 Vegetation and Topsoil Removal and Replacement

Vegetation will be cleared and topsoil stripped on a periodic basis immediately ahead of the mine face and placed immediately behind the mine operations onto areas previously prepared for rehabilitation.

Direct return of topsoil will increase the potential success of the revegetation programme as it will prevent or reduce the amount of biological deterioration in the soil. The topsoil (top 10 cm) will contain the majority of the viable seed store, and also a large amount of vegetation. Scrapers will generally be used to clear and return vegetation and topsoil.

Direct return of vegetation from cleared areas to the rehabilitation sites behind the mine will decrease the drag force exerted by the flow of air over the ground (see Appendix C of the PER), which will decrease the potential for wind erosion. In addition, the direct return of vegetation will augment natural topsoil seed stores, and provide protection and nutrients to seedlings and fauna.

Direct placement of vegetation and topsoil within the rehabilitation area will occur periodically during the year. Emphasis is expected to occur in the months of April/May, when wind speeds are decreased, and prior to the onset of the rain season. Results from the Rehabilitation Benchmarking Study (see Appendix E of the PER) indicate that rain has the ability to compact the soil surface. This compaction was generally in the form of a thin surface crust that would assist in the reduction of wind erosion. Rainfall will also result in seed germination and growth of early colonisers that will further stabilise the soil surface.

In other areas to be cleared of vegetation and topsoil but not mined, the vegetation and topsoil will be pushed into separate stockpiles and the topsoil will be seeded to allow it to retain a seedbank and micro-organisms, and decrease wind erosion potential. This vegetation and topsoil will be returned to the sites from where it was removed once use of that area has finished.

5.2.3 Subsoil Removal, Stockpiling and Disposal

Up to 150 m ahead of the mine face, the subsoil (to a depth of 90 cm from below the topsoil) will be removed and stockpiled on either side of the mining area, where it will be stored for periods of up to nine months. Once the mine face has passed the stockpiles, the subsoil will be returned to the area from which it was removed to cover the sand tailings.

Neither topsoil nor subsoil will be stripped when wet, as this will lead to increased compaction and loss of structure.

Bulldozers will remove the majority of the subsoil. In cases where the width of the mine path exceeds the economic pushing distance, scrapers will be used to clear the central area. Stockpiles will be placed in areas where they will not be disturbed by future mining. In addition, all stockpile locations will be signposted “SUBSOIL STOCKPILE”, No: XXXX.

The subsoil stockpiles will vary in width between 30 m and 70 m depending on the width of the pit and the volume of material to be stockpiled. For the initial pit width of 700 m the stockpile width will be approximately 70 m. As the pit reduces to 200 m wide, the stockpile will reduce to 30 m. The stockpiling areas will be cleared of vegetation but not stripped of topsoil. The subsoil stockpiles will be <2m high and covered with an emulsion or cover crop to help stabilise the soil and to combat wind erosion.

The stockpiled subsoil will be spread on top of the sand tailings by bulldozer. The subsoil will form 90 cm layer above the brackish tailings. Where required, the replaced subsoil area will be sprayed with a stabiliser to minimise wind erosion and dust formation prior to the replacement of topsoil and cleared vegetation.

5.2.4 Overburden Removal and Disposal

Sand containing uneconomic mineral values (overburden) which lies above the ore zone will be removed once the subsoil layer has been stockpiled. The overburden will be placed directly into the bottom of the mined-out area(s) as the mining operation moves forward, thus decreasing the need for stockpiling.

The average depth of overburden replaced into the bottom of the pit is likely to vary from zero to 15 metres.

5.2.5 Tailings Production and Disposal

Ore will be mined and pumped in a slurry to a Wet Concentrator where the heavy minerals will be extracted. Tailings from the concentrator will be returned to the mined excavation. Approximately 1% of the ore will be recovered as heavy mineral concentrate.

Approximately 3% of the original ore will be returned as clay fines or “slimes”. The fines will be deposited in a trench adjacent to the eastern pit wall (refer to Fig. 3). It is anticipated that the fines will take time to dry sufficiently before tailings, subsoil and topsoil can be placed on them. For this reason, some stockpiles of subsoil and topsoil will need to be retained on the outside edge of the slimes trench, for use in progressive rehabilitation as the slimes dry. By placing the soil required for rehabilitation on the outside of the slimes pits, no vehicles will need to disturb the rehabilitation areas when the soils are placed over the slimes.

Due to the length of time the soils to be used to rehabilitate the slimes trench will be stored, revegetation will occur on these stockpiles to combat erosion and maintain active populations of beneficial soil microbes.

The remaining 96% of the ore mass will be returned as clean sand tailings with a salinity of approximately 10 ppt. Sand tails will be dewatered using cyclones and deposited on top of the overburden for a depth of approximately 16 metres. Bulldozers will then be used to contour the tailings into the required landforms.

Given the conservative assumptions of returned water salinity of 10 ppt and a soil moisture of 8%, the predicted salt content of the returned sand tailings (21.6 mS/m) is expected to be less than the maximum value obtained for the Amy Zone pre-disturbance (25 mS/m), and still within the range that has minimal effect on plant growth (<50 mS/m, Moore G. 1998). This salinity is expected to further decrease in the years after rehabilitation due to leaching. Therefore, due to minimal change in the salt concentration of the soil, the salinity of the rehabilitated soil profile is not expected to affect revegetation.

The undisturbed soil profile can contain up to 40% fine grained particles (< 0.212mm) which contribute to the retention of soil moisture within the profile (Appendix C). The rainfall received from high intensity, short duration storms is unlikely to penetrate deeper than 1 m into the soil profile (D. Blandford, pers comm.). It is only the rainfall from lower intensity and longer duration events that is capable of penetrating to depths of two metres or greater. This is likely to explain the high percentage of vegetation roots located in the top metre of the soil profile (Appendix C). The direct return of the top 1 m allows this trend to continue in the reconstructed profile.

It is anticipated that up to two-thirds of the fine grained particles will be removed from the sand tails and will eventually report to the slimes trench. The loss of these fines from the lower soil profile (> 1m below surface) is unlikely to greatly impact on the success or otherwise of the rehabilitation effort. It is expected that the sand tailings will retain enough fines to hold water for use by vegetation with root depth > 1 m. However, the success of the rehabilitation effort is also affected by the ultimate moisture content of the reconstructed upper soil profile, which is very much dependant on the nature and characteristics of individual rainfall events (D Blandford, pers comm.).

5.3 Revegetation of Stabilised Soil

Although a seed bank is present in the topsoil, further seeding will improve the success and rate of revegetation. Seeding may be done by hand after all earthworks are complete, or with a commercially available seeder attached to a multi-tyned bulldozer.

Seed will be collected from species in the areas to be disturbed prior to mining and infrastructure development. An outline of the flowering periods of the vascular plants found within the Project Area has been provided by Mattiske Consulting Pty Ltd (Appendix J of the PER). As mining operations are likely to result in the removal of plants listed as Priority Species, particular attention will be paid to seed collection from these individuals in order to retain their populations within the local area.

Seeding programmes within the rehabilitation area will occur seasonally. The majority of the seeding will occur in May, just prior to the expected rain season. Rehabilitation areas will initially be seeded with species known to be successful colonisers. Seeds of species that prefer more established ecosystems (late successional species) will be introduced into the rehabilitation areas once an initial vegetation cover has been established.

Seeds will be returned into areas where the particular species are known to survive. For example, *Eucalyptus* seeds will not be sown in areas that were previously dominated by *Acacia* species, and species that are currently exclusive to dune swales will only be returned to rehabilitated dune swales.

In the selection of species for possible use in revegetation (see Attachment A), Mattiske Consulting Pty Ltd suggest three main considerations:

1. All species should be native to the area. To help maintain the local character of rehabilitated areas only species found in previous local flora surveys should be included.

2. The species mix should include as many annual species as possible, as these will usually germinate within the first winter and quickly provide protection from wind erosion. With this in mind all native annual plants recorded in the Mattiske Consulting Pty Ltd 2004 survey were included in Attachment A.

3. Plants should be adapted to the new habitat that is likely to prevail over the long term. Therefore, in addition to native annuals, local species known to be tolerant of salinity, or known to naturally grow in sand dunes were included in Attachment A.

Seed collection will occur in early to mid summer before the seeds have fallen from the parent plant. Seed will be collected from as wide a range of species as possible, based on the list provided in Attachment A. This will improve the chances of at least some species thriving, while optimising the diversity of the resulting vegetation.

The seed mix will contain a substantial portion of annual or perennial herbs and grasses to quickly stabilise the soil surface. Seed mixes will include some *Acacia* spp. as these are able to grow quickly and fix nitrogen in poor soils, facilitating the later establishment of non-leguminous species. The Rehabilitation Benchmarking Study identified two species of native shrubs (*Acacia ligulata* and *Stylobasium spathulatum*) as successful colonisers of disturbed areas.

Seeds of recalcitrant species (species with high levels of seed dormancy or specific germination requirements) will be treated to increase germination potential. Those seeds of late successional species will be treated to prevent insect and fungal attack before being placed in suitable dry storage areas, protected from vermin and insect predation. These seeds will then be spread once an initial colonising community has established.

5.4 Further Measures

Further procedures that will be implemented to improve rehabilitation include:

- All water points generated through the construction of the mine or the mining process will be fenced in order to deny access to mammalian fauna. Minimal fauna populations currently exist within the Project Area, however the addition of water to the site may attract many species. This increase in population may affect the rehabilitation process through increased grazing pressure, and also act as a prey trap, as the increase in species populations may indirectly increase populations of introduced predators. Therefore, it is in the Proponent's best interest to deter all animals from any water points created. Matting will be placed on the edges of the water points in order to allow exit points for small mammals and reptiles that may have gained entry through the fencing, as well as exit points for birds.

- To prevent damage to soil surface crusts that provide protection from wind erosion, vehicle access to all recently rehabilitated areas will be banned unless absolutely essential.

Research and field studies conducted to date (refer to Section 4) suggest that the methods outlined previously will be sufficient to provide an effective and successful rehabilitation programme. However, in an effort to make the rehabilitation process more efficient, several methods will be trialled during the early years of the mining and the Rehabilitation Plan modified accordingly.

Alternatively, corrective measures will be considered should rehabilitation performance not achieve nominated completion criteria, or be trending away from the nominated criteria. The requirement for any of these measures to be implemented as part of a corrective process will be identified by the monitoring and reporting programme.

Some of these alternatives will be trialled during the initial stages of rehabilitation in order to determine their effectiveness. These options include:

- An emulsion may be used to seal the soil surface to help protect against erosion. For example, the North Stradbroke Island Mineral Sands mine successfully use a dilute bituminous substance (Terolas) to initially stabilise the soil (see Appendix E of the PER) prior to the vegetation being re-established. Vegetation can grow through the soil stabiliser prior to it weathering to produce an inert crust. Groundwater monitoring in rehabilitated areas at North Stradbroke Island has not detected any hydrocarbon contamination.

- A seed mix for a cover crop. If local species cannot provide adequate cover it may be necessary to sow a cover crop to protect the soil. The crop will be an infertile annual species that will die off after a one-year period and not reproduce, therefore incapable of spreading into areas where it is not required. The cover crop will provide initial assistance for the indigenous species by increasing protection against wind and soil erosion. This was another procedure that is believed to benefit rehabilitation at the North Stradbroke Island Mineral Sands mine.

- Seed treatment. Some seed germination rates are dramatically improved if the seeds are treated prior to planting. A range of treatments are available and will need to be investigated to maximise revegetation success and cost effectiveness.

- Refine seeding mixture. It will be possible to refine seeding prescriptions by comparing the rehabilitation flora with the flora from topsoil/vegetation donor sites. Species that regenerate well from re-spread topsoil and vegetation material can be dropped from the list, and efforts can be directed at re-establishing ‘recalcitrant’ species.

- Fertiliser. The use of a fertiliser will increase soil nutrients, and thus may increase the germination and growth rates of vegetation during early years of revegetation.

- Cleared vegetation. Current research suggests that the respreading of cleared vegetation with topsoil will decrease wind speed, provide seed and seedling protection, and provide habitat for fauna. However, site trials may determine that rehabilitation will be improved if the vegetation is treated differently. Examples used in other rehabilitation sites include removing and replacing cleared vegetation separately to topsoil, mulching vegetation prior to respreading, placing vegetation in windrows or considering alternative spreading methods.

- Windbreaks. This is a technique that has been successfully used at the Namakwa Sands mine. Their results suggest that windbreaks provided wind protection to seedlings as well as catching dew and providing the seedlings with an additional source of moisture.

- Biodegradable matting. This is another option available to stabilise soils. This method may be particularly successful in areas of high wind speeds, such as dune crests. Generally woven from a coconut based fibre, the matting stabilises soil, allows seedlings penetration and breaks down over a period of 2-5 years to provide nutrients to the vegetation.

- Soil moisture testing. Given the initial positive growth of vegetation at the test pit site (Appendix E of the PER), the reconstructed profile appears able to retain the soil moisture required for seed germination and seedling survival. However, soil moisture retention at a lower level is unknown, as is the ability of the reconstructed profile to support the mature vegetation communities that survived prior to disturbance. Research and development projects will target these issues by comparing soil moisture retention abilities of rehabilitated areas with adjacent undisturbed areas. Any significant loss of soil moisture will lead to the implementation of alternative soil reconstruction methods.

- Herbivore proof fencing. Herbivore populations in the Project Area are currently low, however the growth of young, nutrient rich vegetation may entice herbivores into the rehabilitation areas. The increase in grazing pressure may decrease the rate of rehabilitation. Therefore, herbivore proof fencing may be required around rehabilitation zones to protect seedlings from grazers if grazing pressure is found to significantly affect regrowth.

- Weed control. Weeds were found to be a primary coloniser at the Coburn test pit (Appendix E of the PER) so they are likely to colonise future rehabilitation sites. Weed control may be required if these weed species are found to negatively affect the growth of native species on disturbed sites, or found to colonise undisturbed areas where they were not previously located. A range of herbicides are available and will be assessed during the research and development programme. For example, the Rehabilitation Benchmarking Study recorded that a disturbed area on Eurardy Station was sprayed with the herbicide Simazine. This product is designed to prevent growth of shallow rooted vegetation, which is the case with the many introduced weed species. Rehabilitation after a seven-year period found significant native vegetation regrowth and little evidence of introduced weed species.

- Dominant species control. Remedial works may also include management of over representation of particular native species. The minimum area to be considered for the application of supplementary seeding, planting or removal contingency measures is 0.5 ha. In each case the benefits of remedial actions need to be evaluated against the impact of any intrusive remedial work.

- Additional seeding or planting of seedlings. These may be required during the rehabilitation process to increase site density and floristics.

A key criterion for determining the need and scale of remedial actions will be the trend in rehabilitation performance. If the monitoring programme indicates landscape dysfunction or loss of health over time, direct intervention may be required. Where performance criteria are not achieved but the underlying trend is positive, it is possible that the rehabilitated landscape simply requires more time. For example, the Rehabilitation Benchmarking Study has shown that some disturbed ecosystems in close proximity to the Project Area are likely to take a significant period of time to reach climax vegetation. In these instances, intrusive remedial action may be inappropriate, with the rehabilitation only requiring further intensive monitoring.

Completion Criteria

The Rehabilitation Benchmarking Study found that disturbed areas in the region take many years to recover to levels comparable to analogue sites. Therefore, the completion criteria in this Rehabilitation Plan reflect existing knowledge of the local environment and its ability to recover from disturbance, and also reflect the technology currently available to achieve these goals. However, given that there is a lack of knowledge on rehabilitation in the region given similar disturbances, the criteria will be regularly reviewed over the course of the mine life. Research and development programmes implemented by Gunson will advance techniques that should facilitate an improvement in the rehabilitation rate and outcome. This indicates that completion criteria will be reviewed as the knowledge base improves, with these amendments made to the satisfaction of the relevant stakeholders.

The following completion criteria are designed to set well defined and achievable targets for the return of the disturbed areas to their prior landuse. Criteria have been established for years 0, 1, 2, 5, 15 and 30.

ELEMENT	STANDARD NUMBER	CRITERIA
Year 0		
Landform	0-A	The landform will have been reconstructed to a form that visually merges with the surrounding land contours.
Soils	0-B	The reconstructed soil profile contains two major elements: upper 10cm of topsoil and 90 cm subsoil, within a small margin.
Vegetation	0-C	Brush has been spread over rehabilitation area.
	0-D	Seeding of early colonising native species in rehabilitation areas has been conducted prior to rain season.
Access	0-E	Access roads have been retained around the rehabilitation area, as required for ongoing fire and weed management, and landscape monitoring.
Safety	0-F	No hazards remain from the mining process that may jeopardise health and safety, or negatively affect the rehabilitation process.

ELEMENT	STANDARD NUMBER	CRITERIA
Year 1		
Soils	1-A	The rehabilitation area shows no signs of major surface instability, with some sections developing a surface crust.
	1-B	Infiltration rates comparable to those found in analogue sites.
Vegetation	1-C	Native seedlings present and providing >1% of projected foliage cover.
Access	1-D	Access roads have been retained around the rehabilitation area, as required for ongoing fire and weed management, and landscape monitoring.

ELEMENT	STANDARD NUMBER	CRITERIA
		Year 5
Soils	5-A	The rehabilitation area shows no signs of major surface instability, with >60% of the surface soil having developed a crust.
	5-B	Zone Infiltration, Zone Stability and Zone Nutrients indexes rates comparable to those found in analogue sites.
Vegetation	5-C	Projected foliage cover values >20% of analogue sites.
	5-D	Average species diversity >20% of analogue sites.
	5-E	Native seedlings present and providing >10% of projected foliage cover.
	5-F	Projected foliage cover of weed species in analogue sites has not significantly increased
Access	5-G	Access roads have been retained around the rehabilitation area, as required for ongoing fire and weed management, and landscape monitoring.

ELEMENT	STANDARD NUMBER	CRITERIA
		Year 15
Soils	15-A	The rehabilitation area shows no signs of major surface instability, with surface soil characteristics comparable to those of analogue sites.
Vegetation	15-B	Projected foliage cover values >50% of analogue sites.
	15-C	Average species diversity >50% of analogue sites.
	15-D	Native vegetation providing >50% of projected foliage cover.
	15-E	Decrease in projected foliage cover of weed species.
	15-F	Projected foliage cover of weed species in analogue sites has not significantly increased
Access	15-G	Access roads have been retained around the rehabilitation area, as required for ongoing fire and weed management, and landscape monitoring.

ELEMENT	STANDARD NUMBER	CRITERIA
Year 30		
Vegetation	30-A	Projected foliage cover values comparable to those of analogue sites.
	30-B	Average species diversity >80% of analogue sites.
	30-C	Native vegetation providing >80% of projected foliage cover.
	30-D	Projected foliage cover of weed species is comparable to analogue sites.
	30-E	Projected foliage cover of weed species in analogue sites has not significantly increased.
Access	30-F	Access roads have been retained around the rehabilitation area, as required for ongoing fire and weed management, and landscape monitoring.
Infrastructure	30-G	All infrastructure associated with the Coburn Mineral Sand Project has been removed and all areas, apart from access roads required for fire control and monitoring programmes, are undergoing rehabilitation.
Final Land Use	30-H	Rehabilitation is progressing towards characteristics of analogue sites.
	30-I	Vegetation is capable of sustaining grazing.
	30-J	The site meets the agreed end land use/s.

8.1 Monitoring Programme

Performance indicators will be established from data collected at both rehabilitation and analogue sites using the following methods:

- Quarterly monitoring in order to determine landform and surface stability. Landscape function analysis (Tongway and Hindley, 2004) is a monitoring programme used for minesite rehabilitation. This approach may be used as it monitors the health and functionality of soils and vegetation at the landscape scale.
- A soils characterisation program will be implemented that will identify potentially dispersive soils prior to mining. If dispersive soils are located, they will be placed at depth in the rehabilitated profile. This will ensure dispersive soils do not negatively affect the rehabilitated soil profile.
- A soil monitoring programme will be implemented. The loss of some fine materials during the mining process is expected to decrease the moisture holding ability of the sand tailings. However, the undisturbed profile contains up to 40% of fine grained sand (<0.212 mm) and the loss of some of this material and the soil fabric is not expected to significantly impact on the moisture retention ability of the soil profile. The monitoring plan will compare the particle size distribution, density, and soil moisture in undisturbed analogue sites and the reconstructed profile.
- Annual site assessments (including regular photographic records) will be conducted to ascertain the survival and growth of the rehabilitated vegetation. The data collected will be analysed to provide possible recommendations for improved rehabilitation techniques. The establishment of permanent vegetation monitoring plots will assist in determining the success of the rehabilitation.
- Further permanent vegetation plots will be established in undisturbed areas in order to monitor any changes brought about by mining in the vicinity (ie. increased weed presence) and provide a comparison to rehabilitated areas.
- Further permanent fauna monitoring plots will be established in undisturbed areas in order to monitor any changes brought about by mining in the vicinity and provide a comparison to rehabilitated areas. This will also help monitor any increases in exotic herbivore populations that may have negative implications for the rehabilitating vegetation.
- Audit results against completion criteria and determine if intervention is required.
- These results will be reported to CALM, DOIR and DoE in the Annual Environmental Report.

The frequency at which different environmental factors will be monitored in the rehabilitation areas and the surrounding permanent plots is provided in the Performance Indicators Table (Table 1). This table has been developed to fulfil two purposes:

1. to provide a checklist for implementation by mining and rehabilitation staff; and
2. to provide a checklist for auditing of rehabilitation performance by regulators.

Further information will be required for completion of the table. The additional fields include aspects such as:

- Responsibility - who was responsible for completing the criteria;
- Status – e.g. ‘not yet applicable’, ‘complete’, in progress’, ‘non-compliant’.
- Timing – start and finish dates for tasks.
- Corrective actions – details of any management required to address non-compliance.

Table 1
Performance Indicators

Task	Frequency	Timing
Rehabilitation grazing survey	Quarterly	All seasons
Erosion	Quarterly	All seasons
Groundwater	Quarterly	All seasons
Seeding	Annually	Late summer
Seed development	Annually	Spring
Natural recruitment	Annually	Spring
Weed establishment	Annually	Spring
Plant species richness, and % foliage cover	Annually	Spring
Fire control	Annually	Late Spring
Soil studies: litter depth, soil nutrients, organic matter accumulation, water infiltration, compaction	3 yearly	Autumn/spring
Fauna survey	3 yearly	Spring

8.2 Reporting

A comprehensive annual review will be undertaken to determine the success of the rehabilitation performance in meeting the completion criteria. The findings of the review will be included in the Annual Environmental Report. This report will also include results from the rehabilitation research and development programme and opportunities for improvement for consideration in future rehabilitation programmes.

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Summary Of Local Plant Species To Be Considered For Use In Revegetation Works

Trees and large shrubs (>3m)

Acacia chartacea
Acacia cochlearis
Acacia ligulata
Acacia rostellifera
Acacia sclerosperma subsp. *sclerosperma*
Alectryon oleifolius subsp. *oleifolius*
Banksia ashbyi
Brachychiton gregorii
Codonocarpus cotinifolius
Duboisia hopwoodii
Eucalyptus fruticosa
Eucalyptus mannensis subsp. *vespertina*
Eucalyptus obtusiflora subsp. *obtusiflora*
Exocarpos sparteus
Grevillea eriostachya
Grevillea gordoniana
Grevillea stenobotrya
Gyrostemon ramulosus
Hakea stenophylla subsp. *notialis*
Pittosporum phylliraeoides
Santalum acuminatum

Medium and small shrubs (<3m)

Acanthocarpus preissii
Alyogyne pinoniana var. *pinoniana*
Anthobolus foveolatus
Anthocercis littorea
Atriplex paludosa subsp. *moquiniana*
Atriplex vesicaria subsp. *variabilis*
Beaufortia sprengelioides
Calothamnus blepharospermus
Chenopodium gaudichaudianum
Enchylaena tomentosa var. tomentosa
Eremophila occidens (ms) (P2)
Hannafordia quadrivalvis subsp. *quadrivalvis*
Melaleuca leiopyxis
Mirbelia ramulosa
Pembertonia latisquamea

Pileanthus vernicosus
Rhagodia latifolia subsp. *latifolia*
Rhagodia preissii subsp. *obovata*
Scaevola sericophylla
Scaevola tomentosa
Scholtzia sp. Folly Hill (P2)
Senna glutinosa subsp. *chatelainiana*
Solanum hesperium
Solanum orbiculatum subsp. *orbiculatum*
Stylobasium spathulatum
Thryptomene strongylophylla

Perennial herbs and grasses

Austrostipa elegantissima
Austrostipa nitida
Brachyscome ciliaris
Conostylis candicans subsp. *flavifolia*
Dampiera incana var. *fuscescens*
Dianella revoluta var. *divaricata*
Eragrostis eriopoda
Erodium cygnorum
Euphorbia drummondii subsp. *drummondii*
Maireana carnosa
Maireana trichoptera
Monachather paradoxus
Sclerolaena fusiformis
Solanum esuriale
Threlkeldia diffusa
Triodia danthonioides
Triodia plurinervata
Triodia pungens
Wurmbea inframediana

Annual herbs and grasses

Actinobole condensatum
Aristida contorta
Austrostipa macalpinei
Bulbine semibarbata
Calandrinia liniflora
Calandrinia polyandra

Calandrinia remota
Calocephalus francisii
Calocephalus multiflorus
Calotis multicaulis
Cephalipterum drummondii
Chenopodium melanocarpum forma *leucocarpum*
Crassula colorata var. *acuminata*
Cynoglossum australe
Euphorbia boophthona
Euphorbia tannensis subsp. *eremophila*
Gnephosis sp. Pt. Quobba
Gnephosis tenuissima
Goodenia berardiana
Haloragis gossei
Lawrencella davenportii
Lobelia heterophylla
Nicotiana occidentalis subsp. *hesperis*
Paractaenum novae-hollandiae subsp. *novae-hollandiae*
Parietaria cardiostegia
Podolepis canescens
Podotheca gnaphalioides
Poranthera drummondii
Ptilotus exaltatus var. *exaltatus*
Ptilotus gaudichaudii var. *parviflorus*
Ptilotus grandiflorus var. *grandiflorus*
Ptilotus polystachyus var. *polystachyus*
Rhodanthe citrina
Rhodanthe humboldtiana
Rhodanthe maryonii
Salsola tragus subsp. *tragus*
Schoenia ayersii
Schoenia cassiniana
Stackhousia muricata
Stenopetalum pedicellare
Swainsona cornuta
Tetragonia cristata
Tetragonia diptera
Trachymene coerulea subsp. *leucopetala*
Waitzia corymbosa
Zygophyllum iodocarpum