APPENDIX H

GUIDELINE FOR REHABILITATION

There is a high predictability that the top 5 - 10 cm of soil will contain the majority of the seedbank, but simply applying this topsoil to a well prepared rehabilitation site does not result in the same species richness and diversity as the surrounding areas. A primary reason for this is that not all plants produce dormant (i.e. soil stored) seeds. A study in coastal Namaqualand indicated that the seedbank represents only about 50% (108 out of 230) of the species in standing vegetation. The most abundant species in the seedbank were shown to be short-lived species, while the standing vegetation mostly consists of perennial species. Recruitment from the seedbank would therefore be biased in favour of short-lived species, which does not necessarily facilitate long-term vegetation recovery.

Restoration ecologists in Namaqualand cannot rely solely on the seedbank and seed dispersal. In order for rehabilitated areas to achieve similar species richness, composition, vegetation structure and ecosystem functioning as undisturbed areas, many perennial species need to be introduced with appropriate natural vegetation rescued from disturbed areas before construction activities begin and/or through the use of a local seed mix.

1. Plant groups

Plant species can be grouped according to their morphological form, their relationship with other plants and the function which they fulfil in the ecosystem. Plant species which belong to the same group looks similar and share certain characteristics.

Within natural, mature plant communities, there are generally a variety of plant species which fulfil different functions within the ecosystem. Dividing plant species into recognisable groups can assist in determining whether a rehabilitated area has a community of plant species with various forms and functions. The variety of plant groups which have established can be a good indication of successful rehabilitation in an area. The absence of one plant group can be an indication that an area has not successfully rehabilitated. In areas which have been recently rehabilitated, additional time may be required for the natural establishment of more diverse plant groups. In older rehabilitated areas where mature plant establishment is scarce and consists of only a few plant groups, it may be necessary to physically introduce certain plant groups through, for example, sowing of seeds or planting of certain plant species in order to improve the state of the rehabilitation in that particular area.

2. Plant groups present on the Wind Energy Facility development site

Namaqualand Strandveld:

Typical features of true Namaqualand Strandveld include a high percentage of succulents and leaf deciduous shrubs, moderate bulb diversity, and no Fynbos elements such as Ericaceae (heaths) and Proteaceae (proteas), with few Restionaceae (Cape reeds) (refer to Photograph 1).

Photograph 1: View of typical tall Namaqualand Strandveld on the development site, showing dominant succulent perennials

Typical indigenous species found in the Namaqualand Strandveld are listed Table 1.

Table 1: Typical indigenous species found in the Namaqualand Strandveld

Species name	Common name
Shrubs	
Zygophyllum morgsana	Skilpadbos; slaaibos
Othonna cylindrica	Ossierapuisbos
Tetragonia fruticosa	Klimopkinkelbossie
Othonna coronopifolia	
Tripteris oppositifolia	
Lycium cinereum	Muisbos
Salvia africana-lutea	Bruinstrandsalie
Berkheya fruticosa	
Lebeckia sericea	Fluitjiesbos

Species name	Common name
Ruschia floribunda	
Lampranthus watermeyeri	
Euphorbia caputmedusae	Volstruisnek
Euphorbia rhombophyllum	
Euphorbia burmannii	Steenbokmelkbos
Chrysanthemoides incana	Grysbietou
Mesembryanthemum crystallinum	Soutslaai
Hermannia scordifolia	
Hermannia trifurca	Poprosie
Hermannia sp. nov	
Thesidium spinosum	
Nenax arenicola	
Exomis microphylla	
Willdenowia incurvata	Sonkwasriet
Senecio bulbinifolius	
Vanzijlia annulata	
Cephalophyllum sp	
Microloma sagittatum	
Pteronia divaricata	
Pteronia ovalifolia	
Euryops multifidus	Gombos
Manulea cinerea	
Tylecodon wallichii	Krimpsiektebos
Stoeberia utilis	Asbos
Manochlamys albicans	Spanspekbos; seepbos; soutbos
Cissampelos capensis	
Conicosia elongata	Vetkousie
Arctotis canaliculata	
Eriocephalus racemosa	Kapokbossie; wilderoosmaryn
Asparagus africana	
Helichrysum tricostatum	
Woody shrubs[1]	
Rhus glauca	Blue kuni bush
Gymnosporia buxifolia	Pendoring
Diospyros austro-africana	
Euclea racemosa	Sea guarrie
Grasses[2]	
Ehrharta calycina	Rooisaadgras
Stipagrostis zeyheri	

[1] Scattered larger woody shrubs are a feature in some areas, especially in transitions to Sand Fynbos.

[2] Grasses may be prominent after rains.

Species name	Common name
Bulbs	
Babiana brachystachys	
Babiana grandiflora	
Lachenalia unifolia	
Oxalis flava	
Oxalis luteola	
Trachyandra divaricata	duinekool
Trachyandra falcata	veldkool
Drimia sp.	
Boophone haemanthoides	gifbol
Annuals	
Helichrysum moeserianum	
Oncosiphon spp	
Dischisma spp	
Polycarena spp	
Manulea spp	
Zalusianskya pusilla	
Dorotheanthus bellidiformis	bokbaaivygie
Ursinia spp.	

Photograph 2: *Babania* sp.

Photograph 3: *Lachenalia* sp.

Photograph 4: *Lachenalia rubida*

Photograph 5: *Boophone haemanthoides*

Namaqualand Sand Fynbos:

This vegetation type is typically found on paler, neutral to acid sands which are present in the lower lying areas and on the old dunes in the north of the Wind Energy Facility development site. A number of subtypes (communities) can be recognised, many of which are ecotonal (transitional) with the Strandveld.

True Namaqualand Sand Fynbos is characterised by the presence of the species listed in Table 2, although not all of these are necessarily present in any one area:

Table 2: Plant species characteristic of the Namaqualand Sand Fynbos

Species name	Common name
Macrostylis decipiens	fynblaar buchu
Macrostylis crassifolia	buchu
Wiborgia obcordata	
Thesium strictum	
Lachnospermum fasciculatum	
Trichogyne repens	
Leucospermum rodolentum	Sandveld speeldekussing
Calopsis marlothii	
Ischyrolepis macer	
Psammotropha quadrangularis	
Muraltia namaquensis	
Aspalathus spinescens ssp. *lepida*	

The species listed in Table 3 are common in this vegetation type, and are restricted to Fynbos habitats, but in themselves are not diagnostic of pure Sand Fynbos (i.e. they also occur in Strandveld ecotones). However, where they are dominant this can be considered to be Sand Fynbos.

Table 3: Plant species common in the Namaqualand Sand Fynbos, but which are in themselves not diagnostic of pure Sand Fynbos

Species name	Common name
Willdenowia incurvata[3]	
Thamnochortus bachmanii[4]	
Stoebe nervigera	
Kedrostis psammophila	
Trichogyne ambigua	
Elytropappus rhinocerotis	renosterbos[5]

[3] Often dominant on dune ridges.

[4] Dominant on the flats between dune ridges.

[5] Renosterbos occurs only where soils are thin, especially in shallow sands over ferricrete hardpans, and is never as dominant as it is in Renosterveld.

In true Fynbos areas succulents are rare, and the only prominent species are *Lampranthus montaguensis* and *Ruschia subpaniculata*. The Namaqualand Sand Fynbos endemic shrub *Nenax arenicola* is often common.

Photograph 6: Sand Fynbos in the foreground on a dune ridge (note paler sands), with yellow flowered Strandveld elements (*Othonna cylindrica*). Taken from the north of the Wind Energy Facility development site looking south.

Small patches of taller woody shrubs (small trees) may occur, usually comprising *Euclea racemosa* (sea guarrie), *Rhus laevigata* (dune taaibos), *Diospyros lycioides* and *Gymnosporia buxifolia* (pendoring). Other shrubs found in the Fynbos may include *Struthiola ciliata, Melianthus elongata* (kruidjie roer my nie), *Felicia* sp., *Hermannia scordifolia, Thesium elatius* and *Salvia lanceolata* (salie). Bulbs include *Oxalis luteola, Babiana grandiflora, B. brachystachys, Arctopus monacanthus, Boophone haemanthoides* (gifbol) and *Brunsvigia orentalis*, whilst annuals include *Polycarena* sp., *Zalusianskya pusilla*, *Dischisma* sp., *Ursinia anthemoides, Manulea altissima* and *Nemesia affinis*. The graminoid *Ficinia argyropa* is quite common.

Short Strandveld on clay soils:

Sparsely vegetated clay areas are present mainly in the south-eastern part of the Wind Energy Facility development site and on a hill at the western edge of the strip ploughed area. These areas support a distinct plant community that is not represented elsewhere on site, with species such as *Cephalophyllum* sp., *Drosanthemum* sp. (bead leaf vygie), *Salsola* sp. (gannabos), *Trachyandra involucrata, Bulbine praemorsa*, *Leipoldtia schultzei, Monilaria* sp., and *Psilocaulon junceum* (asbos).

Photograph 7: View of sparsely vegetated clay soils, sometimes with quartz pebbles. Characterised by a community of small succulents not found in the adjacent Strandveld.

3. Succession

The definition of succession is the progress of one thing to another over time. In plant ecology, succession refers to the gradual replacement of one plant community with another plant community over time through natural processes. Plant succession occurs generally after a disturbance has occurred in an area.

For example, a **pioneer plant community** comprises mainly of emerging plant species which require high concentrations of nutrients and can survive on unstable soil surfaces. A pioneer plant species generally create conditions which would be favourable for the next plant community to establish in the area (e.g. through the stabilisation of the soil in an area, etc.).

Over time, one plant community replaces another until a stable equilibrium or **climax plant community** is established. In the Namaqualand Strandveld, plant species can be classified in the following categories: opportunistic or early emerging plant species, and early, middle and late succession plant species. Classification of plant species into these categories depends on the characteristics of the plant species and the period after disturbance when the plant species emerges and is most abundant. Plant species which are most successful on rehabilitated areas include those categorised as opportunistic or early emerging plant species, and early succession plant species. A climax plant community comprises mostly of middle and late succession plant communities with few emergent and early succession species.

Examples of plant species categories found in the study area are presented in the table below.

Species name	Common name	Functional plant groups
Mesembryanthemum crystallinum	Soutslaai	Emergent species
Zygophyllum morgsana	Skilpadbos; slaaibos	Middle succession species
Othonna cylindrica	Ossierapuisbos	Middle succession species
Othonna coronopifolia		Middle succession species
Lebeckia sericea	Fluitjiesbos	Middle succession species
Ruschia floribunda		Middle succession species
Lycium cinereum	Muisbos	Middle succession species
Chrysanthemoides incana	Grysbietou	Middle succession species
Manochlamys albicans	Spanspekbos; seepbos; soutbos	Middle succession species
Conicosia elongata	Vetkousie	Middle succession species
Tripteris oppositifolia		Late succession species
Salvia africana-lutea	Bruinstrandsalie	Late succession species
Hermannia scordifolia		Late succession species
Hermannia trifurca	Poprosie	Late succession species
Hermannia sp. nov		Late succession species
Pteronia divaricata		Late succession species
Pteronia ovalifolia		Late succession species
Eriocephalus racemosa	Kapokbossie; wilderoosmaryn	Late succession species
Asparagus africana		Late succession species
Rhus glauca	Blue kuni bush	Late succession species
Most small succulents		Late succession species

4. Seed Collection

Seed collection is an important aspect of rehabilitation work, and is one of the easiest and cheapest ways to collect indigenous plant species. It is also important as the seeds from perennial plant species (which are generally the emergent species) are poorly represented in the topsoil layer. Seed collection should be undertaken by a suitably qualified specialist who is familiar with the various seed types associated with the plant species and rehabilitation in the area.

4.1. Where to collect seed

In order to collect the maximum volume of seed in the shortest time, it is important to identify where the species which is to be collected is most abundant. The more plants which occur in an area, the more seed can be collected in as short a time as possible. Therefore, it is important to determine where specific plant species occur within the area such that seeds can be collected at the appropriate time (i.e. when these plants are seeding). The locality of these plant species should be recorded with a GPS and indicated on a map/plan of the development site.

4.2. When to collect seed

Most individuals of the same species which occur in the same area should flower and produce seed at the same time. It is preferable to wait until the majority of plants in an area are producing seed before collection begins. In areas where plants produce seeds at different times, it may be necessary to collect seeds more than once in a season.

It is important that seeds are collected when they are ripe. The collection of unripe seeds will reduce the percentage germination thereby reducing the effectiveness of the rehabilitation efforts. How to determine if seeds are ready for collection depends on the species being considered, and should be undertaken by a suitably qualified individual. In general, the following is applicable:

» *Vygies:*
  - The seed capsules change from green to red/black and feel dry and 'woody' when the seed is ripe.
  - The seed colour changes from a white/yellow to a brown colour.

» *Other species:*
  - The husk is dry and breaks open with a racking sound (e.g. *Lebekia sericea*), or the seed wings change from green to brown in colour (e.g. *Tetragonia, Zygophyllum*).
  - There is a colour change in the fruit (e.g. *Asparagus* from green to red or sometimes black; *Zygophyllum morgsnan* from green to brown).
  - The seed is dry and hard.

* The seed rattles inside the seed pod (e.g. *Lebekia sericea*)

In general, the growing season of plants on the Wind Energy Facility development site occurs from May to October.

4.3. Equipment

Seed must not be collected in plastic bags, as these are likely to promote the growth of mould which reduces the viability of the seeds. It is better to use a Hessian sack or paper bag for smaller seeds. Larger seeds can be collected in cardboard boxes, provided these are closed to avoid the seeds from being blown away.

Most seeds can be picked directly from the plant by hand. Gloves generally hinder the effective and quick collection of seeds, but can be used for species which have small thorns or sharp branches (e.g. *Lycium* species).

A 'vacuum harvester' can be an effective tool for certain plant species (e.g. grasses), but does not work effectively for most Namaqualand species.

It is important to know whether any of the plant species from which seeds will be collected are poisonous. If poisonous plant species occur in the area, it must be ensured that the seed collectors are aware of these and that the necessary protective clothing is provided.

4.4. The drying and storage of seeds

For every 1% reduction in the moisture levels of a seed, the seed lifespan doubles. It is also important that seeds or other plant material is adequately dried before storage in order to reduce the possibility of mould growth which reduces the viability of the seeds. After the seeds (and any other plant material) are adequately dried, the seed should be stored according to the following guidelines:

» Store seeds in a cool, dry, dark place (not in direct sunlight).
» Store seeds in paper bags, large envelopes or cardboard boxes.
» Use appropriate insect and anti-mould spray or powder in order to combat insect infestations and the growth of mould. It is important not to use sprays or powders which are poisonous to humans, as they will need to handle the seeds during sowing.
» Ensure that there are no vermin (such as mice and rats) which can eat the seeds.
» Never leave seeds outside overnight.
» Under no circumstances must seed be temporarily stored in a vehicle standing in the sun. High temperatures inside the vehicle can destroy the seeds.

In general, the viability of seeds reduces over time. The germination is therefore expected to be highest in the first year after collection. It is therefore best to use seeds within one year after collection and should, in general, not be stored for longer than 2 years.

5. Relocation of plants

Some plants can be successfully rescued during construction and utilised for rehabilitation of disturbed areas. This is a fast and effective way of introducing mature plants into an area.

Replanting must be undertaken only during the middle of the winter season (i.e. June – August). The best time for planting is directly after a rainfall event while the ground is still wet. The chances of survival are very low when plants are planted in dry soils.

Rescue of the plants before construction must be undertaken by a suitably qualified specialist with experience in rehabilitation in the area. The following guidelines must be considered:

» Loosen the soil on all sides of the plant, without breaking or damaging the roots close to the plant. Dig down about 20 – 30 cm.
» Dig the spade under the plant, and lift the plant up with the spade.
» Pack the plant in a crate or on a wheelbarrow.
» Pack the plants onto a vehicle, keeping different species separate.
» Cover the vehicle if open in order to protect the plants during transportation, and to protect against drying out.
» It is important to replant the plants into bags the same day as they are collected. Never store the plants overnight or for a few days.
» Ensure that the plants are sufficiently watered in order to ensure their survival.
» Store the plants in an on-site nursery (if sufficient water is available), or at an appropriately located off-site nursery.

When replanting the plants, the following guidelines should be considered:

» In the area designated for the replanting of the plants, dig a hole which is slightly larger and deeper than the plant which must be placed therein.
» Place the plant in the hole and ensure that it is deep enough that the roots are covered.
» Replace enough soil in the hole to cover the roots and compact the soil to secure the plant in the hole. Use more soil if necessary and compact again.
» Make a depression around the plant with a spade such that water will drain towards the plant.
» Do not plant the plants in straight lines, but rather randomly as in the natural environment.

» Ensure that plants are sufficiently watered in order to ensure their survival.

Practical experience in Namaqualand with plant relocation has shown that it makes little difference to the success rate whether the soil is retained around the roots or not during the rescuing process. It has also been shown that smaller plant individuals are more successfully relocated than larger specimens.

Certain plant groups are more suitable for relocation than others. In general, those with succulent leaves or stems or underground bulbs are more successful. Plant groups which have been practically shown to be successfully relocated include:

» Upright vygies
» Creeping vygies
» Large succulents
» Bulbs
» Certain shrubs (only those with succulent leaves such as *Othonna* and *Teragonia*).

6. Monitoring and evaluation of rehabilitated areas

The Namaqualand Restoration Initiative (NRI) has developed a monitoring and evaluation system which is based on a points system. This system has been developed in order to establish whether are area has been successfully rehabilitated. More points are assigned for areas where more plant groups have established. In terms of this system, and area must obtain above a certain score in order to be classified as a successfully rehabilitated area. It is therefore important that the rehabilitation manager and team members can identify the different plant species and groups in order to make a conclusion regarding the number of plant groups which have established in an area. This is also important in order to ensure that recommendations can be made as to whether additional plant groups need to be introduced into an area.

Should rehabilitation in an area not appear to be successful, it may be necessary to investigate the use of restoration packs in consultation with the Namaqualand Restoration Initiative. The nature of the restoration pack required in an area will be dependent on the ecological characteristics of the area, and practical experience in terms of rehabilitation and scientific research which has been undertaken in the Namaqualand area over the past few years. Restoration packs utilise the following principles:

» **Small soil indentations** which concentrate water and nutrients in one area, and protect seedlings from wind.
» **Soil additives** which aid in the faster growth of the seedlings and enhance the longevity of the seedlings (e.g. plant fertilizers).
» **Wind shields** which protect the seedlings from wind erosion and blowing sand particles, thereby allowing them to survive in the harsh conditions. Large wind

shields comprise wind nets and stabilise the ground at a large scale. Smaller wind shields around areas where seeds are sown can be made from cardboard boxes and can be used to protect small seedlings.

7. Assistance with Namaqualand restoration and rehabilitation

Restoration of disturbed areas in Namaqualand is likely to be greatly facilitated by taking advantage of the specific adaptations of indigenous organisms to the prevailing environmental conditions. Successful rehabilitation will therefore require the intervention of individuals/organisations who understand the area and the vegetation common to the area. Support can be obtained from, *inter alia*, the following parties:

Namaqualand Restoration Initiative (NRI), an initiative of the Department of Botany Institute for Plant Conservation, University of Cape Town: provide training in Namaqualand restoration techniques through EcoSolutions: Telephone 021 650 4046; e-mail raldo.kruger@uct.ac.za

NM Restoration located in Koiingnaas and currently undertaking restoration work for De Beers

KGR currently undertaking restoration work for NamakwaSands, Koekenaap.