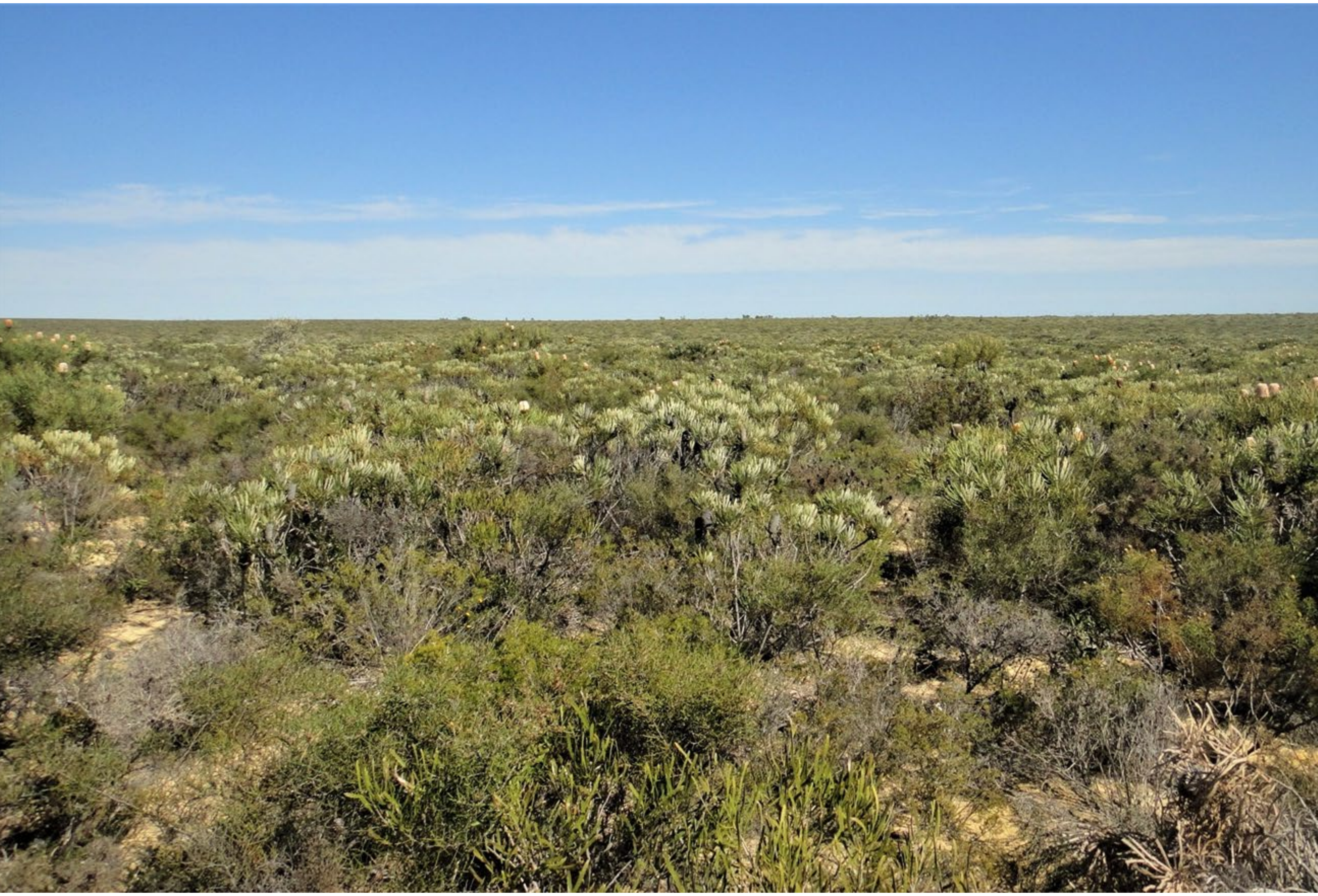

Arrowsmith Silica Sand Project

REHABILITATION STRATEGY

APRIL 2022

PREPARED FOR VRX SILICA LTD
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1 BACKGROUND

1.1 LOCATION

VRX Silica Ltd (VRX) is seeking to develop the Arrowsmith North Silica Sand Project (Project), a high-grade silica sand mine in the Geraldton Sandplain bioregion of Western Australia (WA). The regional location of the Project is shown in Figure 1. The Project is based on the Mining Lease M 70/1389 and Miscellaneous Licence L70/208 to support connection to Brand Highway(Current land use and tenure are discussed further in Section 3.2.1). VRX has been granted the Mining Lease and Miscellaneous Licence subject to the Yamatji Nations Indigenous Land Use Agreement. The Project is scheduled to proceed through environmental approvals. This strategy has been prepared to document the key issues associated with rehabilitation of this vegetation type and incorporates the local experience and rehabilitation trials into the identified strategy.

The Project is located approximately 260 km north of Perth and lies within M 70/1389 and L70/208 held by Ventnor Mining Pty Ltd a 100% subsidiary of VRX.

Access to the site will be via an access corridor which will connect the Mine to Brand Highway .

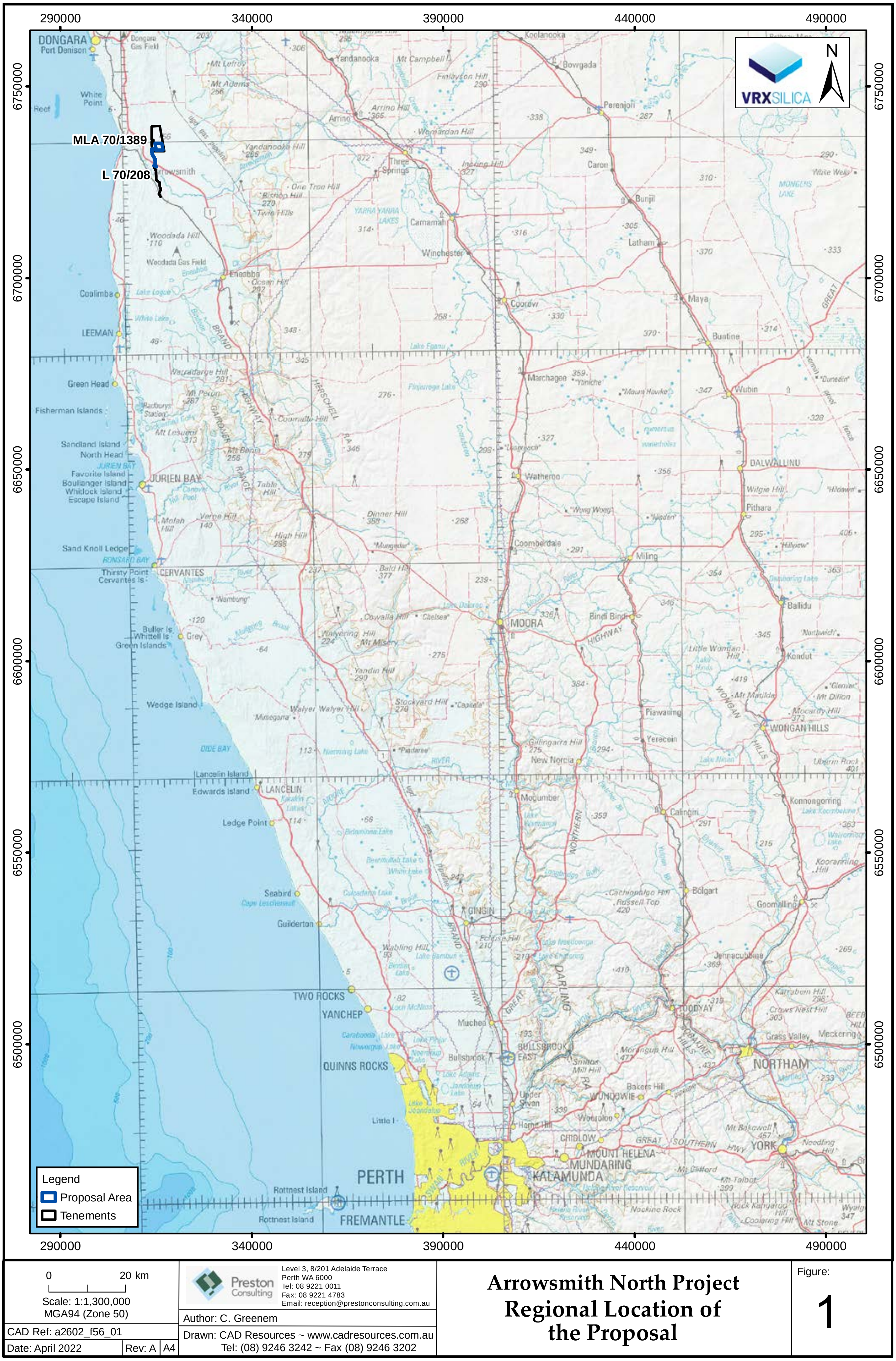


Figure 1: Location of the Project

1.2 PROJECT DESCRIPTION

The Project involves sequentially mining 8 – 15 m of sand from below the surface of the soil profile. Mining will be performed in sections by removing blocks (typically 150 m x 150 m), with an estimated five blocks being mined per year. Long-term infrastructure will include access / haul roads, pipelines, water storage dams, processing plant, power station, stockpiles and laydown area.

Mining is to be performed with a front end loader which will deposit mined sand into a Mine Feed Plant (MFP) located near the face of the mine. The sand is then transported by conveyor and processed through a screen and rotating trommel. Processed sand is then combined with water and pumped via a mobile surface pipeline to a Silica Processing Plant (SPP) for mechanical upgrading; the processing plant is located remote to the mining area - adjacent to the Eneabba-Geraldton rail line. Processed sand is to be stockpiled and dried prior to being loaded onto a rail wagon for transport to and export from the Geraldton Port.

The Project is based on a Probable Ore Reserve of 223 Mt comprising of 99.7% SiO_2. The life of the Project is estimated to be 30 years, with additional reserves available that could extend this mine life (pending approval).

The Project will use an integrated approach to produce high grade silica sand and high-quality rehabilitation using the Vegetation Direct Transfer (VDT) method and infill planting process outlined in the following sections. The selection of VDT as a rehabilitation method is based on significantly improved biodiversity re-establishment compared to conventional mine rehabilitation (as historically and currently conducted at mineral sands operations along the west coast of WA).

The Project is illustrated in a video prepared by VRX (accessible via this link: https://vrxsilica.com.au/miningandrehabilitationmethodology/

1.2.1 DEVELOPMENT ENVELOPE DESIGN

During the initial planning phase of the Project, VRX identified that environmental factors should have a significant influence on the design and location of the mine layout and infrastructure. Several baseline environmental surveys have been conducted, which have enabled VRX to incorporate avoidance and mitigation measures into the Proposal design.

The Project is comprised of two development envelopes, the Mine Development Envelope (MDE) and the Access Development Envelope (ADE). The development envelopes and proposed disturbance footprint (Figure 2) have been selected to exclude unique vegetation that may contain priority flora and vegetation that provide suitable Carnaby's Black Cockatoo breeding and roosting habitat. Furthermore, cleared land and areas of degraded vegetation were favoured during the access corridor design.

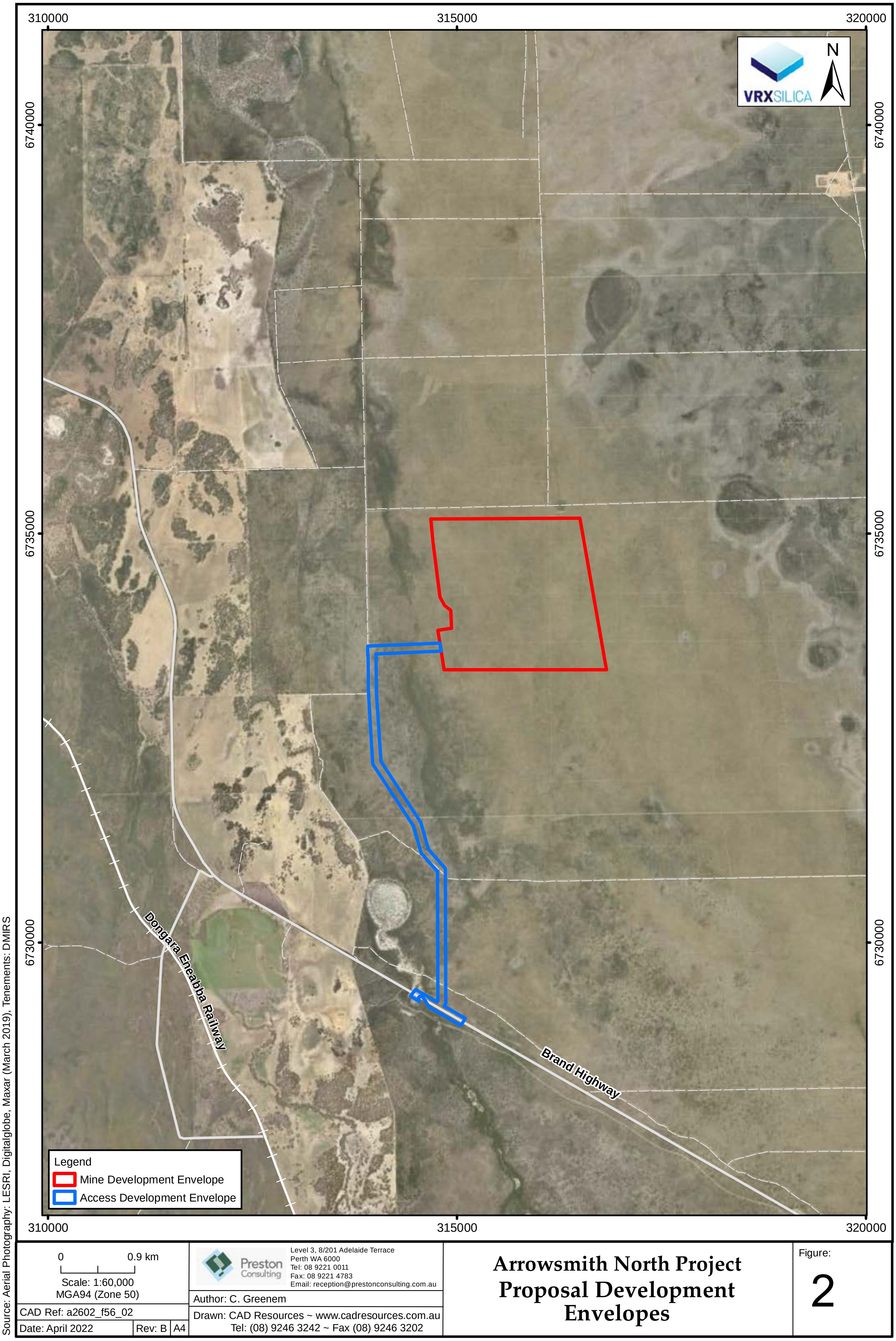


Figure 2: Development envelopes and indicative disturbance footprint of the Project

1.2.2 Detailed Description

Planning

Mine planning is integral to the production of high-grade silica sand and delivering high-quality rehabilitation. The initial mine life is proposed to be 30 years, with additional reserves available to extend the mine life to 100 years (pending approval). Baseline vegetation, flora and dieback surveys have been completed for the MDE. The mine plan will be reviewed annually and every five years with the aim of integrating the management of ongoing mine development, mining and revegetation processes. Mine planning will be ongoing and based on the following key points:

- The mine plan is set for annual and five-year time frames;
- The mine plan will integrate the management of the mine development, mining and revegetation processes;
- The mine plan will establish the levels for the floor of the mining operation designed to tie into the levels at the boundaries of the mining area to ensure no significant slopes are left at closure;
- Pre-mining flora surveys will be conducted to confirm presence or absence of conservation significant flora;
- Pre-mining dieback surveys will be conducted to evaluate the extent of *Phytophthora* infestation; and
- A schedule of mine preparation and rehabilitation activities will be prepared for the period to include:
  - Any surveys required, seasonal constraints to inform the next annual and five year plans;
  - A budget and resources (including seed, seedlings, personnel, equipment) required to execute the mine plan;
  - Any research/trial plots to be created and preserved; and
  - Any knowledge gaps requiring research activities for rehabilitation with a focus on the Carnaby's Black Cockatoo.

Mine Preparation

To provide the best mining and rehabilitation outcomes, the mine area will be prepared prior to mining. The following mining preparation activities will be applied:

- Once all checks are completed to confirm any constraints to mining activity, areas to be cleared are to be marked in the field;
- Vegetation is trimmed to 10-40 cm height in preparation for relocation;
- Mulch from the trimming will either be left on the ground surface or retained for other rehabilitation purposes;
- Vegetation and topsoil will be removed with purpose-built equipment (modified Front End Loader) designed to minimise the risk of fracturing the soil profile and damaging roots; and
- The vegetation and soil material will be translocated to a pre-prepared area (see Rehabilitation Preparation) as part of the Vegetation Direct Transfer process (VDT, Section 5.2).

A small amount of the clearing for the Project will remain disturbed for the life of the Project. This will include areas utilised for access, water supply, process plant, stockpiles and transportation of product. These areas are not likely to be able to utilise VDT as the rehabilitation methodology. Conventional mine rehabilitation approaches will be used for these areas; topsoil (notionally top 40 cm) will be removed and stockpiled adjacent for later rehabilitation.

Mining and Processing

The mining process at Arrowsmith North is detailed below:

1. Silica sand is mined in panels allowing for continuous rehabilitation of the site;
2. A dry mining method will be employed using conventional front-end loaders;
3. Silica Sand is won and loaded into a MFP located at the mine face which will remove organic and oversize material;
4. The sand is then mixed with water from the mine storage tank to form a slurry;
5. The slurry is pumped to the SPP.

Once the slurry has been transferred to the SPP it is treated in a Constant Density tank prior to being upgraded. The upgrading process is detailed below:

1. Undersized material is deslimed and passed through attrition scrubbers to produce coarse sand (stacked separately) and sized deslimed feed.
2. The sized deslimed feed will be processed via gravity separation.
3. Two final clean sand products will be dewatered using screens and stockpiled.

Tails comprised of approximately 1.5% clay will report to a thickening tank where flocculant is added for disposal as a single mine tail. The mine tail will be stockpiled for later sale and transport from the site.

Rehabilitation Preparation

To ensure the mined area is suitable for rehabilitation, the following preparation activities will be carried out:

- The mined area will be land formed to ensure it is consistent with the surrounding landscape (i.e. pit edges tie in with existing levels, no areas with slopes above;
- The post mining substrate will be ripped to a depth of 60 cm ensure that any compaction associated with machinery traverses is alleviated.

Revegetation

Revegetation is achieved using the following techniques:

- Intact sods of topsoil, soil microbiota and vegetation are translocated to the mined and prepared land using VDT (Section 5.2)
- In areas where VDT is not applicable, stockpiled topsoil will be respread for rehabilitation;
- VDT and topsoil respreading will be supplemented with infill planting/seeding of targeted species; and
- The sods will tend to fray at the edges with disturbance. Sods will be placed in a staggered formation with spaces that will promote site drainage (infiltration into the soil profile), leave small areas of bare soil for infill planting.

Monitoring and Corrective Actions

VRX will monitor the progress of rehabilitation throughout the life of the Project and implement corrective actions where required. Monitoring activities are discussed in detail in Section 8, a summary is provided below:

- Annual and five yearly review of this Rehabilitation Strategy;
- Ongoing annual monitoring of rehabilitated areas; and
- Rehabilitation progress is evaluated against the preliminary closure objectives.

Potential corrective actions for the Project include:

- Supplementary infill planting/seeding for areas not meeting preliminary closure objectives;
- Weed management;
- Pest control;
- Fire Management;
- Management of site access;
- Modification to site drainage; and
- Revisions to the rehabilitation strategy.

Infrastructure

To facilitate the Project, the following infrastructure will be developed:

- Mine Feed Plant;
- Moveable transfer conveyor;
- Slurry pipeline;
- Silica Processing Plant;
- Freshwater supply bores and pipelines;
- Access / haul road;
- Train loadout;
- Administration building;
- Gas fired and ancillary solar power supply;
- Potable water storage; and
- Associated infrastructure such as communications, workshop, laydown etc.

1.3 Applicable Guidelines

This rehabilitation strategy will form a key component for planning mine closure in accordance with the applicable guidelines. Further guidance on completion criteria for mine closure have been developed as reported in Young et. al. (2019) and provided by the Department of Mines Industry Regulation and Safety (DMIRS) as Guidance for Developing Completion Criteria. Both of the above documents reference national and other guidance relevant to mine rehabilitation and closure.

2 PURPOSE AND SCOPE

The purpose of this document is to outline the strategy for rehabilitation of Kwongan Heath specific to the Arrowsmith North Silica Sand project. This document has been prepared to inform the environmental planning and approval of the proposed mining operations. It will be updated as operations commence, reference quadrats for native vegetation are established, and rehabilitation prescriptions and monitoring data are analysed.

The scale, rate and details of the mining method enable a 'direct replacement' rehabilitation methodology as the key step in the rehabilitation process. Pioneering work on this methodology has been undertaken by Iluka Resources Pty Ltd (Iluka) at their Eneabba mining operations. Iluka refer to the methodology as VDT.

Clearing of the vegetation within the development envelope will be progressively rehabilitated using the VDT method. This document will act as a reference and basis for the detailed planning and integration of rehabilitation into mine planning and mining activities. This document addresses the following topics:

- Overarching Rehabilitation objectives;
- Environmental values and floristic assemblages;
- Hydrology;
- Drainage;
- Dieback management;
- Final landform;
- Rehabilitation methodology;
- Preliminary Completion Criteria:
- Threats to rehabilitation;
- Site Management; and
- Monitoring.

2.1 Scope

The scope of this document applies to the initial 30 year mine life of the Arrowsmith North Project but is likely to be suitable for the planned 100 year mine life (pending approval). It necessarily includes pre-mine planning, mining, rehabilitation, monitoring and closure activities. In doing so, it identifies the basis for the development of completion criteria for the Project.

The scope of this document includes only the MDE for the Project.

The information contained in this Rehabilitation Strategy will be reviewed and utilised in the triennial updates of the Mine Closure Plan required under the Mining Act for the Arrowsmith North Project.

3 CLOSURE OBJECTIVES

3.1 OVERARCHING OBJECTIVES

In considering objectives for rehabilitation for a mine site it is critical to identify the objectives of key regulatory agencies and to understand the environmental context and mining process planned for the site.

The key agencies responsible for management of environmental impact assessment (Environmental Protection Authority, EPA) and environmental management of mines (DMIRS) and their rehabilitation and mine closure objectives are as follows:

> "The EPA's objective for Rehabilitation and Decommissioning is to ensure that premises are decommissioned and rehabilitated in an ecologically sustainable manner."

and

> "…for rehabilitated mines to be (physically) safe to humans and animals, (geo-technically) stable, (geo-chemically) non-polluting/ non-contaminating, and capable of sustaining an agreed post-mining land use."

The Western Australian Biodiversity Science Institute (WABSI) have recently released a framework for developing mine-site completion criteria in Western Australia (Young et al (2019) that has been endorsed by DMIRS. The definition for closure objectives provided in Young et al (2019) has been used to inform the structure and hierarchy of objectives for rehabilitation of the Arrowsmith North Project:

> "Required outcomes, for each aspect, that will allow return of disturbed land to a safe, stable, non-polluting/ non-contaminating landform in an ecologically sustainable manner that is productive and/or self-sustaining and is consistent with the agreed post-mining land use. Closure objectives should be i) realistic and achievable; ii) developed based on the proposed post-mining land use(s); and iii) as specific as possible to provide a clear indication on what the proponent commits to achieve at closure. They may include, but should not be limited to, compliance, landforms, revegetation, fauna, water, infrastructure and waste."

The closure objectives considered in this rehabilitation strategy, therefore, are specific to landforms, revegetation, fauna and water. This strategy has been prepared specifically to inform Environmental Impact Assessment for the Project. The Mine Closure Plan (as required under the Mining Act) to be prepared for the Project, will identify other closure objectives.

3.2 POST MINING LAND USE

Before establishing rehabilitation objectives it is necessary to consider the post-mining land use (PMLU), as the target post-mining land use can be influential in the specific rehabilitation objectives. Young et al (2019) considered PMLU and recommends the use of the Australian Land Use and Management (ALUM) classification (ABARES 2016) (Table 1).

Table 1: Summary of Australian Land Use and Management Classification (from ABARES 2016)

Primary class	Definition	Secondary classes
1. Conservation and Natural Environments	Conservation purposes based on maintaining the essentially natural ecosystems present.	Nature conservation; Managed resource protection; Other minimal use.
2. Production from Relatively Natural Environments	Primary production with limited change to the native vegetation.	Grazing native vegetation; Production native forests.
3. Production from Dryland Agriculture and Plantations	Primary production based on dryland farming systems.	Plantation forests; Grazing modified pastures; Cropping; Perennial horticulture; Seasonal horticulture; Land in transition.
4. Production from Irrigated Agriculture and Plantations	Primary production based on irrigated farming.	Irrigated plantation forests; Grazing irrigated modified pastures; Irrigated cropping; Irrigated perennial horticulture; Irrigated seasonal horticulture; Irrigated land in transition.
5. Intensive Uses	Land subject to extensive modification, generally in association with closer residential settlement, commercial or industrial uses.	Intensive horticulture; Intensive animal production; Manufacturing and industrial; Residential and farm infrastructure; Services; Utilities; Transport and communication; Mining; Waste treatment and disposal.
6. Water	Water features.	Lake; Reservoir; River; Channel/aqueduct; Marsh/wetland; Estuary/coastal waters.

In determining post-mining land use, it is important to consider a range of factors (see Table 2 below from Young et al 2019). The considerations made in relation to Arrowsmith North are identified below (Table 2).

Table 2: Post Mining Land Use considerations (from Young et al 2019)

Factors	Definition	Comment
Land tenure	Existing land tenure that specifies what the PMLUs will be.	Existing tenure expected to remain or be modified as agreed to be managed by Traditional Owners under the Yamatji Nations Indigenous Land Use Agreement (ILUA).
Strategic planning	Local and regional land planning schemes by relevant authorities such as Department of Primary Industries and Regional Development; Department of Planning, Lands and Heritage; Mid-West Development Commission.	The development envelope lies within the land use category: 'General Farming', under the Shire of Irwin Local Planning Scheme No. 5 (may be modified as a result of ILUA). Historically, the deep sands have not been widely developed for agriculture due to their low water and nutrient holding capacity and propensity to erode.
Pre-mining conditions	Conditions of the area prior to mining.	Native vegetation that has been explored for minerals and petroleum is in Pristine to Excellent condition. Vegetation is extensively cleared in gridlines and rehabilitated. A Range of Threatened and Priority Flora have the potential to occur in the mining areas and the surveys to date have highlighted the presence of Priority flora species.
Acceptability to key stakeholders	Feedback received through continuous stakeholder engagement.	Ongoing discussions with key stakeholders.

Factors	Definition	Comment
Heritage (natural, cultural or historical)	Impact associated with the PMLUs on heritage and agreement with relevant government departments and stakeholders.	There are no Aboriginal heritage sites or Other Heritage places listed by the Department of Lands and Heritage (DPLH) within M 70/1389. No other historic or cultural significance noted. VRX has a Heritage Protocol with the NT claimants for area for the preservation and management of Aboriginal heritage within the areas of the mining leases
Physical, chemical and biological hazards (anthropogenic and naturally occurring)	Hazardous materials, unsafe facilities, contaminated sites, radioactive materials, among others.	Heat stress, ticks.
Consistency with other mines in the area	PMLUs proposed by other nearby mines where applicable and justified as the most acceptable approach.	Tronox Dongara Project, Iluka Eneabba. New approach to completion criteria since these were approved.
Compatibility with surrounding area	Integration of the PMLUs with the surrounding landscape in terms of aesthetics, land capability, etc. taking into account the changes occurred over the life of mine.	PMLU assumes same management will apply as for surrounding Unallocated Crown Land (UCL).
Feasibility/viability	PMLUs should be achievable in the context of post-mining land capability.	Considered feasible.
Added value	Value generated as a result of the PMLUs.	Potential for additional Carnaby's foraging species in rehabilitation.

3.2.1 CURRENT TENURE, LAND USE AND LEGISLATIVE CONSTRAINTS

The current tenure at Arrowsmith North is largely:

- Underlying UCL;
- Mining Act leases and licences.

The Project also has minor intersections (all associated with access corridor options) with:

- Road reserve (the Brand Highway, Land ID number: 3728866); and
- Stock route (reserve, R 19219 – proposed to be incorporated into Beekeeper Reserve).

The recently completed ILUA with the Yamatji Nations will have implications for land use and represents a form of tenure, providing rights of access and involvement in management of the land.

VRX has completed a Mining Project Agreement with the Southern Yamatji People, Native Title claimants over the project areas.

The negotiated terms provide for a set of shared long-term objectives for the parties and a range of measures designed to achieve those objectives over the term of the Agreement (being the life of the Project). These include:

- The preservation and management of Aboriginal heritage within the areas of the mining leases pursuant to an agreed heritage protocol;
- The promotion of awareness of the Southern Yamatji People's traditional laws and customs and facilitation of cross-cultural exchange between the members of the Southern Yamatji People and VRX and its employees and contractors;

- Ensuring the environmental impact of agreed mining operations is managed in accordance with relevant statutory obligations;
- Maximising employment and contracting opportunities for Southern Yamatji People contractors in connection with agreed mining operations; and
- The provision of agreed initial and ongoing compensation to the Southern Yamatji People for the effects on native title arising from the grant of the mining leases and miscellaneous licences within the native title claim area, the conduct of mining operations and the issue of agreed project approvals.

Tenure, land use and management for the Arrowsmith North Project area and surrounds are shown in Figure 3.

The selection of PMLU is based on an assumption of "no change" to the current flexible purpose of land use. Although UCL has not particular defined use, it is recognised that the large area of native vegetation within and surrounding the proposed mining area has conservation values associated with both flora and fauna species. The current values of the land are associated with nature conservation, managed resource protection and extraction and other minimal uses.

Examples of mine rehabilitation in this region demonstrate that this assumption is realistic and may be enhanced by the type of mining and rehabilitation process being proposed.

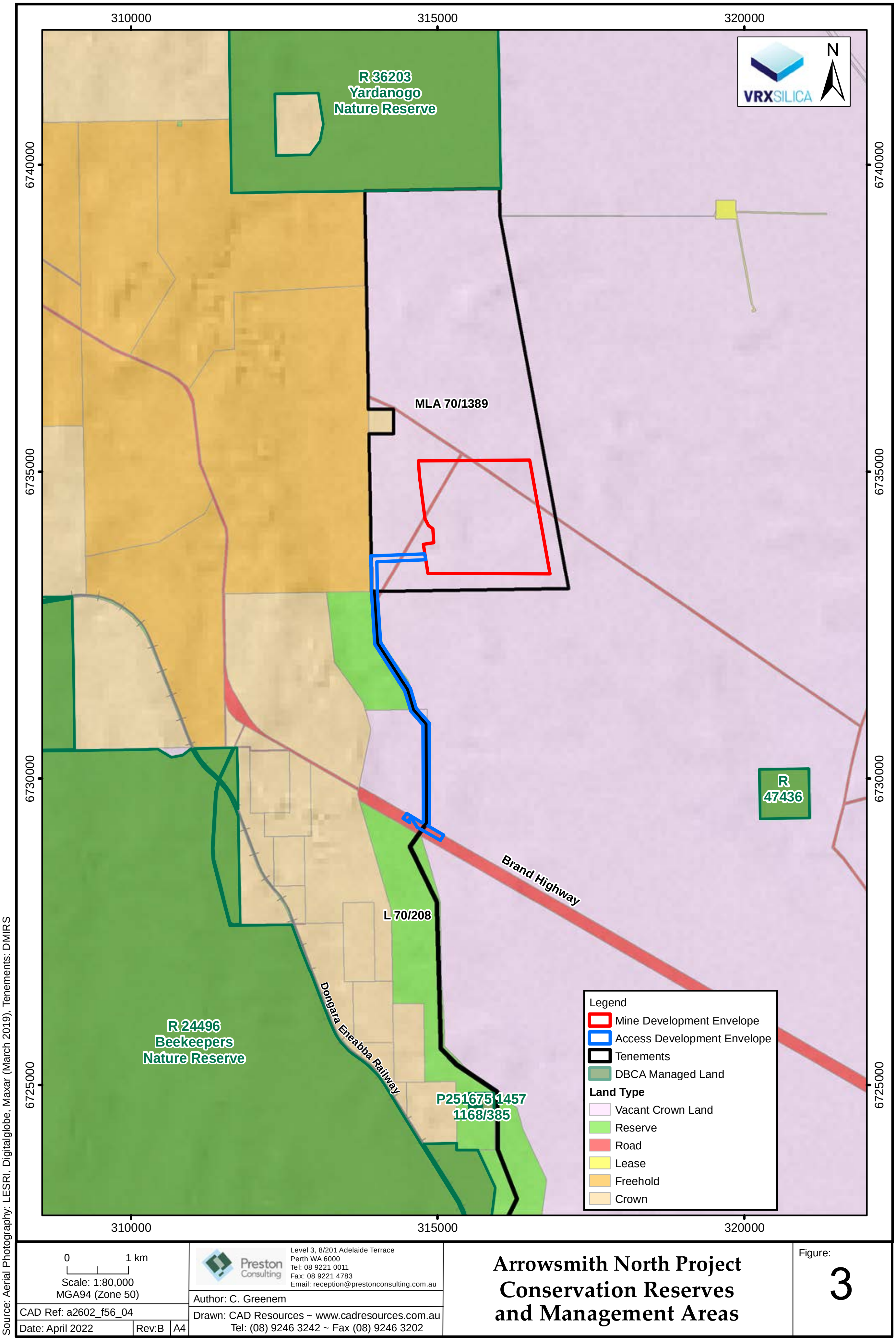


Figure 3: Tenure, land use and legislative constraints of the Project area

Mining Act Leases and Licences

Mining Act and Petroleum Act Leases and Licences confer specific rights and obligations on the holder. The rights include the rights to the minerals (able to be mined only with the required environmental approvals). The obligations include obligations that are identified as conditions of Mining Leases (M), Miscellaneous Licences (L) and Exploration Licences (E). Tenement conditions can be varied at any time by DMIRS and hence can be expected to change over time. Tenement conditions will also be used to confer the obligation to implement a Mining Proposal and Mine Closure Plan as described. VRX will comply with all relevant tenement conditions.

Unallocated Crown Land

The current land use for the Project is aligned with item 1 in Table 1: whilst the site is not a conservation reserve, it is effectively managed for multiple purposes – it has mineral resources, is largely in-tact in terms of native vegetation and habitat and is managed to maintain that native vegetation. This is consistent with other areas of Western Australia where Mining Act tenure overlies UCL. This tenure combination represents the majority of the Project Area. The remaining Project areas are associated with the access corridor that traverses freehold land, road reserves and a stock route (R 19219). These may be considered for alternative PMLU's. They represent small components of the Project Area and are discussed in further detail relating to their individual mine closure domains.

With UCL relying on native vegetation, soil and land needs to be able to be retained in a condition that protects the vegetation from becoming degraded. Rehabilitated areas need to be sufficiently safe, stable and non-erodible to allow for the re-establishment of native vegetation appropriate to the area. Ultimately, the land manager, DPLH, will not wish to have any additional management burden associated with the mining area once rehabilitation is complete.

VRX also recognises that PMLU must be suitable for use by the Traditional Owners (TO) of the land. Therefore, VRX has executed a Mining Project Management Plan with the Southern Yamatji People to ensure the cultural values of the land are retained.

3.2.2 ACCESS CORRIDORS

Reserves

The Access Corridor lies within the lease boundary of miscellaneous licence L 70/208 (Figure 3) and traverses a Stock Route reserve (R 19219) and UCL. It is assumed the PMLU would be returned to their current land uses, resulting in "no change". There are no reserves underlying the western access corridor option.

The Beharrah Springs reserve (R 47436) is an Aboriginal Heritage Place located to the east of the Access Corridor and will not be impacted by the project (Figure 3).

4 REHABILITATION OBJECTIVES

Overarching objectives for mine closure and rehabilitation for the Project (Section 3.1) are consistent with the objectives and considerations of PMLU outlined in the WABSI Framework for Developing Mine-site Completion Criteria in Western Australia (Young et al 2019).

The key attribute for rehabilitation of Arrowsmith North is the native vegetation. Consideration is made not only for what specific targets are to be developed for the rehabilitated native vegetation, but also for its ongoing management. Rehabilitation objectives form a key structural component to the establishment of completion criteria for mine closure and rehabilitation and, as proposed by Young et al (2019), are identified in relation to key themes or elements that will need to be addressed during closure – called "aspects". Preliminary completion criteria for the Project are based on aspects and objectives from baseline surveys and experience from nearby mining operations. Preliminary completion criteria are provided in Section 7.

Section 3 identified the overarching objectives specified for mine closure and rehabilitation by the responsible agencies. With those objectives in mind, the following objectives are proposed for rehabilitation of vegetation within the MDE:

- Native vegetation with values that:
    - Provides similar habitat opportunities for Threatened Fauna that are known to occur in the area;
    - Provides similar habitat opportunities for other general native fauna;
    - Are similar in vegetation species richness, diversity, structure and density to reference sites;
    - Provides conditions for the establishment and persistence of Priority Flora species;
    - Show similar retention and cycling of water and nutrients to reference sites; and
    - Do not require additional land management actions by responsible agencies when mining and rehabilitation is complete.
- Landforms, soils and hydrology that is able to sustain the native vegetation;
- Provides continued foraging opportunities for Carnaby's Black-Cockatoo and other native fauna;
- Does not introduce dieback; and
- Requires similar land management practices as the current native vegetation.

4.1 ASPECTS AND ATTRIBUTES

Identified aspects may also be known as Environmental Factors. Because these have a specific meaning under the *Environmental Protection Act 1986*, the term "aspect" is used in this document.

Attributes are "A specific parameter that can be quantified, or task that can be verified to have been achieved" (Young et al 2019). These are identified in the reference (existing) native vegetation. They serve to inform the level of performance required for attributes used in completion criteria.

The set of aspects proposed for Arrowsmith North are explained in the section below. For each aspect, one or more attributes are proposed – as parameters that can be quantified or a task that may be able to be verified when complete. These are then summarised in Table 8.

4.1.1 Landforms

The MDE lies entirely within a large Aeolian sand dune area that is elevated above the surrounding areas. The dune is characterised by the following Attributes:

- Elevations of 30 to 45 m RL;
- Aeolian sands, parameters are outlined in the following section;
- Slopes less than 3 degrees;
- No outcrop of rock.

The preliminary rehabilitation objectives for the Landform Aspect are:

- Elevations of 30 to 35 m RL;
- No imported materials;
- Rehabilitation slopes of less than 3 degrees; and
- No rock outcrop.

4.1.2 Soils

The MDE is entirely comprised of coarse to medium sandy soils characterised by the following Attributes:

- Particle Size Distribution (PSD) at surface: about 95% between 106 and 850 µm;
- High infiltration rate (hydraulic conductivity of 5-20 m/day);
- Low levels of organic matter;
- pH between 5.5 to 6.5;
- Non-saline;
- Soils that are devoid of acid generating and neutralising potential; and
- No gravelly soils.

The preliminary rehabilitation objectives for the Soil Aspect are:

- pH between 5.5 to 6.5;
- Non-saline.

4.1.3 Water and Drainage

Water and drainage in the MDE are characterised by the following Attributes:

- High infiltration rate (hydraulic conductivity of 5-20 m/day);
- No defined surface water flow features;
- Fresh groundwater (Salinity: 1,000 to 1,700 mg/L) in a superficial, unconfined aquifer; and
- Fresh to brackish groundwater in the Yarragadee confined aquifer.

The preliminary rehabilitation objectives for the Water and Drainage Aspect are unchanged from above.

4.1.4 Vegetation

The vegetation growing on sandplains such as at Arrowsmith North is known as Kwongan Heath and is well known for its biodiversity (Pate and Beard, 1984). Historically, mining of mineral sands has been conducted on Kwongan Heath further south and east (near Eneabba), and has resulted in an extensive knowledge base for mine rehabilitation in this vegetation type.

Vegetation in the MDE is characterised by the following Attributes:

- A mix of open to closed heath communities consisting of *Banksia attenuata*, *Banksia hookeriana*, *Melaleuca leuropoma* and *Conospermum triplinervium*, over mixed Myrtaceae, Restionaceae and Haemodoraceae species;
- No threatened or priority ecological communities;
- Vegetation condition ranged from pristine (96.5%) to excellent (3.5%).;
- 213 native vascular plant taxa;
- 26 annual plant species (11.76% of all taxa);
- The majority of taxa are widespread locally and broadly; and
- The incidence-based coverage estimator of species richness was 264.96.

The preliminary rehabilitation objectives for the Vegetation Aspect are to be defined based on the establishment of control quadrats in equivalent vegetation types in areas within the Mining Lease that will not be disturbed. They will include metrics related to cover, biodiversity, variability and weeds.

4.1.5 Flora

Flora in the Mine DE is characterised by the following Attributes:

- No threatened flora species were recorded although a few have been recognised as potentially present in the area;
- Six priority flora have been recorded to date, these were comprised of:
  - *Comesperma rhadinocarpum* (P3)
  - *Hemiandra sp. Eneabba* (H. Demarz 3687) (P3)
  - *Hypocalymma gardneri* (P3)
  - *Banksia elegans* (P4)
  - *Schoenus griffinianus* (P4)
  - Schoenus sp. Eneabba (F. Obbens & C. Godden I154) (P2)
  - Stawellia dimorphantha (P4)
- 11 introduced weed species, none of which are declared pests.

The preliminary rehabilitation objectives for Flora are to be defined based on the establishment of control quadrats in equivalent vegetation types in areas within the Mining Lease that will not be disturbed, and monitoring on rehabilitation performance in relation to the list of Priority Flora above.

4.1.6 Dieback

Dieback in the MDE is characterised by the following Attributes:

- No *Phytophthera cinnamomi*;

- *Phytophthera arenaria* has been recorded in and around the mine DE; and
- 235.2 ha were assessed as uninfested and therefore classified as protectable.

The preliminary rehabilitation objectives for the Dieback Aspect are:

- No records of *Phytophthora cinnamomi;* and
- The mine area and surrounds are interpreted as protectable.

4.1.7 Carnaby's Black-Cockatoo Habitat

The MDE is characterised by the following Attributes:

- No breeding or roosting habitat; and
- Vegetation that provides habitat for Carnaby's Black-Cockatoos that has a foraging value of 7 (BCE, 2020) and is comprised of:
  - *Acacia saligna*
  - *Banksia attenuata*
  - *Banksia hookeriana*
  - *Banksia leptophylla*
  - *Banksia menziesii*
  - *Banksia prionotes*
  - *Eucalyptus todtiana*
  - *Hakea costata*
  - *Hakea polyanthema*
  - *Melaleuca leuropoma*
  - *Mesomelaena pseudostygia*

The foraging habitat value ascribed to rehabilitation for Carnaby's Cockatoo Habitat for the purposes of offset calculation has been set at 3 – at rehabilitation age of ten years. This is considered to be conservative, and planning is adopting a higher foraging habitat value as an objective.

The preliminary rehabilitation objectives for the Carnaby's Cockatoo Habitat Aspect are:

- Rehabilitate areas with proportions of Carnaby's foraging species similar to undisturbed vegetation as defined in control quadrats; and
- Be able to rate the revegetation as a score of 7 using the Bamford Consulting Ecologists (BCE) method for calculating foraging values of vegetation for Carnaby's Black Cockatoo (BCE, 2020b & c).

4.1.8 General Fauna Habitat

The MDE is characterised by the following Attributes:

- An expected fauna assemblage comprised of 10 frogs, 52 reptiles, 114 birds, 15 native mammals and 9 introduced mammals;
- General habitat for 24 conservation significant species (Table 3); and
- Frequented by feral fauna species including foxes and cats.

Table 3: Conservation significant fauna within the Arrowsmith North study area (BCE, 2022)

Species	Conservation listing	Presence within Study Area	Expected Status
Invertebrates			
Millipede (*Antichiropus* Eneabba 1)*	Locally Significant	Unconfirmed	Uncertain Records within 12 km of the Survey Area
Bothriembryontid Land Snail (*Bothriembryon perobesus*)	P1	Confirmed	Resident Recorded by Bennelongia (2021b).
Kwongan Heath Shield-Backed Trapdoor Spider (*Idiosoma kwongan*)	P1	Confirmed	Resident Records within 20 km of Survey Area Recorded by Bennelongia (2021b) and BCE (2022).
Springtime Corroboree Stick Katydid (Eneabba) (*Phasmodes jeeba)*	P3	Unconfirmed	Uncertain Records within 50 km of Survey Area
Thorny Bush Katydid (Moora) (*Hemisaga vepreculae*)	P2	Unconfirmed	Uncertain Records within 50 km of Survey Area
Woollybush Bee (*Hylaeus globuliferus*)	P3	Unconfirmed	Uncertain Records within 50 km of Survey Area
Reptiles			
Woma (*Aspidites ramsayi*)	P1	Unconfirmed	Locally extinct?
Carpet Python (*Morelia spilota imbricate*)	Locally Significant	Unconfirmed	Resident
Black-striped Snake (*Neelaps calonotos*)	P3	Confirmed	Resident
Birds			
Malleefowl (*Leipoa ocellata*)	V, S3	Unconfirmed	Irregular visitor
Fork-Tailed Swift (*Apus pacificus*)	M, S5	Unconfirmed	Irregular visitor
Peregrine Falcon (*Falco peregrinus*)	S7	Unconfirmed	Irregular visitor
Rainbow Bee-eater (*Merops ornatus*)	Locally Significant	Confirmed	Regular migrant
Carnaby's Black-Cockatoo (*Calyptorhynchus latirostris*)	E, S2	Confirmed	Regular visitor
Western Ground Parrot (*Calyptorhynchus latirostris*)	E, S2	Unconfirmed	Locally extinct?
Rufous Fieldwren (*Calamanthus campestris*)	Locally Significant	Confirmed	Resident
Shy Heathwren (*Calamanthus cautus*)	Locally Significant	Confirmed	Irregular visitor
White-browed Babbler (*Pomatostomus superciliosus*)	Locally Significant	Unconfirmed	Vagrant
Crested Bellbird (*Oreoica gutturalis*)	Locally Significant	Unconfirmed	Resident
Mammals			
Brushtail Possum (*Trichosurus valpecula*)	Locally Significant	Unconfirmed	Locally Extinct?
Brush Wallaby (*Notamacropus Irma*)	P4	Confirmed	Resident
Rakali (*Hydromys chrysogaster*)	P4	Unconfirmed	Irregular visitor

Species	Conservation listing	Presence within Study Area	Expected Status
Fish			
Western Minnow (*Galaxias occidentalis*)	Locally Significant	Unconfirmed	Irregular Visitor
Western Pygmy-perch (*Nonnoperca vittata*)	Locally Significant	Unconfirmed	Irregular Visitor

EPBC Act listed species: V = Vulnerable, E = Endangered, C = Critically Endangered, M = Migratory.
BC Act listed species: S1 – S7 = Schedule 1 - 7;
*DBCA Priority Species: P1 - P5 = Priority 1 - 5. * SRE*

The preliminary rehabilitation objectives for the General Fauna Habitat Aspect are:

- Have general fauna habitat attributes similar to control quadrats; and
- Rehabilitation areas have a fauna assemblage with key species composition and levels of abundance that fall within the natural variation of these parameters.

4.1.9 Land Management

The MDE is characterised by the following Attributes:

- Low intensity management associated with UCL;
    - Planned prescribed burning;
    - Active feral animal, weed and dieback management associated only with mining and petroleum activities;
- Land management reporting associated with mining and petroleum activities; and
- Maintain current linkages with surrounding native vegetation.

The preliminary rehabilitation objectives for the Land Management Aspect are:

- To have no additional land management requirements in excess of the surrounding UCL; and
- To have no significant barriers to gene flow with surrounding vegetation.

4.1.10 Summary

Aspects and attributes have been identified from baseline surveys. Attributes have been considered in terms of how they may be able to be quantified after site rehabilitation to monitor progress toward completion, and ultimately to provide criteria to demonstrate completion. The aspects and attributes have been compiled into a summary and utilised as the basis for specific thresholds and targets for preliminary completion criteria in Section 7.

5 REHABILITATION METHODOLOGY

5.1 WHAT IS VEGETATION DIRECT TRANSFER?

Vegetation Direct Transfer (VDT) is a variation on conventional mine rehabilitation.

5.1.1 CONVENTIONAL MINE REHABILITATION

Conventional mine rehabilitation relies on complete removal of all above ground plant matter (clearing), then stripping a shallow layer of topsoil (notionally the top 10 cm). The topsoil is usually stockpiled for a period until it can be used in rehabilitation. In some strip mining operations, with good planning, significant proportions of the topsoil can be "direct replaced" – that is, avoiding any stockpiling. Direct replaced topsoil results in significantly greater biodiversity in rehabilitation (Australian Government, 2016) than from stockpiled topsoil.

5.1.2 VEGETATION DIRECT TRANSFER

VDT is the practice of salvaging and replacing intact sods of soil (topsoil and sometimes subsoil) with minimal disturbance to plant roots (Figure 5, Ross et al. 2000). Prior to salvage, the vegetation can either be left intact, or manipulated to reduce leaf area and hence evaporative stress on the plants. Some species survive the transfer process, and others do not. The topsoil seed bank is transported with the sod, together with any micro-fauna, soil bacteria, mycorrhizal and other fungi, organic matter, nutrients and subterranean plant propagules.

VDT has not been applied on mineral sands mines due to the mining method. Typically, mineral sand mines require the excavation of a void and mineralised ore which is later backfilled with stockpiled topsoil. Mineral sands mines are significantly larger and tend to be long and linear, resulting in large distances between areas being stripped of topsoil and being rehabilitated. Silica sand mining does not have these problems.

The deep sandy soil profiles at Arrowsmith North are ideally suited to the use of VDT – the sandy soils are easy to handle, with little resistance to machinery and fewer problems with materials "sticking" to machinery in handling or rocky materials that cause additional fracturing and difficult handling. The placement of sods at Arrowsmith North will be done in a staggered formation allowing for a small gap between sods. This formation will allow for better drainage and accumulation of organic material as well as providing a protected bed for seed and infill planted seedlings. A graphic illustration of the complete mining and rehabilitation methodology is available via the following link:
https://vrxsilica.com.au/miningandrehabilitationmethodology/

Historically, excavators with conventional bucket attachments have been used for VDT (Figure 4). This machinery has the potential to fragment the sod, exposing roots to the air and therefore requires a high degree of operator skill to ensure the structural integrity of sods are maintained. With improved machinery, in this case a purpose-built wide mouth front end loader attachment (measuring 3 m x 3 m x 40 cm), as depicted in Figure 5, reduced scope of operator error and better control will increase the likelihood of successful VDT.

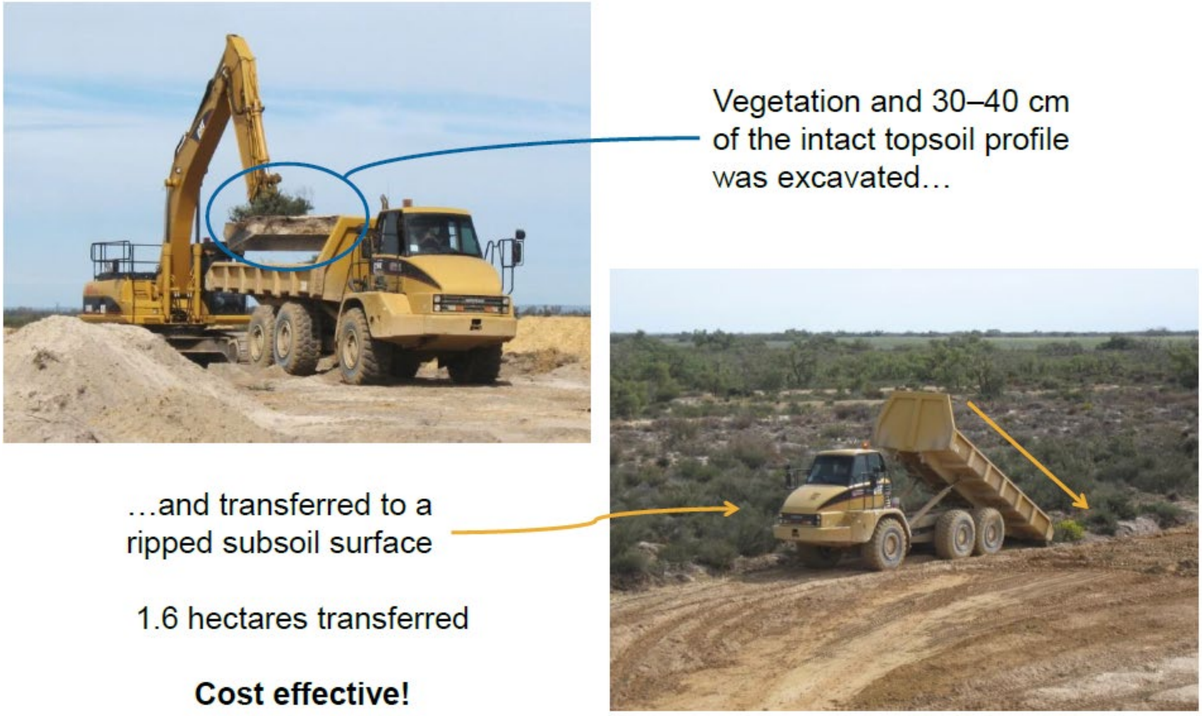


Figure 4: VDT method used for Iluka Eneabba VDT trial (from Dobrowolski 2016)

Figure 5: Vegetation Direct Transfer method

Rehabilitation of Arrowsmith North will be achieved through a combination of progressive VDT, supplemented with selective planting of, seeds, cuttings and tube stock. Larger species with deep root systems may not be successfully rehabilitated via this method (Mattiske, 2020b) and will require infill planting with seed or seedlings to maintain floristic assemblages.

Iluka successfully established 1.6 ha of Kwongan heath using VDT at the Eneabba Mineral Sands Project in the Mid-West Region of Western Australia in 2012. The most recent result from this trial are reported in Mattiske (2020c). The use of this technique by Iluka in the former Jennings mining area vastly improved the establishment of sedge and rush (largely understory) species. These species are less well represented in rehabilitation via other techniques, due to their low or complete lack of seed production (Norman and Koch 2007), but often dominate local heath communities (Mattiske, 2020c). The ability to include those species in rehabilitation solves a significant problem for mine rehabilitation on Kwongan heath. Neil McMulkin, former Rehabilitation Superintendent for Iluka Resources, advised that if starting Eneabba mining again, that VDT would be the preferred rehabilitation method, and for a small disturbance footprint operation like Arrowsmith North, it is even more suitable (due to the small distance between the clearing and rehabilitation areas) (N. McMulkin Pers. Comm. 2020).

VDT performance exceeds standard rehabilitation practice (complete removal of above-ground components, stripping topsoil with a scraper or equivalent, stockpiling or direct replace, soil erosion protection, seeding and infill planting) when measured after three years using simple vegetation metrics (Dobrowolski, 2016) (Figure 6). In particular, the comment that species diversity is 2.5-3 times greater (than in comparison to conventional mine rehabilitation) Vegetation density, ground cover and presence of recalcitrant species provide further evidence of the superior outcomes of VDT over conventional mine rehabilitation (Figures 7,8,9,10).

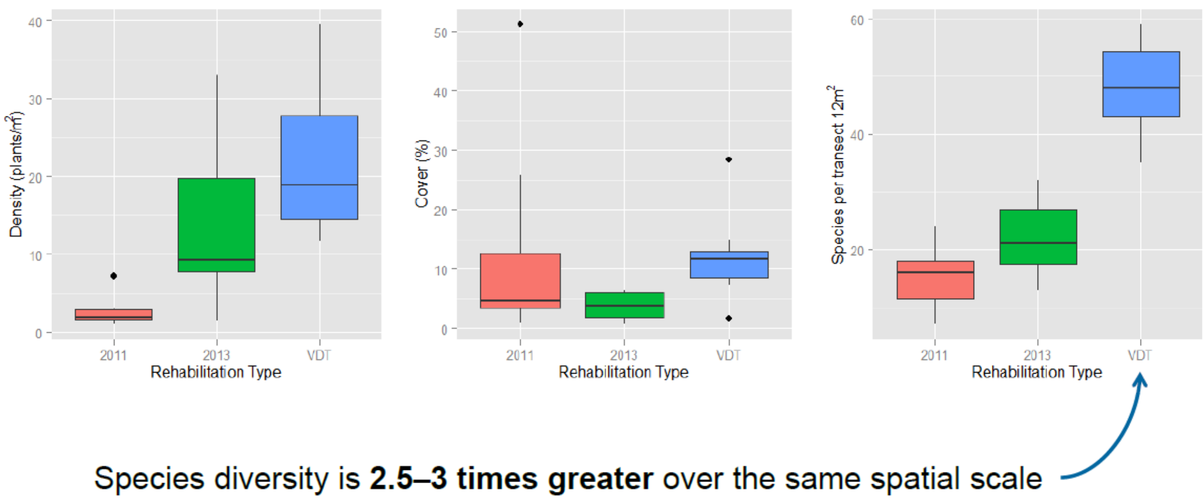


Figure 6: Simple vegetation metrics on Eneabba VDT (from Dobrowolski, 2016)

Figure 7: VDT trial at Eneabba in 2016 (planted 2012) (from Dobrowolski 2016)

Figure 8: Example recalcitrant species from Eneabba VDT trial (from Dobrowolski 2016)

Figure 9: Example recalcitrant species from Eneabba VDT trial (from Dobrowolski 2016)

Figure 10: Example recalcitrant species from Eneabba VDT trial (from Dobrowolski 2016)

Whilst VDT has been used successfully at operational scales in other climate and soil settings, the local application of it as a technique applied to a similar mining methodology provides the highest level of confidence that it will meet the rehabilitation objectives for the Arrowsmith North Project. In addition to the positive results in trials at Eneabba, VDT was successfully implemented by Iluka on 2.5 ha of Palusplain vegetation at the Tutunup South Mineral Sands Project in the South West region of Western Australia in 2010.

The Kwongan vegetation complex of Arrowsmith North is made up of mainly of myrtaceous and proteaceous heaths, and scrub-heaths on sandy earths on undulating sandplains. Kwongan vegetation, and the mid-west region in particular, is rich in endemics. Many of these species are difficult to re-establish in mine rehabilitation (recalcitrant). For the Project MDE, 131 species are reported to be present, 57 (43%) of these are considered to be recalcitrant.

As yet the difference between conventional mine rehabilitation and VDT in terms of infiltration rates, runoff characteristics, ability to carry fire and a number of other attributes have not been measured (indeed they have not been measured on conventional mine rehabilitation in many places). The lack of physical alteration of the soils and the improved diversity and understory characteristics are expected to have a positive bearing on these attributes. The Project will enable data to be gathered on these aspects.

Tube stock planting of the tree species will be used to supplement establishment – particularly for those species that do not tolerate cutting and root pruning (e.g. larger *Banksia* species). Oversowing with stabilising species may be utilised to ensure plant density targets are met.

5.2 Why Vegetation Direct Transfer?

The VDT rehabilitation method has been selected for this Project because it:

- Improves re-establishment of species that are recalcitrant using conventional mine rehabilitation methods (because the rootstock is preserved, re-sprouting species (that may not produce viable seed) can survive the mining and rehabilitation process);
- Preserves the in-situ seed bank, soil microbiology and organic matter. This generally reduces the risk of soil erosion/sandblasting affecting seedling establishment and growth;
- Reduces soil compaction, better preserves soil structure and surface stability due to the absence of repeated machinery handling and traverses;
- The mining method only requires a small open area at any one time, meaning traverse distances for blocks of soil and vegetation being transferred do not have to be transported far;
- The results will provide far more groundcover and potential habitat and to carry fire; and
- The soil type and vegetation characteristics are appropriate for the methodology to be operationalised.

There is significant documented evidence in support of VDT as a preferred rehabilitation technique for Kwongan heath.

Conventional mine rehabilitation fails to return significant numbers of species to Kwongan vegetation. These species are referred to as "recalcitrants". Species from the Cyperaceae, Restionaceae and Ericaceae form the majority of these recalcitrants, with the former two families representing a plant life-form largely absent from rehabilitated vegetation in comparison to undisturbed Kwongan (Dobrowolski 2014). The use of VDT by Iluka in the former Jennings mining area was to demonstrate the sustainability of translocating largely recalcitrant sedge and rush species, which tend to be less well represented in rehabilitation via other techniques, due to their low or complete lack of seed production (Norman and Koch 2007), but which often dominate local heath communities. The use of deep profile direct return of the topsoil and overburden in one pass (VDT) may provide a large scale method of translocating rhizomatous and tuberous species in rehabilitated areas (Norman and Koch 2007).

The value of fresh topsoil in rehabilitation is well documented – Alcoa report that 60% of the species on restored sites originate from seeds in fresh topsoil and immediately returned. VDT does this, but without the physical disturbance associated with conventional methods of topsoil handling. Fresh topsoil is documented to result in 33% more species than stockpiled topsoil (Australian Government, 2016). Conventional mine rehabilitation is enhanced by stripping the surface horizon separately from the subsoil to re-create, as nearly as possible, the original soil profile, with the nutrient and microbial rich A horizon at the surface where it will be maximally exploited by plants' roots. The majority of root material is noted to occur in the top 30 cm of soil (Figure 11)(Dodd et. al. 1984, Mattiske 2020b) - VDT preserves the soil profile in an intact sod – including topsoil and subsoil horizons with its organic matter and soil biology.

Figure 11: Soil pit showing majority of root material in top 30 cm (from Mattiske 2020b)

Given the above, there are numerous advantages to utilising VDT as a rehabilitation technique, such as: continuation of recycling of plant and soil materials; faster re-vegetative growth; restoration of the whole ecosystem (including microbes and fungi); and erosion control (Ross et al. 2000). Rehabilitation using this method allows for the retention of root stock, seed banks and soil micro-organisms. These factors are particularly favourable when rehabilitating vegetation assemblages that have recalcitrant species, such as those absent from mine rehabilitation in the Kwongan sandplain (Rodgers *et al.* 2011, Dobrowolski 2016).

International experience with VDT has been largely driven by attempts to restore or preserve degraded ecosystems, not necessarily by mining. A brief recount of these assessments is provided below.

Vecrin and Muller (2003) specifically examine the advantage of translocating plants with topsoil in-tact, as is being proposed for Arrowsmith North. The results showed that:

> "the soil translocation technique permitted the development of many meadow species, including two legally protected species, and few ruderal species despite a large area of bare ground. This technique seems effective in terms of number and abundance of meadow species compared to natural regeneration and commercial seed sowing. In the case of the two classical methods, species richness was lower and only widespread species were present. Topsoil translocation provides a good compensatory method to avoid habitat and species destruction".

Benetková et. al. (2020) examined the addition of soil and plant litter to an already afforested limestone quarry. Whilst they were attempting to improve previous quarry rehabilitation, their observations on species diversity and soil organisms are pertinent to the rehabilitation method:

> "In agreement with other studies (Moradi et al., 2018; van der Bij et al., 2018) we found that for most ecosystem components soil transplantation shifted communities much closer to the reference sites. It has been proved that restoration techniques, such as soil addition, are suitable for reintroduction of target species (Boyer et al., 2011; Wubs et al., 2016), especially when spread onto bare soil like shortly abandoned fields, spoil heaps or sites after topsoil removal. Added soil can provide a viable seed bank or refuge for transferred soil organisms, until conditions in the surrounding soil are good enough to spread there. Sod introduction also led to more than 50% coverage of characteristic plant species and also to increased microbial biomass and number of soil animals (van der Bij et al., 2018; Waterhouse et al., 2014)."

In assessing the value of translocation for the conservation of wet meadows, fens, and heaths as threatened habitat types in Europe, Swiersczcz et. al. (2019a) found that the shift in values of particular indices was not considerable. VDT is being actively pursued in Europe as a "last chance" measure to conserve particular vegetation types that are threatened by anthropogenic activities (Swiersczcz et. a. 2019b).

The transplantation of soil was observed to be a "particularly effective technique for improving wetland plant establishment and limiting cattail encroachment in areas disturbed by dike construction" (Brown and Bedford, 1997).

The efficacy of VDT as a rehabilitation method, particularly for the rehabilitation of the resprouting, rhizomatous and tuberous species that dominate the heath communities of the proposal area, are reported in a report on the Application of VDT by Mattiske (2020c). The most recent monitoring data highlighted the following advantages of VDT over conventional topsoil stripping, stockpiling and replacement for mine rehabilitation:

- Rootstock is mostly preserved allowing re-sprouting species survival (many recalcitrant);
- Seed bank preserved;
- Soil microbiology preserved;
- Soil compaction absent;
- Soil structure preserved;
- Surface stability achieved; and
- A large number of plant species have roots in the upper soil layer of 0 to 30cm.

VDT provides a rehabilitation surface that is far less susceptible to erosion by wind or water, having a stable cover layer transferred from the harvested area. This significantly reduces the risk of rehabilitation failure due to sandblasting or poor establishment conditions (Figure 12). The need to sow a surface cover crop such as cereal rye, or any other form of surface stabilisation to protect against wind erosions is avoided. The transferred plants together with residual organic matter do not degrade in stockpile and provide an excellent retention of nutrients, soil mycorrhiza and micro flora and fauna.

Figure 12: Wind Erosion on rehabilitation area at Eneabba in summer (from Dobrowolski 2016)

A disadvantage of VDT is that the rootstock of dominant deep rooted or large rooted species i.e. larger *Banksia* species, *Xylomelum, Eucalyptus* and *Macrozamia* may be too deep or difficult to handle and re-establish after translocation. This has not been researched or demonstrated at this stage. The VDT trial at Eneabba has shown that two Banksia species (*Banksia nivea* subsp. *nivea* and *Banksia shuttleworthiana*) were successfully translocated at Eneabba, appearing in some of the VDT plots (Mattiske 2019).

The silica sands operation has a small annual clearing requirement (a maximum of 36 ha per year, compared to around 50 ha/yr in mineral sands mining) and does not need to follow long strandlines (as does mineral sands mining). These attributes make it ideally suited to the method – where the soil blocks being harvested need only be transported fifty to a hundred metres to the pre-prepared rehabilitation area.

The inability to direct transfer some deeper rootedspecies can be offset by infill planting with seedlings, or direct seeding in the gaps between soil blocks in the rehabilitation areas. These larger species species are generally easily grown from seed at a nursery and have also been successfully established in mine rehabilitation. Combining these species with the ability of VDT to ensure recalcitrant species are largely retained (along with the other advantages listed above), makes VDT a logical choice for rehabilitation method.

5.3 Propagation of Select Species

Propagation of the following species is expected to be required at specialist nurseries through conventional and advanced propagation methods. Rehabilitation planning will focus on species with conservation values. Table 4 includes both threatened and priority flora species that have been recorded within the Development Envelope and also species that are reported to be species that Carnaby's Cockatoo forage upon. Some of these species are expected to survive the VDT process, but the entire list is provided as infill planting may be adopted as a means of enhancing Carnaby's foraging habitat value of the rehabilitation.

Table 4: Priority Flora and Carnaby's Cockatoo Foraging Species Recorded within the Development Envelope

Family	species
Cyperaceae	***Mesomelaena pseudostygia***
Dilleniaceae	*Hibbertia crassifolia*
Ecdeiocoleaceae	*Ecdeiocolea monostachya*
Fabaceae	***Acacia saligna***
Goodeniaceae	*Dampiera spicigera* *Scaevola spinescens*
Lamiaceae	*Hemiandra sp. Eneabba*
Myrtaceae	*Darwinia pauciflora* ***Eucalyptus todtiana*** ***Melaleuca leuropoma*** *Verticordia grandis*
Proteaceae	***Banksia attenuata*** ***Banksia hookeriana*** ***Banksia leptophylla*** ***Banksia menziesii*** ***Banksia prionotes*** ***Hakea costata*** ***Hakea polyanthema*** *Stirlingia latifolia* *Xylomelum angustifolium*
Xanthorrhoeaceae	*Xanthorrhoea drummondii*

Note: Bold text denotes flora identified as suitable foraging habitat (DEC, 2011).

Bamford (2020) provides an estimated stem density of Banksia spp. for vegetation that represents Carnaby's Black-Cockatoo foraging habitat. The following stem density comprised of *B. prionotes, B. menziesii* and *B. attenuata* is representative of moderate to high value Carnaby's Black-Cockatoo foraging habitat:

- *B. prionotes* - >400-500/ha
- *B. menziesii* - >50-75/ha
- *B. attenuata* - >1,000-2000/ha

This equates to a stem density of one plant per 4 - 7 m2. VRX has taken a conservative approach to infill planting, committing to approximately one stem per 5 m^2. These tube stock species would be used as supplementary planting or may be direct seeded into a suitable seed bed in some areas. Other, easy to propagate species may be used to improve establishment and stability eg. *Hyalosperma cotula* and *Waitzia acuminate.* Seed collection and nursery stock will be managed by a competent revegetation service provider.

5.4 Management for Effective Rehabilitation

5.4.1 Planning

Planning is essential to both the successful implementation of both mining and rehabilitation processes. Integration of the processes not only provides better chances of success, but also provides opportunities for efficiency and cost savings.

Key Steps

- Mine plan to incorporate rehabilitation and development areas to balance;
- Slash/mulch vegetation to about 10-30 cm in new mining area;
- Rip roots and plan for Macrozamia if necessary then modified FEL to remove top 40 cm of intact soil profile;
- Spread any coarse materials to be incorporated into profile. Soil ripped to 60-80 cm and re-level;
- Prepare rehabilitation surface for placement of VDT sods;
- Tram soil sod to new location and place where required;
- Infill plant with seedlings where required; and
- Apply top up seed, slow release, low phosphorus fertiliser at 50 kg/ha.

Dieback management

The presence or absence of dieback will alter the plan and procedure for mining. It is important to have a current dieback map, similar to the one provided in Figure 13, to plan the sequence of clearing. In most cases, dieback affected areas will be avoided during mining, or if not, will be subject to specific hygiene controls. Control of any infestations may require treatment with fungicides (phosphite or similar). Application of hygiene management practices for vehicles and personnel entering and leaving the site will be defined in a procedure that may be updated from time to time. Hygiene management will be a split phase operation designed to ensure all machinery is clean before allowed in to the mining ore rehabilitation areas, and once rehabilitated, areas are monitored on foot (clean) and using drones..

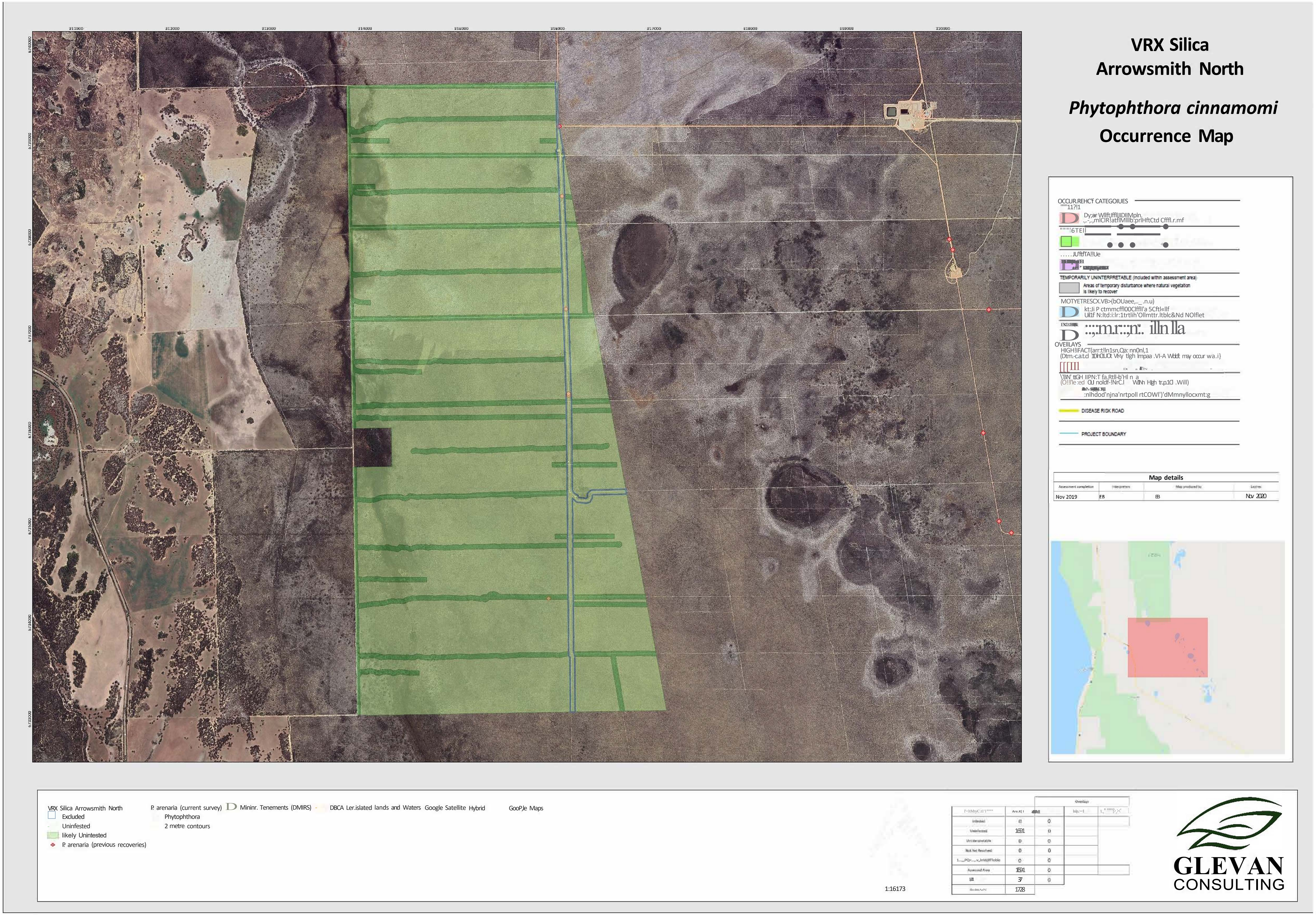


Figure 13: Dieback map Glevan (2020)

5.4.2 Materials Management

Topsoil and subsoil is preserved through VDT, as it is removed in-situ and placed back carefully onto a prepared bed. The bed will be the base of the mine excavation, levelled or shaped as required to tie in with existing topography and ensure that no rehabilitation areas will have slopes in excess of three degrees. Areas of the bed will have been used to re-spread coarse rejects that represent <0.05% of total material moved. These areas will either be incorporated in-situ, or if necessary, moved to a preferred location for incorporation into a particular area. The base of mining will form the new subsoil for rehabilitation with incorporated materials. The topsoil and S1 (upper subsoil) layers will remain intact and placed onto the new subsoil.

A small amount of topsoil associated with the fixed plant and infrastructure will need to be stockpiled for the life of the Project. This will be used for rehabilitation of those areas.

Some clearing is required for an access road and infrastructure corridor over freehold (cleared land). This soil will be contaminated with weeds and will be kept completely separate from the native vegetation areas. Machinery used in these areas will need to be cleaned down prior to entry into the native vegetation areas.

Physical and chemical characterisation of materials

<u>Sand</u>
The orebody characterisation work has shown a very consistent particle size distribution and silica content, such that all materials are considered to be ore. In addition, the drilling completed to date has confirmed that all materials at all depths are classified as coarse to medium sand (200 - 2,000 µm) with 99% of all material being sized between (75 and - 1,180 µm; Figure 14).

As the mining will remove up to 15 m of sand, the potential for a change in soil type between top and bottom of pit has been assessed. PSD analysis was conducted on six composite samples each derived from three drill holes from within the Arrowsmith North tenement (Figure 15). Each of the composite samples were selected to be representative of the north, mid and south ends of the drilled area. There is minimal differentiation through the profile of the sand to be mined and the base of mining. The results are shown numerically in Appendix 1.

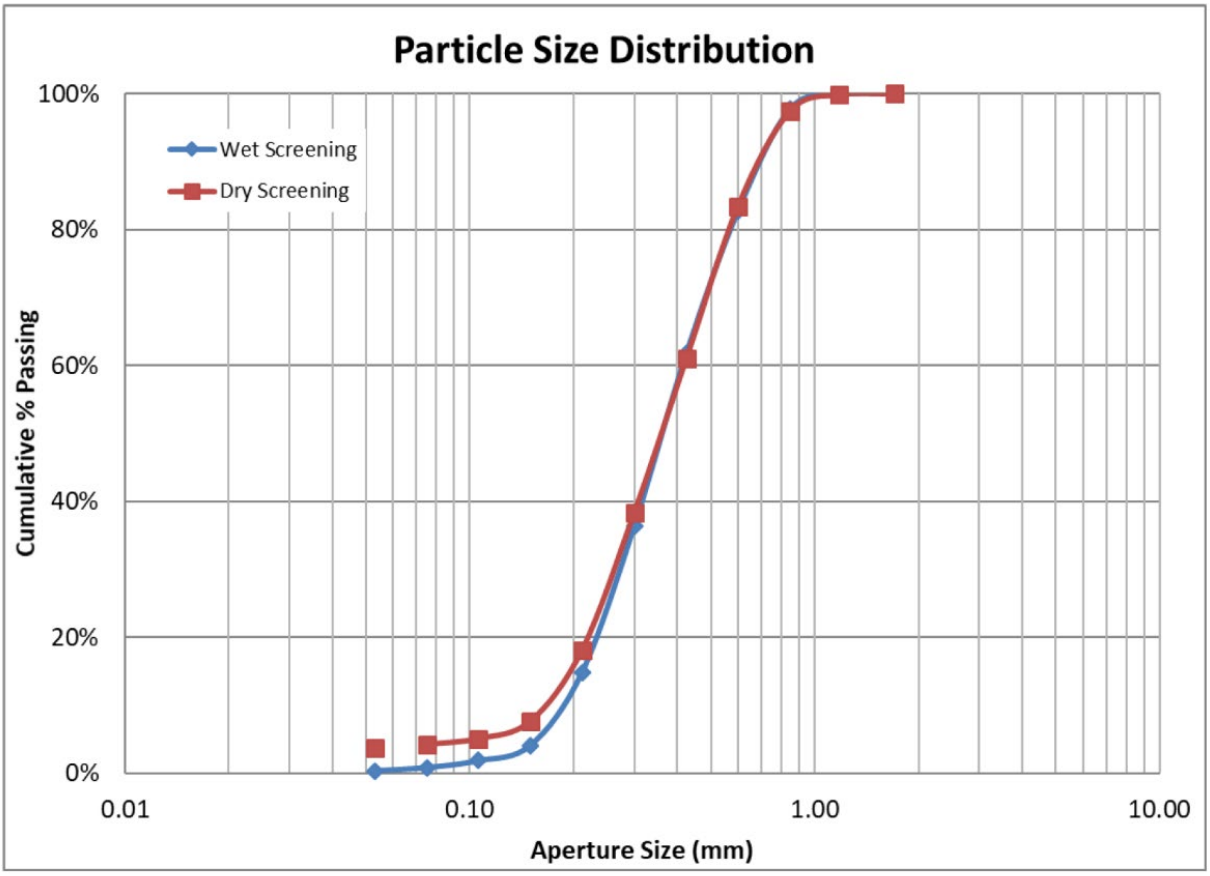
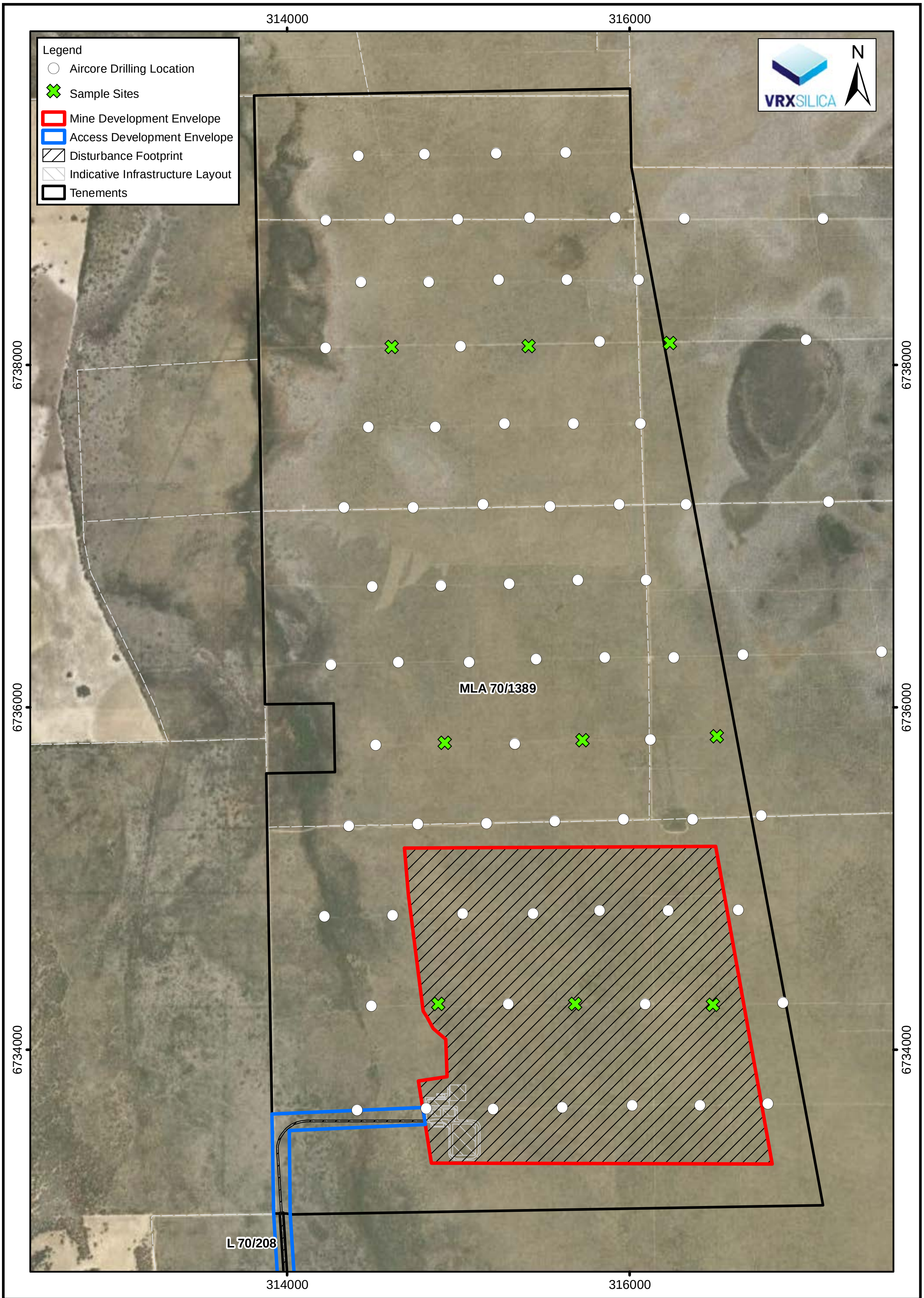


Figure 14: Particle size distribution from 30 year mining area metallurgical composite



Source: Aerial Photography: LESRI, Digitalglobe, Maxar (March 2019), Tenements: DMIRS

0 500 m Scale: 1:30,000 MGA94 (Zone 50)	Preston Consulting Level 3, 8/201 Adelaide Terrace Perth WA 6000 Tel: 08 9221 0011 Fax: 08 9221 4783 Email: reception@prestonconsulting.com.au	**Arrowsmith North Project** **Drill hole and sampling locations**	Figure: 15
CAD Ref: a2602_f56_22	Author: C. Greenem		
Date: April 2022 Rev: B A4	Drawn: CAD Resources ~ www.cadresources.com.au Tel: (08) 9246 3242 ~ Fax (08) 9246 3202		

Figure 15: PSD Sampling Locations, Arrowsmith North

Using the ISO 14688-1:2002 classification scheme (Appendix 2) to describe the particle size categories, a comparison of the composite samples from the north, mid and south all show minimal difference in soil classification (Figure 16 to Figure 18). All samples retaining a classification of 'medium sand'. The material at the base of the pit will become the subsoil in the rehabilitation profile, and subsoil classification is not changing from sand to clay, or even silt. The lack of clay particles in the samples is also notable – all samples show particle size portions of less than 52 µm (approximately fine silt) represent 0.3% or less of the sample.

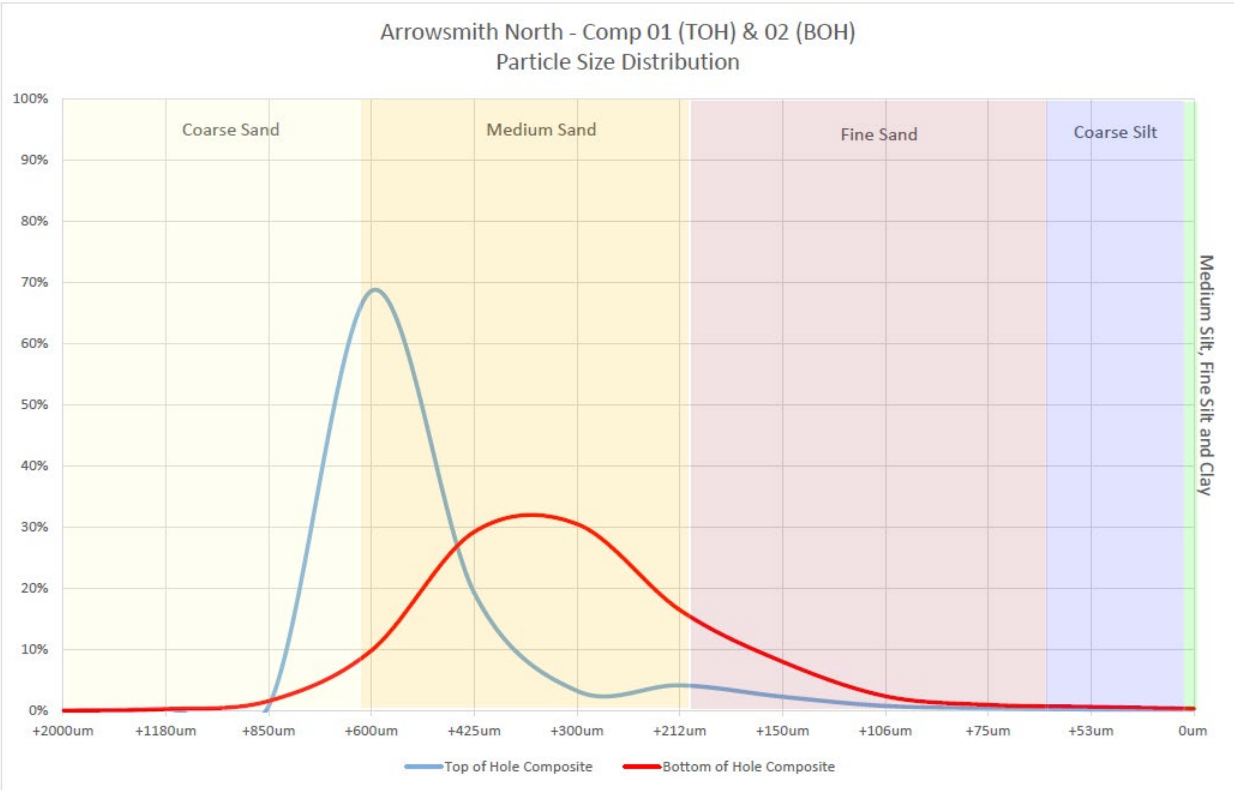


Figure 16: Top and Bottom of Profile PSD - North

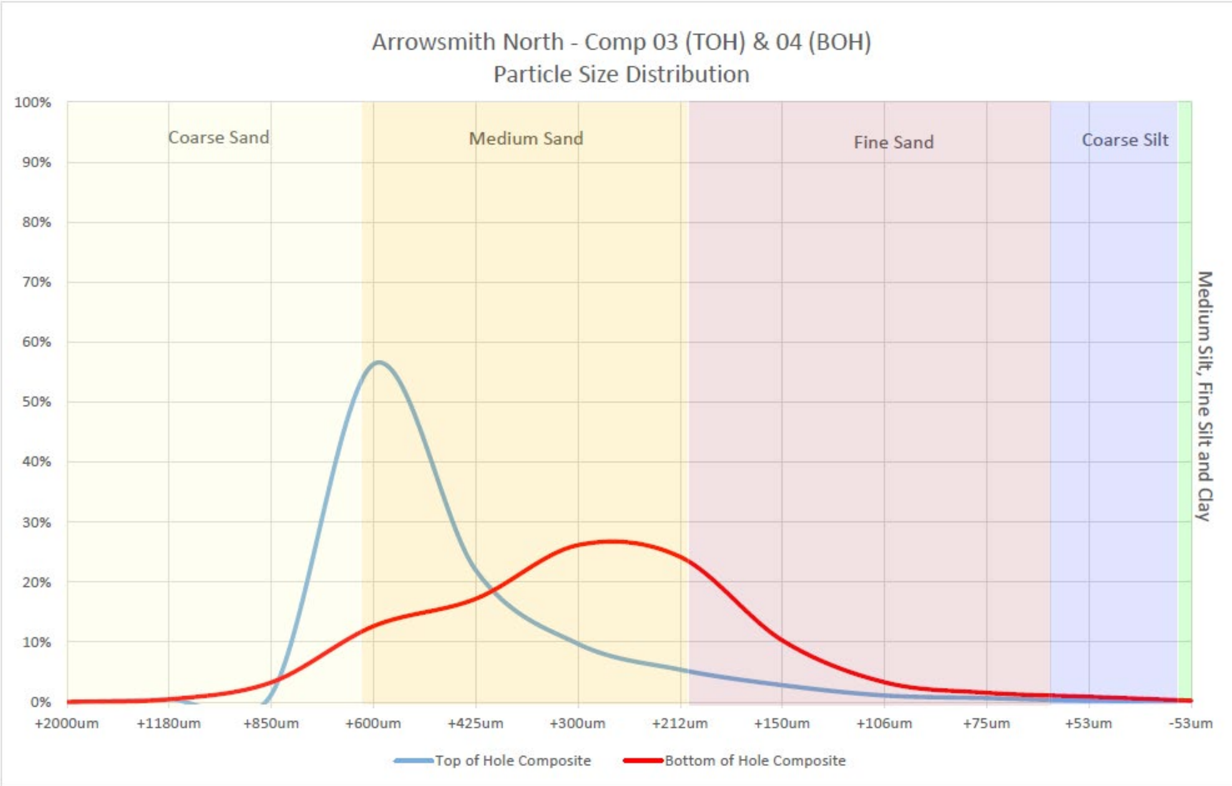


Figure 17: Top and Bottom of Profile PSD – Mid

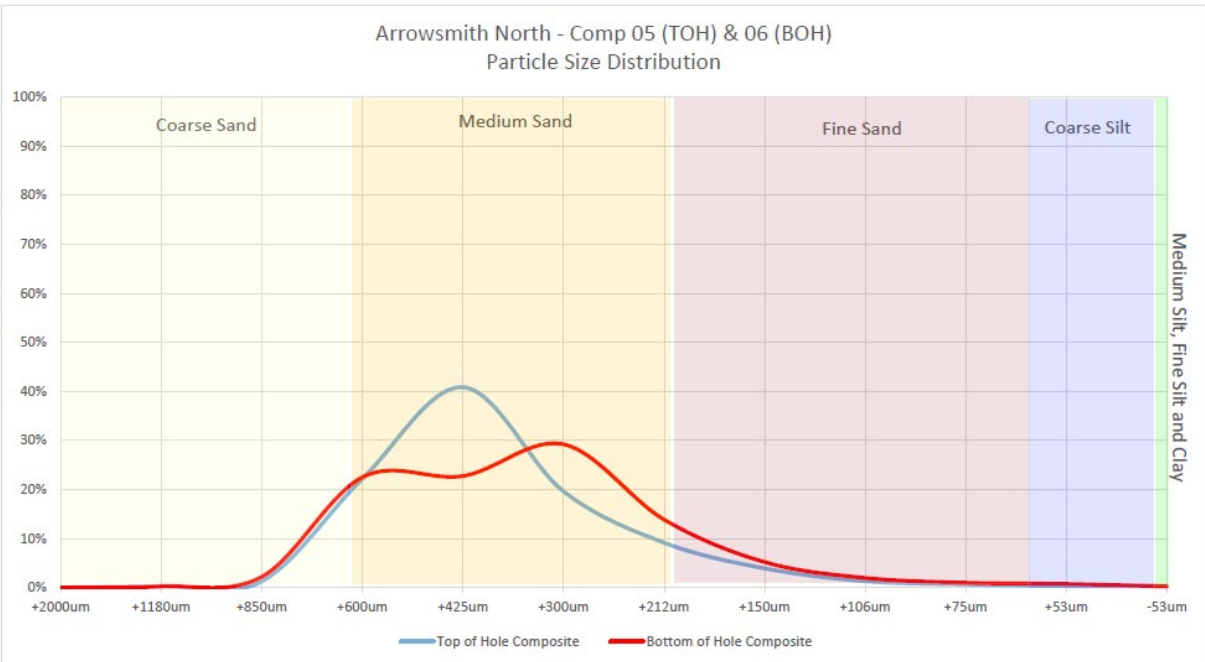


Figure 18: Top and Bottom of Profile PSD - South

Results from the PSD analysis show:

- Particle sizes at the proposed mining surface samples are distributed as follows:
    - 1.07% of the sample is less than 106 μm (fine sand);
    - 97.5% is greater than 106 μm but less than 850 μm (medium – coarse sand); and
    - 1.47% is greater than 850 μm in diameter (coarse sand – gravels).
- The average post mining PSD is 100 to 150 μm smaller in diameter than surface PSD;
- Fines represent approximately 2% of the mineral resource.

Even noting the minor change to slightly finer sand at the bottom of the deposit, the resulting changes in behaviour of soil are expected to be minor. Plant available water for medium to course sand is expected to be in the range 0.4 – 0.8 mm/cm of soil, and fine sand is 0.6-0.8 mm/cm (Table 5) in contrast with loams and clays (1.0-2.2 mm/cm). The slightly finer sand subsoil post-mining can therefore be expect to hold marginally more plant available water than did the original profile.

Changes in soil hydraulic conductivity between medium and fine sands are also relatively subtle with values expected to be in the range 2.5 -45 m/day (Table 6). These changes are less than the multi-order of magnitude differences between clays, loams and sands.

Table 5: Soil Texture and Plant Available Water (Government of South Australia, 2014)

Texture Group	Total Available Water (8-1500 kPa) mm/cm soil
Medium to Coarse Sand	0.4 - 0.8
Fine Sand	0.6 - 1.0
Loamy Sand	0.8 - 1.2
Sandy Loam	1.0 - 1.4
Light Sandy Clay Loam	1.1 - 1.7
Loam	1.4 - 2.0
Sandy Clay Loam	1.3 - 1.8
Clay Loam	1.5 - 2.2
Clay	1.2 - 2.2

Table 6: Hydraulic Conductivity for Different Soil Textures (Todd, 1995)

Material	Hydraulic Conductivity (m/day)
Gravel, Coarse	150
Gravel, Medium	270
Grave, Fine	450
Sand, Coarse	45
Sand, Medium	12
Sand, Fine	2.5
Silt	0.08
Clay	0.0002

Acid Producing Potential

Mine Waste Management Pty Ltd (MWM, 2020) conducted an acid base accounting analysis on five composited samples from the Project area. The results of this analysis show:

- Samples are devoid of both acid generating and neutralising potential;
- All samples are classified as non-acid forming as per the Australian Mineral Industries Research Association classification system;
- Samples exhibit a rinsed pH range of 5.5 to 6.5; and
- Have fresh leachates representative of minimal salinity.

The observed lack of acid generation capacity or salinity is in line with expectations for material collected from a silica sand deposit located entirely above the water table.

<u>Fines</u>
As the fine materials are also largely silt-sized silica particles (not clay), and represent a small portion of the material that is processed, they are able to be marketed. These materials will be separately stockpiled at the processing plant. This means that there are no fine materials (often referred to as "Tails") to be returned to the mine.

<u>Coarse Fraction</u>
The orebody characterisation work has shown that less than 0.05% of the mined material is larger than 1.7mm (Figure 14). The mine site trommel is sized at +2/3mm therefore, there will be almost no coarse fraction returned to the post mined area.

<u>Roots and organic matter</u>
Screens and trommels will be used to ensure that organic materials do not contaminate product. These will separate out roots and lignotubers that will be present in small quantities. They will be re-used for use in landscaping in small areas such as road sides, around the plant site etc.

Fine organic materials may also find their way into the fines to go back onto the mine floor for drying. To ensure no anaerobic zones within the soil profile, organic materials will not be allowed to aggregate into continuous layers. If present, they will be spread or moved to other locations for use in rehabilitation.

5.4.3 Timing

Transpiration stress for transferred plants will be highest in summer. Having just had their roots severed at a depth of 30-40 cm, they will be susceptible to drought stress. The influence of timing on the outcome of VDT has not been researched. Early rehabilitation trials will test the effect of timing of VDT operations to determine if there is any systematic difference between operational timing outcomes.

Infill planting and supplementary seeding will be done only after rainfall at the break of season (usually April- June).

5.4.4 Burning

Burning of vegetation prior to VDT represents another element that has not been researched. Research by Grant et. al. (2007) demonstrated rehabilitated jarrah forest was able to cope with fire, but there has been no research on the use of fire prior to topsoil stripping or VDT. General principles suggest that burning the vegetation prior to VDT would:

- Present an increased risk of erosion of bare ground (by wind and water);

- Reduce utilisation of both bradysporus (canopy derived) and geosporus (soil derived) seed; and
- Only benefit resprouting varieties.

Burning vegetation prior to VDT is not being considered at this stage but may be incorporated into the rehabilitation research program.

5.4.5 Mulching

Vegetation will be slashed with a hammer mulcher (or similar equipment) to a height of 10 cm, this will reduce transpiration. The mulch produced will be allowed to drop on the soil surface in-situ and will be translocated with the soil in the DVT process. Any excess mulch will be spread strategically within rehabilitated areas.

5.4.6 Ripping/Root Pruning

To prevent compaction of the pre-prepared rehabilitation beds they will be ripped over at least 90% of their area to a depth of 0.6 m. This will also incorporate any coarse reject materials that will be spread over the area.

The VDT process has the potential to prune the roots of some flora species however, ripping and extraction is planned to occur below the majority of roots within the Project area, which extend no further than 200 - 300 mm below the surface. Where appropriate, these species will be included in the list of plants for supplementary infill planting.

5.4.7 Weeds

A total of six weed species were recorded during the Mattiske (2020) Flora and Vegetation survey of the Arrowsmith North survey area. None of these species are declared pest organisms pursuant to section 22 of the *Biosecurity and Agriculture Management Act 2007* or listed as Weeds of National Significance (DAWE, 2020). A list of weed species recorded within the survey area, their ecological impact and invasiveness ratings (DPAW, 2013) are shown in Table 7.

Table 7: Weeds recorded within the Survey Area (Mattiske, 2020)

Species	Common Name	Ecological Impact (DPAW, 2013)	Invasiveness Rating (DPAW, 2013)
Aira caryophyllea	Silver Hair Grass	High	Rapid
Hypochaeris glabra	Smooth Cats Ear	Low	Rapid
Lysimachia arvensis	Scarlet Pimpernel	Low	Rapid
Trifolium arvense var. arvense	Hare's Foot Clover	Unknown	Moderate
Ursinia anthemoides	Mountain Marigold	High	Rapid
Wahlenbergia capensis	Cape Bluebell	Unknown	Rapid

While there are no specific management requirements for the weed species recorded in the survey area, management will follow the prioritisation management for weed species of the Mid-west region of WA provided by DPAW (2014), which includes:

1. Early Detection/Rapid Response: Any new infestations and/or introductions of any weed species in an area, no matter their impact and/or invasiveness, should be eradicated immediately;
2. Eradication of those species which are still in small enough populations for this target to be achieved; and
3. Management of high impact, rapidly-moderately invasive species that are impacting on high value conservation assets.

At a minimum, the following weed management practices will be employed:

- Vehicles, plant and equipment to be maintained and cleaned to reduce the spread of weeds throughout the Development Envelope;
- Prior to commencing ground disturbance the area will be inspected for evidence of weeds within and immediately surrounding the disturbance area;
- Identified weed infestations will be georeferenced and mapped;
- Restrict movement of machines and other vehicles to within the Development Envelope or on designated tracks outside the area;
- Stockpiled topsoil will be monitored for weed infestations;
- Infested topsoil will be stored separately from un-infested topsoil;
- New weed infestations resulting from the Proposal will be eradicated;
- Plant and soil materials are not allowed to be brought to site unless approved for a specific purpose; and
- Comply with the requirements of the Biosecurity and Agriculture Management Act 2007 (BAM Act) for listed Declared Pests recorded within the Development Envelope.

Projected mine areas will be assessed periodically to determine the extent of weed invasion within the area, this information will be used to determine the level of management required to enable successful rehabilitation of the site.

Furthermore, all seedlings and root stock used for the rehabilitation of the site will be sourced from reputable nurseries that practice good hygiene and engage in strict quarantine control measures.

5.4.8 Fauna Return

Fauna return to mine rehabilitation is not as well understood as plant return. There is currently no data on the potential for VDT to affect the rate and diversity of fauna return to rehabilitation areas. The movement of entire blocks of soil means that in addition to the direct transfer of plants, there is likely to be some direct fauna transfer too. Research is required to determine whether some fauna species are being transferred, and whether or not they survive the relocation process. An increased personnel presence will allow for the identification and observation of feral animals. This will allow VRX to implement feral animal control measures where practical further increasing fauna return in the area.

6 THREATS

6.1 DIEBACK

If dieback were to be introduced to the MDE it could potentially spread outside of the mine area and make areas downslope unprotectable. Within the MDE it could selectively infect susceptible species and limit the diversity within rehabilitation areas.

The control measures for this threat need to be applied during the mining phase and include:

- Dieback mapping in areas every two years, within the 5 year mine plan area;
- Dieback mapping in rehabilitation areas every 5 years;
- Hygiene measures to include:
    - Clean equipment only permitted into site (access road and car park excluded);
    - Washdown facility and strict procedures to be implemented if dieback is detected in the MDE;
    - Strict hygiene standards required for nursery stock; and
    - Dieback management plan to be prepared and implemented.

6.2 LANDFORMS NOT SUITABLE FOR REHABILITATION

Pit walls left at high slope angles with large faces would not be suitable for rehabilitation due to the erosion risks on sandy soils and steep angles. Intensive soil protection measures, mulches and rock armouring could be applied to control erosion, but it is considered preferable to plan to "daylight" the mining area without leaving large steep faces (i.e. mine to levels that match up with existing landform).

Mine planning is the principal control for avoiding this risk, with a contingency to batter any steeper slopes down to a low slope angle (5 degrees), if required. VDT blocks will be able to be placed at this slope angle.

6.3 SOIL STRUCTURE AND PROPERTIES COMPROMISED

The principle risk identified is that the amount of fines in the remnant subsoil profile when mining is complete (i.e. the pit floor) affects the VDT blocks in unexpected ways – due to a soil profile that retains too much moisture and is unsuitable for some Kwongan species. The change from top to bottom of the mined area is expected to be restricted to a change from coarse sand to medium sand, or medium sand to fine sand and soil properties can be seen to be very similar between these soil groups. However, the following contingency measures are identified:

- Incorporation of additional coarse materials into the rehabilitation subsoil; and
- Changes to the infill planting and seeding mix to grow species adapted to the changed subsoil type.

6.4 VDT Process Threats

As the VDT process has not been adopted at an operational scale in this region, monitoring, research and development will be conducted. As with all methodologies, there can be issues in the scale-up from trial to operational, and it is expected that some aspects will require information gaps to be addressed. These gaps are required to be identified and addressed in Mine Closure Plans that are updated every 3 years.

Should the VDT process continue to fail to deliver the expected results, conventional mine rehabilitation techniques will be utilised with most areas able to adopt best practice conventional mine rehabilitation and have topsoil direct replaced.

6.5 Infill Planting Threats

Infill planting is known to be a very reliable establishment method, so this risk is not considered to be high. Direct seeding is an alternative, or development or alternative translocation methods for deeper rooted species. Both methods will be tested in initial rehabilitation.

6.6 Fire

The impact of fire on VDT rehabilitation has not been tested. Based on experience at Eneabba, rehabilitation areas are not expected to carry a fire for 7-10 years, however it is noted that VDT will result in more groundcover species than conventional mine rehabilitation, meaning VDT rehabilitation areas would be more likely to carry fire.

Mining activities must be conducted to minimise the risk of starting fire. The controls imposed shall ensure that:

- Mining operations comply with Bushfires Act and local vehicle movement bans for activities in native vegetation;
- VRX will participate in local and regional fire management activities managed by DWER. Fire-breaks and other fire management actions will be considered;
- Fire fighting equipment shall be retained on site and agreements for local support with neighbouring activities will be negotiated; and
- Should rehabilitation areas be burnt, monitoring of the appropriate attributes will be conducted to determine the response.

6.7 Weeds

Due to the inherently low nutrient levels and lack of fertiliser application, weeds can generally be expected to die off after 2 -3 years in rehabilitation. Nevertheless weed hygiene methods are outlined in section 5.4.7.

6.8 GRAZING

Grazing from stock is not expected to occur. Grazing by kangaroos and rabbits can threaten rehabilitation establishment. Kangaroo and rabbit proof fencing has been effective at locations where this problem has occurred.

6.9 PUBLIC ACCESS

Public access will be controlled by mine management with signs, fences and gates used where necessary. This is necessary not only for safety reasons, but also to ensure all vehicles and personnel are not spreading dieback.

7 COMPLETION CRITERIA FRAMEWORK

7.1 PRELIMINARY COMPLETION CRITERIA

Completion criteria are preliminary and will be refined over the life of the Project. The first stage of refinement will be based on establishing control quadrats within representative vegetation types that will not be disturbed over the life of the Project. These quadrats will serve as a reference point for measuring the natural values for the attributes being used to judge completion. The criteria have been prepared in accordance with the framework guidance reported in Young et. al. (2019) and provided by DMIRS as specific guidance for developing completion criteria (https://www.dmp.wa.gov.au/Documents/Environment/Framework_developing_mine-site_completion_criteria_WA.pdf).

The criteria are based on addressing the ecological principle of ensuring replacement of functional groups, rather than total species numbers.

Specific targets will be identified for plant density and percentage cover at specified times after rehabilitation based on control quadrats and early rehabilitation results. Based on experience from nearby using conventional mine rehabilitation, density of approximately 10 plants per m^2 and 30 % cover can be expected after 10 years.

Table 8: Summary of Attributes and Aspects of the Project area

Aspect	Attribute	Baseline	Preliminary Completion Criteria	Comment	Monitoring
Landforms	Elevations	30 to 45 m RL	20 to 35 m RL		Carry out contour mapping to ensure elevations and slopes meet preliminary completion criteria.
	Slopes	Less than 3 degrees	Less than 3 degrees		
	Rocky outcrops	None	None		
Soils	Surface PSD			To be determined if PSD is a useful and necessary criteria	Conduct soil sampling and analysis to ensure soil characteristics fall within the natural variation of the site. Sampling will provide the following: • PSD • Infiltration rate • pH • Salinity • Morphology • Acid mine drainage risk
	Infiltration rate	High (5-20 m/day)	High	Profile will be lower. Fines separated from product will be recombined into rehabilitation soil profile.	
	Organic matter	Low	Low	Not required for completion	
	pH	5.5 to 6.5	5.5 to 6.5		
	Salinity	Non-saline	Non-saline	Not required for completion	
	Morphology	Aeolian silica sands	Aeolian silica sands	Not required for completion	
Water and Drainage	Features	No defined drainage lines	No defined drainage lines		Presence of drainage lines can be determined from contour mapping.
	Salinity (Superficial, unconfined aquifer)	1,000 to 1,700 mg/L	1,000 to 1,700 mg/L		Conduct water sampling from monitoring bores upstream and downstream of the MDE to determine salinity.
Vegetation	General Community Composition	*Banksia attenuata* *Banksia hookeriana* *Melaleuca leuropoma* *Conospermum triplinervium* over mixed Myrtaceae, Restionaceae, Haemodoraceae species.	*Banksia attenuata* *Banksia hookeriana* *Melaleuca leuropoma* *Conospermum triplinervium* over mixed Myrtaceae, Restionaceae, Haemodoraceae species.	As determined by monitoring quadrats in rehabilitation and control areas.	Conduct post mining flora and vegetation surveys to determine the post mining variation from the baseline attributes. Monitoring will show changes to: • General community composition • Vegetation condition and how it relates to the predicted disturbed area • Floristic diversity • Species richness • Priority flora • Number of introduced species
	Vegetation Condition	96.5% Pristine 3.5% Excellent	N/A – vegetation will be different.	To be developed on the basis of control quadrats.	
	Floristic Diversity	213 Native vascular plant taxa 26 annual plant taxa			

Aspect	Attribute	Baseline	Preliminary Completion Criteria	Comment	Monitoring
	Species Richness	Incidence-based coverage estimator of species richness of 264.96		To be developed on the basis of control quadrats.	
Flora	Priority Flora	*Comesperma rhadinocarpum* (P3) *Hemiandra sp. Eneabba* (P3) *Hypocalymma gardneri* (P3) *Leschenaultia juncea* (P3) *Persoonia rudis* (P3) *Banksia elegans* (P4) *Schoenus griffinianus* (P4) *Stawellia dimorphantha* (P4)	TBD	To be developed on the basis of control quadrats.	
	Weeds	6 Introduced weed species No declared pests	No new weed species No declared weeds	To be developed on the basis of control quadrats.	
Dieback	Dieback Species Recorded	*Phytophthera arenaria*	No new Dieback species		Conduct routine dieback surveys on the mined area to determine the dieback species present, the extent of infection and the extent of Protectable area.
	Protectable Area	235.6 ha mapped as uninfested and therefore considered Protectable	Mine area does not change Protectable rating on downslope areas.		
Carnaby's Cockatoo Habitat	Extent of Foraging Habitat	300 ha	300 ha	Value of foraging habitat will change over time. Likely to be reduced initially.	Conduct fauna habitat assessments to determine the extent of low and moderate to high Carnaby's Black-Cockatoo foraging habitat
	Foraging Value	Moderate to High (7) Bamford (2020) provides an estimate for stem density of Banksia spp. for vegetation representative of Moderate to High value Carnaby's Black-Cockatoo, estimated stem densities are as follows: • *B. attenuata* >400-500/ha • *B. menziesii* >50-75/ha • *B. prionotes > 1000 - 2000/ha* This equates to an average stem density for *Banksia spp.* of one stem per 4 - 7 m^2.	Minimum of 3.	Original vegetation has limited number and density of Carnaby's foraging species. Initial offset based on rehabilitation value of 3.	

Aspect	Attribute	Baseline	Preliminary Completion Criteria	Comment	Monitoring
General Fauna Habitat	Conservation Significant Species	19 from Study Area	TBA	Targets and sampling methodology to be defined.	Monitor the species composition and abundance in control and rehabilitation plots to ensure that they fall within the natural variation of these parameters.
	Fauna assemblage	Relatively complete	TBA	Targets and sampling methodology to be defined. Some fauna likely to be transferred with VDT blocks. Research required.	
	Species Richness	Rich	TBA	Targets and sampling methodology to be defined.	
	Introduced Fauna Species	Evidence of introduced species accessing the site	No increase in feral animal numbers or introduction of new feral animal species.	Baseline data does not provide sufficient data to base completion criteria on.	Monitor the presence of introduced species within the MDE.
Land Management	Management	No specific burning requirement. No specific feral animal control. No specific weed control Normal Dieback controls.	Responsible agency able to incorporate rehabilitation areas into regional management programmes without need for additional and separate management.	DBCA manage regional prescribed burning, feral animal, weed and dieback controls.	Annual Environmental Reports include rehabilitation summary and data.
	Reporting	No specific reporting on land management for the area	Completion report to accompany tenement relinquishment request.		Annual Environmental Reports include rehabilitation summary and data.
	Linkages	Connected with surrounding vegetation in all directions	NA	Project cannot control surroundings.	

8 MONITORING

Mine rehabilitation is an activity that is best done once, to a high standard. It brings together a range of variables including seasonal variation (not under our control), together with methodology variations (materials used, depth of VDT blocks, vegetation types, seed used, seedlings used, planting dates, timing of operations etc.). The outcome can be influenced by any one or more of these variables. Record keeping is therefore an essential part of monitoring as it can help to explain variations in outcomes.

Monitoring will be completed in the field to measure the rehabilitation outcomes. Completion criteria set the framework for this monitoring, but monitoring is also important to establish a continuous improvement feedback loop for rehabilitation. The monitoring proposed focuses on two key goals:

1. Providing feedback on rehabilitation performance as soon as possible in the rehabilitation process to:
    a. enable early evaluation of the outcomes of methodology variations, and;
    b. provide information from which decisions can be made about the need for interventions to improve the outcome.
2. Provide evidence of progress toward and eventual attainment of completion criteria to enable relinquishment of responsibility for the tenements.

The monitoring therefore has three key time frames where data is essential:

1) The first spring after the VDT process, when plants are re-sprouting and seeds are germinating. This is the time to determine whether any interventions (such as weed control, supplementary seeding or infill tree planting) may be required to meet the ten year criteria. Interventions become more difficult to implement as the rehabilitation progresses, requiring this early identification of potential failures;
2) Notionally at regular intervals, such as years 2, 5 and 10 to provide information on how the rehabilitation is progressing; and
3) After ten or more years, when plants have had the opportunity to grow and establish, to demonstrate that the rehabilitation is attaining the required attributes to be self-sustaining and not require any additional management.

Monitoring will ultimately be compared to a series of reference plots selected in areas that will not be disturbed, in equivalent soils and landform positions, and with equivalent vegetation types. These reference plots are expected to be monitored annually over the life of the project. In the first spring and autumn, the monitoring is planned to include a combination of functional groups, densities and percentage cover, together with selected species counts and densities/numbers in randomly generated spots. This approach is designed to give an immediate indication of the success of germination and establishment, the two key processes that dictate the starting point for the revegetation of the area. This data will be used to not only provide immediate feedback regarding the outcomes of the methodology and seasonal conditions and threats, but will enable the need for any interventions to be identified. For years 2, 5 and 10, the monitoring approach will be to determine how the established species are growing, cover, weeds or other problems, and any recruitment. Some of the completion criteria monitoring will take the form of auditing rather than monitoring. This approach enables a record of completion of key steps in the mine closure process.

9 CONCLUSIONS

The Arrowsmith North Project is a silica sand mining operation requiring clearing and rehabilitation of no more than 36 ha per year. The operation is exploiting a large, aeolian silica sand deposit north of Eneabba in the Mid-West of WA. All mining is shallow 10 – 15 m maximum and will be well above the water table. The vegetation known as Kwongan Heath and is well known for its biodiversity (Pate and Beard, 1984). Historically, mining of mineral sands has been conducted on Kwongan Heath further south and east (near Eneabba), and has resulted in an extensive knowledge base for mine rehabilitation in this vegetation type.

Planning for Arrowsmith North has identified the potential for the Vegetation Direct Transfer (VDT) method of rehabilitation to deliver better rehabilitation outcomes than conventional methods involving topsoil stripping and replacement. VDT uses machinery to remove a whole layer of topsoil with minimal disturbance from its location in-situ, to a newly prepared post-mining location. This direct transfer has a number of advantages over conventional methods that involve complete removal of vegetation (clearing) and removal of topsoil and subsoil layers using machinery such as scrapers, graders or front-end loaders:

- Rootstock is mostly preserved allowing re-sprouting species survival (many recalcitrant);
- Seed bank preserved;
- Macro and micro-invertebrates preserved;
- Soil microbiology preserved;
- Soil compaction absent and structure preserved;
- Surface stability achieved; and
- A large number of plant species have roots in the upper soil layer of 0 to 30 cm.

The outcome is that many recalcitrant species will be returned to the rehabilitation as they survive VDT. This will result in higher biodiversity and better vegetation structure in rehabilitation. The disadvantage is that larger species such as some *Banksia* species do not survive the VDT process and will require infill planting. Unlike recalcitrant species, however, the ability to grow these species from seed or seedlings is well established.

This document reviews the Project Description, identifies preliminary post-mining land use and rehabilitation objectives that set the framework for rehabilitation planning. The approach is consistent with applicable guidelines issued by DMIRS in March 2020 (Statutory Guidelines and How to Prepare a Mine Closure Plan in line with the Statutory Guidelines). A series of aspects and attributes relevant to mine rehabilitation have been identified on the basis of the baseline environmental studies for the Project, and also in consideration of the extensive local experience in mine rehabilitation. Threats to rehabilitation have also been considered and a preliminary completion criteria and monitoring framework is proposed. The monitoring proposed is geared to support continuous improvement of rehabilitation methods and outcomes.

This Rehabilitation Strategy supports the adoption of VDT as the key rehabilitation strategy for Arrowsmith North. It will be combined with infill planting to achieve higher levels of biodiversity and to ensure that species used for foraging by Carnaby's Cockatoo are established in the rehabilitation. It gives confidence that revegetation of the proposed Arrowsmith North mining operations can meet the requirements of post-mining land use and the conservation outcomes anticipated to be required through environmental approvals.

10 GLOSSARY

Term	Meaning
ADE	Access development envelope
ALUM	Australian Land Use Management
Conventional Mine Rehabilitation	Rehabilitation where vegetation tops are removed, topsoil stripped, stockpiled or direct replaced, seed and seedlings applied
DE	Development Envelope
Direct replace	Referring to topsoil in rehabilitation, being placed immediately after stripping onto the rehabilitation site (i.e. not stockpiled)
DMIRS	Department of Mines Industry Regulation and Safety
DPaW	Department of Parks and Wildlife
DPLH	Department of Planning Lands and Heritage
EP Act	*Environmental Protection Act 1986*
EPA	Environmental Protection Authority (WA)
EPA	Environmental Protection Authority
EPBC Act	*Environmental Protection and Biodiversity Conservation Act 1999* (Commonwealth)
ha	Hectares
ILUA	Indigenous Land Use Agreement
km	Kilometres
m	Metres
MDE	Mine Development Envelope
MFP	Mine Feed Plant
Mining Act	*Mining Act 1978*
MLA	Mining Lease Application
PMLU	Post Mining Land Use
Project	Arrowsmith North Silica Sand Project
PSD	Particle Size Distribution
Recalcitrant	Species that do not return to sites where conventional mine rehabilitation methods are used
RL	Reduced Level
SPP	Silica Processing Plant
Strip mining	Where mining proceeds in a linear fashion along a deposit
TO	Traditional Owners
UCL	Unallocated Crown Land
UCL	Unallocated Crown Land
VDT	Vegetation Direct Transfer – method of rehabilitation
VRX	VRX Silica Pty Ltd
WA	Western Australia
WABSI	Western Australian Biodiversity Science Institute

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12 APPENDICES

Appendix 1: PSD comparison results.

PSD Comparison North

ANPSD Comp01 Top of Hole Composite						ANPSD Comp02 Bottom of Hole Composite				
Sieve diameter (um)	Weight g	Weight %	Retain (%)	Passing (%)	Fraction	Weight g	Weight %	Retain (%)	Passing (%)	Fraction
+1180	1.5	0.3	100.0	0.3	Gravel 1.1%	1.6	0.3	100.0	0.3	Gravel 1.8%
+850	4.2	0.8	99.7	1.1		10	1.6	99.7	1.8	
+600	365	68.6	98.9	69.7	Sand 98.2%	63	9.8	98.2	11.7	Sand 96.3%
+425	102	19.2	30.3	88.9		187	29.2	88.3	40.9	
+300	17	3.2	11.1	92.1		195	30.5	59.1	71.4	
+212	22	4.1	7.9	96.2		105	16.4	28.6	87.8	
+150	12	2.3	3.8	98.5		51	8.0	12.2	95.8	
+106	4	0.8	1.5	99.2		15	2.3	4.2	98.1	
+75	2	0.4	0.8	99.6	Silt 0.8%	6	0.9	1.9	99.1	Silt 1.9%
+53	1	0.2	0.4	99.8		4	0.6	0.9	99.7	
-53	1	0.2	0.2	100.0		2	0.3	0.3	100.0	

PSD Comparison Mid

ANPSD Comp03 Top of Hole Composite						ANPSD Comp04 Bottom of Hole Composite				
Sieve diameter (um)	Weight g	Weight %	Retain (%)	Passing (%)	Fraction	Weight g	Weight %	Retain (%)	Passing (%)	Fraction
+1180	2	0.4	100.0	0.4	Gravel 1.7%	2	0.4	100.0	0.4	Gravel 3.7%
+850	6	1.3	99.6	1.7		15	3.3	99.6	3.7	
+600	262	56.3	98.3	58.1	Sand 97.2%	58	12.6	96.3	16.3	Sand 93.7%
+425	102	21.9	41.9	80.0		79	17.2	83.7	33.6	
+300	45	9.7	20.0	89.7		120	26.1	66.4	59.7	
+212	25	5.4	10.3	95.1		111	24.2	40.3	83.9	
+150	13	2.8	4.9	97.8		47	10.2	16.1	94.1	
+106	5	1.1	2.2	98.9		15	3.3	5.9	97.4	
+75	3	0.6	1.1	99.6	Silt 1.1%	7	1.5	2.6	98.9	Silt 2.6%
+53	1	0.2	0.4	99.8		4	0.9	1.1	99.8	
-53	1	0.2	0.2	100.0		1	0.2	0.2	100.0	

PSD Comparison South

ANPSD Comp05 Top of Hole Composite						ANPSD Comp06 Bottom of Hole Composite				
Sieve diameter (um)	Weight		Retain (%)	Passing (%)	Fraction	Weight		Retain (%)	Passing (%)	Fraction
	g	%				g	%			
+1180	1	0.3	100.0	0.3	Gravel 1.6%	1	0.2	100.0	0.2	Gravel 2.5%
+850	4	1.3	99.7	1.6		9	2.2	99.8	2.5	
+600	68	22.2	98.4	23.9	Sand 97.1%	91	22.5	97.5	25.0	Sand 95.5%
+425	125	40.8	76.1	64.7		92	22.8	75.0	47.8	
+300	60	19.6	35.3	84.3		118	29.2	52.2	77.0	
+212	28	9.2	15.7	93.5		56	13.9	23.0	90.8	
+150	12	3.9	6.5	97.4		21	5.2	9.2	96.0	
+106	4	1.3	2.6	98.7		8	2.0	4.0	98.0	
+75	2	0.7	1.3	99.3	Silt 1.3%	4	1.0	2.0	99.0	Silt 2.0%
+53	1	0.3	0.7	99.7		3	0.7	1.0	99.8	
-53	1	0.3	0.3	100.0		1	0.2	0.2	100.0	

Appendix 2: Particle Size Classification Scheme (ISO 14688-1:2002).

Name	Particles	Size Range (mm)	(µm)
Very coarse soil	Large boulder	>630	
	Boulder	200–630	
	Cobble	63–200	
Coarse soil	Coarse gravel	20–63	
	Medium gravel	6.3–20	
	Fine gravel	2.0–6.3	
	Coarse sand	0.63–2.0	630-2,000
	Medium sand	0.2–0.63	200-630
	Fine sand	0.063–0.2	63-200
Fine soil	Coarse silt	0.02–0.063	20-63
	Medium silt	0.0063–0.02	6.3-20
	Fine silt	0.002–0.0063	2-6.3
	Clay	≤0.002	<2