



PO Box 437
Kalamunda WA 6926
+61 08 9257 1625
admin@mattiske.com.au

(ACN 063 507 175, ABN 39 063 507 175)

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VRX Silica Ltd (VRX)
6 Thelma St, West Perth WA 6005
Phone: (08) 9226 3780

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Investigation of Root Systems of the Priority Flora species recorded in the Arrowsmith North mine survey area

Introduction

Mattiske Consulting Pty Ltd (Mattiske Consulting) was commissioned by VRX Silica Ltd (VRX) to determine the viability of Vegetation Direct Transfer (VDT) for the range of priority flora species recorded within Tenement L70/199, Arrowsmith, Western Australia. VDT is the rehabilitation practice of transferring intact topsoil and native vegetation from a natural community directly onto a prepared rehabilitation area. The Kwongan Vegetation including the vegetation in the Arrowsmith North mine survey area has a high botanical diversity with many recalcitrant species – especially in the families Restionaceae, Cyperaceae, Dilleniaceae and Ericaceae. In addition, many species rely on regrowth from underground root structures after disturbance rather than seed. There have been few studies of plant root systems in the Geraldton Sandplains and only generic information could be found for the priority species of interest.

In March 2022, Mattiske Consulting undertook a targeted examination of the root systems of the previously recorded priority species. This information will aid in determining the viability of the VDT rehabilitation practice for these species and also for prioritising options for the different priority species. Such options for some species will include selective transplanting of plants into rehabilitation areas (this has been applied for some species in southwest), seed collection, tube stock planting and potential alternative options that may require further investigations with specialists.

Regional Context

The Arrowsmith North mine survey area lies approximately 35 km North of Eneabba and approximately 20 km southeast of Dongara, Western Australia (Figure 1a & 1b). The survey area is within the Irwin Botanical District of the South-West Botanical Province (Beard 1990) and the Lesueur Sandplain subregion of the Geraldton Sandplains Region of the Interim Biogeographic Regionalisation for Australia (IBRA) (Department of Agriculture Water and the Environment 2022).

Methods

There were eleven priority species identified in the Arrowsmith North mine survey area from the Mattiske Consulting vegetation mapping and targeted surveys conducted between 2018 and 2021 (Mattiske Consulting 2022). These species' locations were uploaded to the Esri iOS application, Collector for ArcGIS on Apple iPads (provided and

maintained by CAD Resources). Data layers accessible in the field included the Arrowsmith North survey area, locations of all known conservation significant flora from both historical and contemporary surveys and aerial imagery supplied by CAD Resources.

One or two mature plants of each targeted priority species were located, and then excavations were made along the edge of the plant with a spade in order to expose a cross section of the root system. The depth of the excavation was determined in-situ as the roots were uncovered and were different depending on the species and site conditions. Hand trowels and brushes were used to expose the finer, more delicate roots. Care was taken to uncover a tap, stilt, adventitious or lignotuberous root system without damage. Measurements were taken in centimetres for plant height and width and root depth and length with a tape measure and in millimetres for root diameter with callipers. Photographs were taken of the root system of each plant and are presented in the results.

A summary and ranking of the species was completed using the recorded root depths. The rankings from Crombie *et al.* (1988) were used to categorise the root system depth as shallow (0-0.5 m), moderate (0.5-2.0 m) and deep (>2.0 m).

Results

Schoenus sp. Eneabba (F. Obbens & C. Godden I154) (P2) – CYPERACEAE

This species is an erect, clumped rhizomatous sedge to 75 cm tall. It is often found growing in grey, yellow or white sand (Plate 1a; WAH 1998-). The WAH houses 13 specimens of *Schoenus* sp. Eneabba (F. Obbens & C. Godden I154), distributed from Eneabba to the Yordanogo Nature Reserve near Dongara. *Schoenus* sp. Eneabba (F. Obbens & C. Godden I154) was recorded from 30 locations within the Arrowsmith North mine survey area totalling 467 plants.



Plate 1: Two different *Schoenus* sp. Eneabba (F. Obbens & C. Godden I154) (P2) plants with roots exposed (Photo: D. Rubick)

Two plants of *Schoenus* sp. Eneabba (F. Obbens & C. Godden I154) from the same population in deep yellow sand on a mid-slope were excavated (Plate 1). Previous collection of *Schoenus* sp. Eneabba (F. Obbens & C. Godden I154) showed that the rhizomes of this species are short with an ascending pattern of growth (Plate 1a). The plants excavated were 57 cm and 55 cm tall with the culms forming tufts. Roots of *Schoenus* sp. Eneabba (F.

Obbens & C. Godden I154) were approximately 30 cm long with a diameter of 2 mm which was uniform along the length. Numerous and mostly uniform roots which also appeared to have some sand binding ability were found. The roots were oriented both laterally and vertically with root depths of 30 cm deep on both plants sampled.



Plate 1a: Rhizomes of *Schoenus* sp. Eneabba (F. Obbens & C. Godden I154) (P2) collection SBR1862 29/10/2020

***Beyeria gardneri* (P3) – EUPHORBIACEAE**

Beyeria gardneri is a shrub to 50 cm high with yellow flowers from August to September. It often occurs on yellow sand. WAH houses 37 records from Cataby to Nerren Nerren in the Shire of Carnamah, Shire of Chapman Valley, Shire of Coorow, Shire of Dandaragan, City of Greater Geraldton, Shire of Irwin, Shire of Northampton, Shire of Shark Bay and the Shire of Three Springs. *Beyeria gardneri* was recorded from eight locations within the Arrowsmith North mine survey area totalling 33 plants.



Plate 2: *Beyeria gardneri* (P3) with roots exposed (D. Rubick)

One plant of *Beyeria gardneri* was excavated in yellow sand on a sandstone ridge (Plate 2). *Beyeria gardneri* was found to have a tap root reaching below 40 cm. The plant also had fine (<1 mm) adventitious roots originating from the tap root. The tap root had a 3 mm diameter at the base of the plant and 2 mm diameter at 20 cm depth. Other adventitious roots were 2 mm in diameter. The height of the plant was 55 cm.

***Hemiandra* sp. Eneabba (H. Demarz 3687) (P3) – LAMIACEAE**

Hemiandra sp. Eneabba (H. Demarz 3687) is a straggly, erect shrub, growing from 0.5 to 0.9 m high with blue/violet/white flowers from September to February. It often occurs on sand. The WAH houses 35 specimens of *Hemiandra* sp. Eneabba (H. Demarz 3687) distributed from Eneabba to Yardarino from the Shire of Carnamah, Shire of Coorow, Shire of Irwin and Shire of Three Springs (WAH 1998-). *Hemiandra* sp. Eneabba (H. Demarz 3687) was recorded from 161 locations within the Arrowsmith North mine survey area totalling 231 plants.

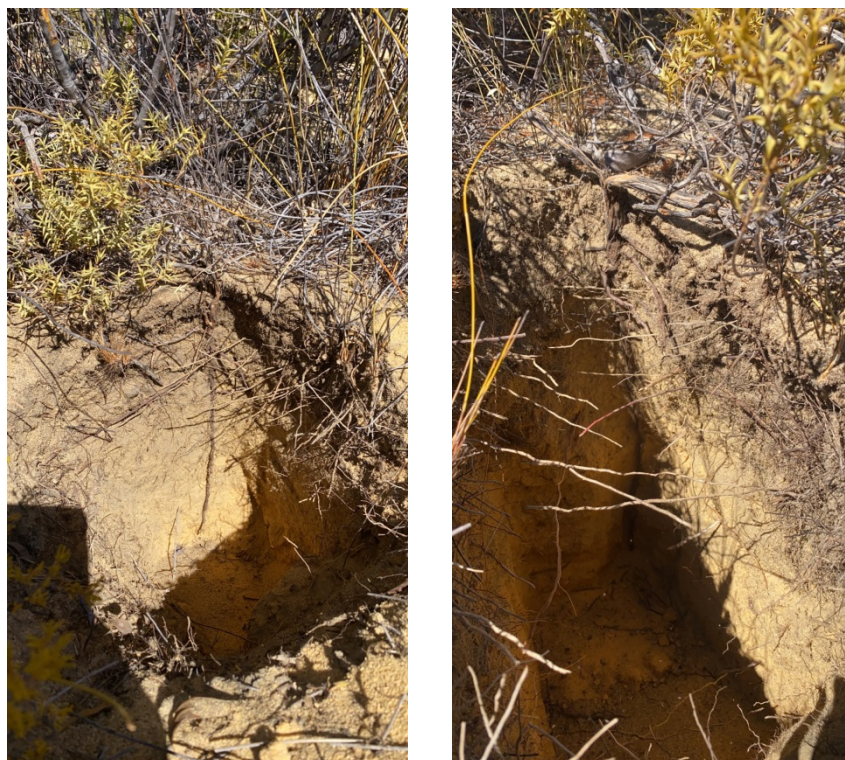


Plate 3: Two plants of *Hemiandra* sp. Eneabba (H. Demarz 3687) (P3) with roots exposed (Photo: D. Rubick)

Two plants of *Hemiandra* sp. Eneabba (H. Demarz 3687) were excavated in deep yellow sand (Plate 3). *Hemiandra* sp. Eneabba (H. Demarz 3687) had a deep and distinct tap root extending more than 60 cm deep. One plant of *Hemiandra* sp. Eneabba (H. Demarz 3687) was 35 cm tall with a tap root of more than 60 cm and the second plant was 20 cm tall with a tap root deeper than 70 cm. The tap root diameters were 8 mm and 11 mm near the surface, 3.5 mm and 4 mm at 30cm depth and 2 mm and 3 mm at 60 cm depth. There are many small, fine lateral roots in the top 10cm of soil that measure between 1mm and 2mm in diameter.

***Hopkinsia anoectocolea* (P3) – ANARTHIACEAE**

Hopkinsia anoectocolea is a rhizomatous, tufted perennial herb that grows 0.5 to 1 m tall with brown flowers from September to December. *Hopkinsia anoectocolea* often occurs in white or grey sand, winter wet depressions, floodplains and salt lakes. WAH houses 50 records from the Shire of Carnamah, Shire of Cunderdin, Shire of Dandaragan, Shire of Irwin, Shire of Tammin and Shire of York (WAH 1998-). *Hopkinsia anoectocolea* was recorded from 85 locations within the Arrowsmith North transport corridor totalling 657 plants.



Plate 4: *Hopkinsia anoectocolea* (P3) with roots exposed (Photo: D. Rubick)

One plant of *Hopkinsia anoectocolea* was excavated in grey sandy clay (Plate 4). Previous collection of *Hopkinsia anoectocolea* showed that the rhizomes of this species had a horizontal unbranched pattern of growth (Plate 4a). The plant excavated was 80 cm tall with the culms forming tufts. *Hopkinsia anoectocolea* has brittle adventitious and sand binding roots that extend sporadically between 30 cm and 40 cm deep. The root diameters were 5 mm at the surface and 2 mm at 30 cm in depth. Roots were oriented downward at an approximately 45-degree angle from the base of the plant.



Plate 4: Rhizomes of *Hopkinsia anoectocolea* (P3) collection SBR1895
22/09/2021

***Hypocalymma gardneri* (P3) – MYRTACEAE**

Hypocalymma gardneri is a shrub growing to 0.3 m high with yellow flowers from August to September. It often occurs on grey-brown sand, laterite, sandplains and upper slopes. WAH houses 22 records from the Shire of Carnamah, Shire of Coorow, Shire of Dandaragan and Shire of Irwin (WAH 1998-). *Hypocalymma gardneri* (P3) was recorded from 152 locations within the Arrowsmith North mine survey area totalling 274 plants.



Plate 5: Two plants of *Hypocalymma gardneri* (P3) with roots exposed. (Photo: D. Rubick)

Three plants of *Hypocalymma gardneri* were excavated in grey or grey-yellow sand (Plate 5). *Hypocalymma gardneri* had adventitious roots to a depth of 15 cm with a diameter of 2 mm. The plant heights were 30 cm to 40 cm. The roots spread more laterally than down and each root was covered in a loose bark like layer. The longest measured root was 38 cm; however, this root was broken and extended further.

***Banksia elegans* (P4) – PROTEACEAE**

Banksia elegans is a shrub with fire-tolerant rootstock growing from 1 to 4 m high, with yellow flowers from October to November. *Banksia elegans* often occurs on yellow, white or red sandplains or low consolidated dunes. WAH houses 44 records distributed from Hill River to Walkaway, from the Shire of Carnamah, Shire of Dandaragan, City of Greater Geraldton, Shire of Irwin and the Shire of Three Springs (WAH 1998-). *Banksia elegans* was recorded from 741 locations within the Arrowsmith North survey area totalling 3395 plants.



Plate 6: *Banksia elegans* (P4) with roots exposed (D. Rubick)

One plant of *Banksia elegans* was excavated in yellow sand on an upper slope (Plate 6). *Banksia elegans* has a deep root structure with a lignotuber and spreading adventitious roots. The lignotuber was 5cm tall above the surface and 5 cm below. The total width was 25 cm. Adventitious roots extended well beyond the 30 cm of the excavation with diameters of 30 mm and 12 mm measured at the lignotuber and 15 mm and 5 mm 30 cm from the lignotuber. The majority of roots were aligned laterally.

***Schoenus griffinianus* (P4) – CYPERACEAE**

Schoenus griffinianus is a small, tufted perennial sedge to 0.1 m high which flowers from September to October. *Schoenus griffinianus* occurs predominantly on white sand, often in disturbed areas. WAH houses 40 records from the Shire of Carnamah, Shire of Chittering, Shire of Coorow, Shire of Dandaragan, Shire of Gingin, City of Greater Geraldton, Shire of Irwin, City of Swan, Shire of Three Springs and Shire of Wongan-Ballidu (WAH 1998-). *Schoenus griffinianus* was recorded from five locations within the Arrowsmith North mine survey area totalling nine plants.



Plate 7: *Schoenus griffinianus* (P4) with roots exposed (Photo: D. Rubick)

One plant of *Schoenus griffinianus* was excavated in yellow grey sand (Plate 7). This species was found to have fine roots up to 10cm with a diameter less than 1 mm. There was no evidence of stilt or tap roots in this species. Roots were oriented downward at an approximately 45-degree angle from the base of the plant.

***Stawellia dimorphantha* (P4) – HEMEROCALLIDACEAE**

Stawellia dimorphantha is a stilt-rooted perennial herb that grows 0.05 to 0.2 m high with purple/cream flowers from June to November. *Stawellia dimorphantha* often occurs on white, grey and yellow sand (Plate 1e; WAH 1998-). WAH houses 23 records distributed from Eneabba to Allanoooka, from the Shire of Carnamah, Shire of Irwin and the Shire of Three Springs (WAH 1998-). In the Arrowsmith North survey area, *Stawellia dimorphantha* (P4) was recorded from 248 locations totalling 398 plants.



Plate 8: *Stawellia dimorphantha* (P4) with roots exposed (Photo: D. Rubick)

Two plants of *Stawellia dimorphantha* were excavated in brown yellow sand in depressions between sandstone rises (Plate 8). *Stawellia dimorphantha* has a shallow stilted root system with roots no longer than 20 cm with diameters less than 1.5 mm. Roots were oriented down and slightly out with each stilt having individual roots.

Table 1: Root system assessment summary and viability for VDT, March, 2022

SPECIES	SCC	NUMBER OF PLANTS	PLANT HEIGHT (cm)	ROOT DEPTH (cm)	ROOT SYSTEM TYPE	ROOT DEPTH RANK
<i>Schoenus sp. Eneabba</i> (F. Obbens & C. Godden I154)	P2	2	55 - 57	30	Adventitious	Shallow
<i>Beyeria gardneri</i>	P3	1	55	>40	Adventitious, tap root	Moderate
<i>Hemiandra sp. Eneabba</i> (H. Demarz 3687)	P3	2	35 - 20	>60	Tap root	Moderate
<i>Hopkinsia anoectocolea</i>	P3	1	80	40	Adventitious, sand binding	Shallow
<i>Hypocalymma gardneri</i>	P3	3	30 - 40	15 - 30	Adventitious	Shallow
<i>Banksia elegans</i>	P4	1	80	> 100	Tap root, lignotuber	Moderate/Deep
<i>Schoenus griffinianus</i>	P4	1	8	10	Adventitious	Shallow
<i>Stawellia dimorphantha</i>	P4	2	4 - 9	18 - 20	Stilt	Shallow

Discussion and Conclusion

A desktop review was completed on the probable root depths of the potential and recorded threatened and priority flora species in the Arrowsmith survey areas in February of 2022 by Mattiske Consulting. This review indicated that many of the threatened and priority species have shallow to moderate root systems. This desktop assessment identified that from the 11 priority species confirmed within the Arrowsmith North mine survey area;

- Two species are most likely to have shallow roots less than 0.5 m (*Schoenus griffinianus* (P4) and *Stawellia dimorphantha* (P4)).
- Six are most likely to have shallow to moderate roots between 0.5 and 2 m (*Schoenus* sp. Eneabba (F. Obbens & C. Godden 1154) (P3), *Beyeria gardneri* (P3), *Comesperma rhadinocarpum* (P3), *Hopkinsia anoectocolea* (P3), *Hypocalymma gardneri* (P3) and *Leschenaultia juncea* (P3)).
- Three species are most likely to have moderate to deep roots more than 2 m (*Hemiandra* sp. Eneabba (H. Demarz 3687) (P3), *Persoonia rudis* (P3) and *Banksia elegans* (P4)), Appendix A.

In March, 2022, an investigation into root systems at Arrowsmith North mine survey area supported background research in the desktop review with the majority of the priority species present recorded with shallow to moderate root systems. Five of the priority species were recorded with shallow root systems which increases the potential for successful vegetation direct transfer. Three species were recorded with moderate to deep root systems indicating there would be less chance of successful vegetation direct transfer.

The five species with shallow root systems were;

- *Schoenus* sp. Eneabba (F. Obbens & C. Godden I154) (P2) is an erect, clumped rhizomatous, perennial, grass-like or herb (sedge), to 0.75 m high (WAH 1998-). At Arrowsmith North this species was recorded with an adventitious and shallow root system up to 30 cm in depth.
- *Hopkinsia anoectocolea* (P3) is a rhizomatous, tufted perennial, herb, 0.5-1 m high, to 1 m in diameter (WAH 1998-). This species at Arrowsmith North was recorded to have shallow roots up to 40 cm.
- *Hypocalymma gardneri* (P3) is a shrub to 30 cm tall and was recorded to have shallow roots up to 30 cm (WAH 1998-).
- *Schoenus griffinianus* (P4) is a small, tufted perennial, grass-like or herb (sedge), to 0.1 m high (WAH 1998-). This species was recorded with fine roots that extend to approximately 10 cm.
- *Stawellia dimorphantha* (P4) is a stilt-rooted perennial, herb that grows 0.05 to 0.2 m high. *Stawellia dimorphantha* was recorded to have stilted roots that reach 20cm deep at the Arrowsmith North mine survey area.

The three species with moderate to deep root systems were;

- *Beyeria gardneri* (P3) is a monoecious shrub at 25 to 50 cm tall with a tap root that reaches at least 40 cm at the Arrowsmith North mine survey site. It is likely that the tap root would reach moderate depths between 50 cm and 100 cm making success difficult during shallow VDT.
- *Hemiandra* sp. Eneabba (H. Demarz 3687) (P3) is a shrub that grows to 50cm high and 40cm wide. It has a confirmed moderately deep tap root that extends 60cm in depth at the Arrowsmith North site.
- *Banksia elegans* (P4) is a shrub that grows to 4 m tall with strong fire tolerance (George A.S. 1999). *Banksia elegans* was recorded with a moderate to deep root system that includes a lignotuber. This species is unlikely to be successful in VDT.

VDT has numerous benefits as a native vegetation restoration technique due to completeness of the vegetation community, soil ecosystem transfer and established root systems. It is likely that the use of VDT will be a successful technique for the establishment of *Schoenus* sp. Eneabba (F. Obbens & C. Godden I154) (P2), *Hopkinsia anoectocolea* (P3), *Hypocalymma gardneri* (P3), *Schoenus griffinianus* (P4) and *Stawellia dimorphantha* (P4). VDT is unlikely to be successful for *Beyeria gardneri* (P3), *Hemiandra* sp. Eneabba (H. Demarz 3687) (P3) and *Banksia elegans* (P4). The size of *Banksia elegans* specimens is likely to be prohibitive to harvest and transportation for VDT due to the large and woody lignotuberous root system.

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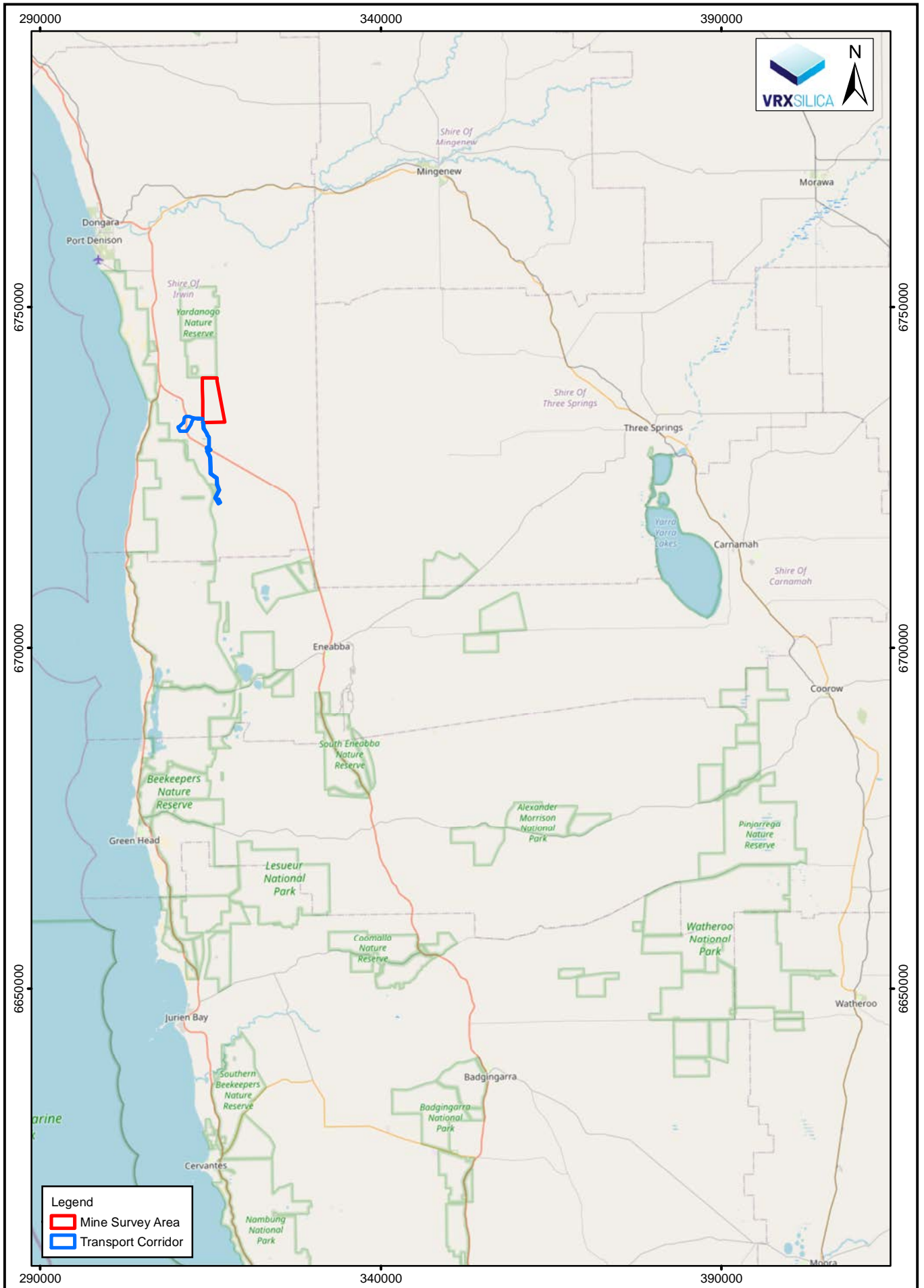
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Attachments

Figure 1a: Arrowsmith North Project Locality

Figure 1b: Arrowsmith Northern Project tenements.

Appendix A: Root length potential T & P



Legend

- Mine Survey Area
- Transport Corridor

0 14 km
 Scale: 1:750,000
 MGA94 (Zone 50)

Mattiske Consulting Pty Ltd
 28 Central Road, Kalamunda WA 6076 - Tel: 9257 1625 - Fax: 9257 1640

Author: E M Mattiske MCPL Ref: VRX2103/002/22

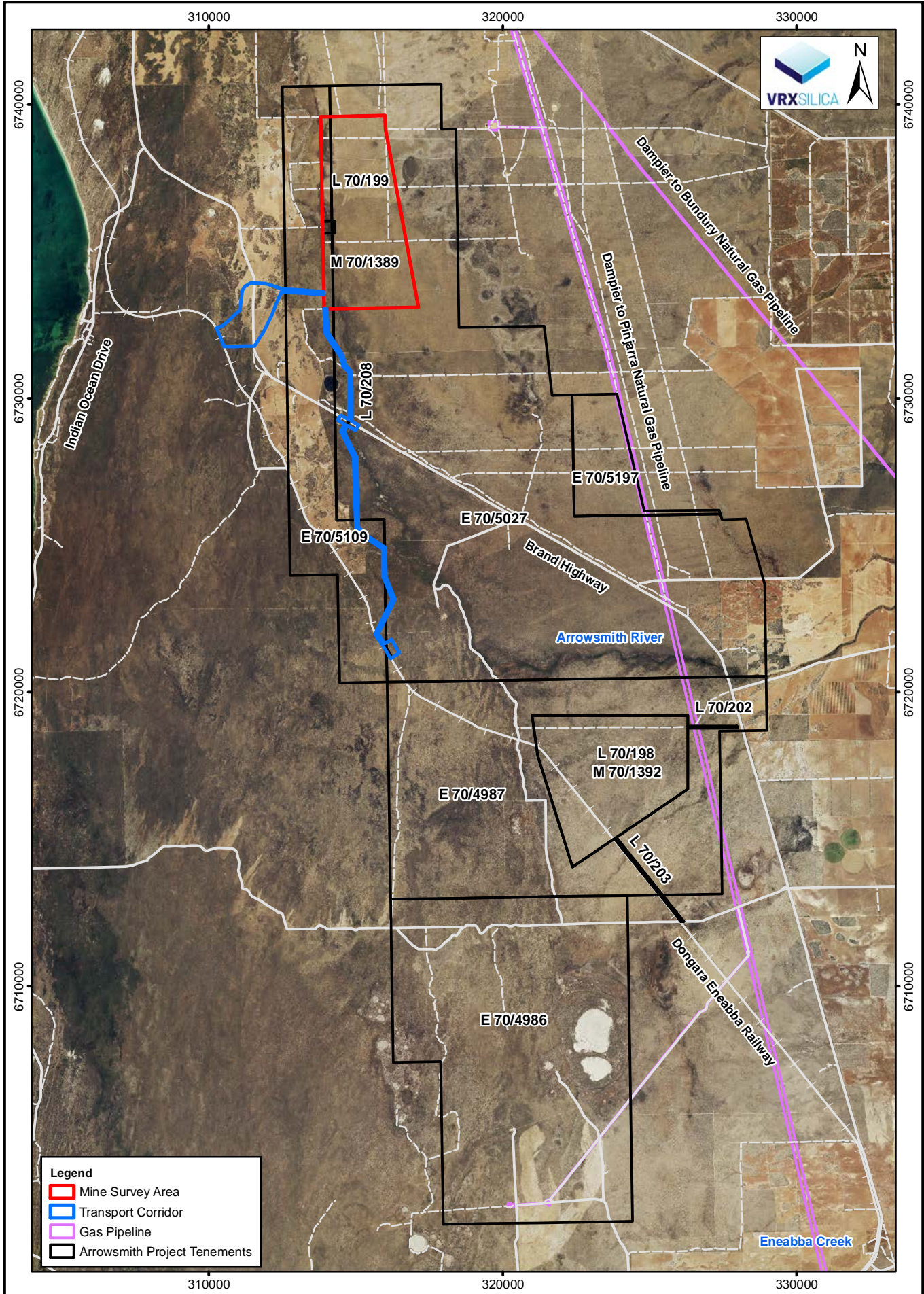
Drawn: CAD Resources ~ www.cadresources.com.au
 Tel: (08) 9246 3242 - Fax (08) 9246 3202

Arrowsmith North Project Locality

Figure:
1a

Imagery: OpenStreetMap

CAD Ref: a2602_f51_01
 Date: February 2022 Rev: A | A4



Source: Aerial Photography, Landgate (Nov. 2016), Tenements: DMIRS (24/06/2019)

Legend

- Mine Survey Area
- Transport Corridor
- Gas Pipeline
- Arrowsmith Project Tenements

0 4 km

Scale: 1:175,000
MGA94 (Zone 50)

CAD Ref: a2602_f51_02
Date: February 2022

Rev: B | A4

Mattiske Consulting Pty Ltd

28 Central Road, Kalamunda WA 6076 - Tel: 9257 1625 - Fax: 9257 1640

Author: E M Mattiske MCPL Ref: VRX2103/002/22

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Tel: (08) 9246 3242 - Fax (08) 9246 3202

Arrowsmith Northern Project Tenements

Figure:
1b

APPENDIX A: ASSESSMENT OF POTENTIAL ROOT DEPTHS OF POTENTIAL AND RECORDED THREATENED AND PRIORITY FLORA IN THE ARROWSMITH SURVEY AREAS

Note: Refer to Appendix A for State (SCC; Department of Biodiversity, Conservation and Attractions 2019) and Federal (FCC; EPBC Act) conservation code definitions. IBRA Distribution: AVW – Avon Wheatbelt; CAR – Carnarvon; COO – Coolgardie; ESP – Esperance Plains; GAS – Gascoyne; GES – Geraldton Sandplains; GVD – Great Victoria Desert; JAF – Jarrah Forest; MAL – Mallee; MUR – Murchison; SWA – Swan Coastal Plain; YAL – Yalgoo. Likelihood of occurrence in survey area is based on a Low, Moderate or High ranking.

Species	Family	SCC	FCC	Root Depth (Assumed)	Root Information	Likelihood of Occurrence
<i>Conostylis dielsii</i> subsp. <i>teres</i>	Haemodoraceae	T	Endangered	Shallow	Shortly rhizomatous (Cooke 1987, WAH) Rhizome and root tissues brightly red-pigmented, or not red-pigmented (WAH 1998-). Not found to have sand binding roots (Smith et al 2011)	Moderate Habitat potentially occurs in survey area.
<i>Conostylis micrantha</i>	Haemodoraceae	T	Endangered	Shallow	Rhizome and root tissues brightly red-pigmented, or not red-pigmented (WAH 1998-). Not found to have sand binding roots (Smith et al 2011)	Moderate Habitat potentially occurs in survey area.
<i>Hemiandra gardneri</i>	Lamiaceae	T	Endangered	Shallow - Moderate	(Stack & Broun 2004) Most species of the Mint family (Lamiaceae) are grown easily from cuttings, though they often develop poor root systems. Seed germination would be required to overcome this problem (B. Conn2 personal communication 1996). <i>H. gardneri</i> has been cultivated by the nursery trade in Western Australia (Burgman and Hopper 1982).	Moderate Habitat potentially occurs in survey area.
<i>Paracaleana dixonii</i>	Orchidaceae	T	Endangered	Shallow	(Hopper & Brown 2006) Perennial geophytic herbs. Root tuber solitary in summer, paired in wet season, annually replaced, new tuber produced at the end of an elongate descending side-dropper (root-like stolon).	Moderate Habitat potentially occurs in survey area.
<i>Drosera pedicellaris</i>	Droseraceae	P1	-	Shallow	A fibrous-rooted perennial herb (Lowre 2002)	Moderate
<i>Lasiopetalum ogilvieanum</i>	Malvaceae	P1	-	Moderate - Deep	Rounded or spindly shrub to 1.5 m tall Associated with low open Eucalyptus todtiana woodland over heath with Hakea, Allocasuarina, or Melaleuca and Beaufortia growing in white, grey, yellow or yellow-brown sand over granite or with laterite (Shepherd & Wilkins 2021).	Moderate Habitat potentially occurs in survey area.
<i>Poranthera asybosca</i>	Phyllanthaceae	P1	-	Shallow	Monoecious, erect <i>annual</i> , 20–45 mm tall (Barrett & Barrett 2015)	Moderate Habitat potentially occurs in survey area.
<i>Verticordia luteola</i> var. <i>rosea</i>	Myrtaceae	P1	-	Moderate	Slender shrub to 2 m, without lignotuber (George & George 1994)	Moderate Habitat potentially occurs in survey area.

APPENDIX A: ASSESSMENT OF POTENTIAL ROOT DEPTHS OF POTENTIAL AND RECORDED THREATENED AND PRIORITY FLORA IN THE ARROWSMITH SURVEY AREAS

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Species	Family	SCC	FCC	Root Depth (Assumed)	Root Information	Likelihood of Occurrence
<i>Comesperma griffinii</i>	Polygalaceae	P2	-	Shallow	<i>C. griffinii</i> appears to be a post-fire ephemeral in this third group (short-lived post-fire ephemeral with a corky rootstock) (Keighery 2002). Herb perennial or possibly annual, 5–15 cm tall, with a slender taproot (Keighery 2002).	Moderate Habitat potentially occurs in survey area.
<i>Schoenus</i> sp. Eneabba (F. Obbens & C. Godden 1154)	Cyperaceae	P2	-	Shallow - Moderate	Erect, clumped rhizomatous, perennial, grass-like or herb (sedge), to 0.75 m high (WAH 1998-)	Recorded in the North Arrowsmith survey area.
<i>Scholtzia calcicola</i>	Myrtaceae	P2	-	Moderate - Deep	Shrub erect, dense, 0.2–2 m high, 0.3–1.2 m wide (Rye 2019)	Moderate Habitat potentially occurs in survey area.
<i>Verticordia argentea</i>	Myrtaceae	P2	-	Moderate - Deep	Erect, open shrub, 0.9-2 m high (WAH 1998-). Regeneration is from seed (<i>Verticordia</i> General) (George 1991)	Moderate Habitat potentially occurs in survey area.
<i>Acacia latipes</i> subsp. <i>licina</i>	Fabaceae	P3	-	Moderate	Diffuse to dense, erect or prostrate shrub 1 m high	Moderate Habitat potentially occurs in survey area.
<i>Banksia fraseri</i> var. <i>crebra</i>	Proteaceae	P3	-	Moderate	Shrub usually less than 50 cm high (George 2005).	Moderate Habitat potentially occurs in survey area.
<i>Beyeria gardneri</i>	Euphorbiaceae	P3	-	Shallow - Moderate	Monoecus shrub 25 to 50 cm tall	Recorded in the North Arrowsmith survey area.

APPENDIX A: ASSESSMENT OF POTENTIAL ROOT DEPTHS OF POTENTIAL AND RECORDED THREATENED AND PRIORITY FLORA IN THE ARROWSMITH SURVEY AREAS

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Species	Family	SCC	FCC	Root Depth (Assumed)	Root Information	Likelihood of Occurrence
<i>Centrolepis milleri</i>	Centrolepidaceae	P3	-	Shallow	Tufted annual 13–35 mm high (Figs. 1, 2A). Primary root always present, 1.1–11 mm long. Adventitious roots up to 15 mm long usually present on epicotyl and/or nodes of leaf rosette, sometimes on the cotyledonary node. Roots on hypocotyl not recorded. Primary and adventitious roots 0.2–0.3 mm (in distal parts up to 0.4 mm) in diameter, with dense root hairs up to 0.5 mm long, usually branching up to the second order. Due to root curving just after departure of a lateral root, branching superficially resembles a dichotomy. Specimens of <i>C. milleri</i> grow with their leaves mostly buried by sand. This semi-subterranean habit is possibly an adaptation to avoid light stress. (Barrett & Sokoloff 2015)	Moderate Habitat potentially occurs in survey area.
<i>Comesperma rhadinocarpum</i>	Polygalaceae	P3	-	Shallow - Moderate	Erect herb to 45cm (Blackall & Grieve 1998). Present in previous VDT Study (Mattiske 2019)	Recorded in the North Arrowsmith survey areas.
<i>Grevillea erinacea</i>	Proteaceae	P3	-	Moderate - Deep	Spreading shrub 0.3-1.8 m high (Makinson 2000)	Recorded in the Central Arrowsmith survey area.
<i>Hemiandra</i> sp. Eneabba (H. Demarz 3687)	Lamiaceae	P3	-	Moderate - Deep	Shrub to 50 cm tall (WAH 1998-). Present in previous VDT Study (Mattiske 2019). Perennial compact shrub 35 cm high x 40 cm wide. Flowers pink, throat mottled. Deep tap roots (Davis -PERTH 06340261, WAH)	Recorded in the North and Central Arrowsmith survey areas.
<i>Hopkinsia anoectocolea</i>	Anarthriaceae	P3	-	Shallow - Moderate	Rhizomatous, tufted perennial, herb, 0.5-1 m high, to 1 m in diameter (WAH 1998-).	Recorded in the North and Central Arrowsmith survey areas.
<i>Hypocalymma gardneri</i>	Myrtaceae	P3	-	Shallow - Moderate	Shrub to 30 cm tall (WAH 1998-). Present in previous VDT Study (Mattiske 2019)	Recorded in the North and Central Arrowsmith survey areas.

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Species	Family	SCC	FCC	Root Depth (Assumed)	Root Information	Likelihood of Occurrence
<i>Leschenaultia juncea</i>	Goodeniaceae	P3	-	Shallow - Moderate	Grass-like, erect perennial, herb or shrub, to 0.5 m high (WAH 1998-)	Recorded in the North Arrowsmith survey area.
<i>Persoonia rudis</i>	Proteaceae	P3	-	Moderate - Deep	Erect, often spreading shrub, 0.2-1 m high (WAH 1998-)	Recorded in the North and Central Arrowsmith survey areas.
<i>Stylidium torticarpum</i>	Stylidiaceae	P3	-	Shallow	Perennial herb, 0.12 to 0.27m high (WAH 1998-).	Recorded in the Central Arrowsmith survey area.
<i>Styphelia filifolia</i>	Ericaceae	P3	-	Shallow - Moderate	Shrub, 30cm to 50cm, multi-stemmed and up to 0.9m wide (WAH 1998-).	Recorded in the Central Arrowsmith survey area.
<i>Verticordia fragrans</i>	Myrtaceae	P3	-	Moderate - Deep	A shrub 45cm to 3 m tall and about 1 m wide without lignotuber (George 2002). Plants have spreading to penetrating root systems (suggested) (George 2002) Regeneration is from seed (Verticordia General) (George 1991)	Moderate Habitat potentially occurs in survey area.
<i>Verticordia luteola</i> var. <i>luteola</i>	Myrtaceae	P3	-	Moderate	Slender shrub to 2 m, without lignotuber (George & George 1994). Regeneration is from seed (Verticordia General) (George 1991)	Moderate
<i>Banksia elegans</i>	Proteaceae	P4	-	Moderate - Deep	Shrub (with fire-tolerant rootstock, often suckering), 1-4 m high (WAH 1998-). Fire tolerant, sprouting from the stems and rootstock. Follicles opening with fire (George AS 1999)	Recorded in the North and Central Arrowsmith survey areas.
<i>Banksia scabrella</i>	Proteaceae	P4	-	Moderate - Deep	Shrub to 2 m tall without lignotuber. Killed by fire regenerates from seed (George AS 1999).	Moderate Habitat potentially occurs in survey area.
<i>Calytrix chrysantha</i>	Myrtaceae	P4	-	Moderate	Shrub, 0.3-1.3 m high (WAH 1998-, Craven 1987)	Recorded in the Central Arrowsmith survey area.

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Species	Family	SCC	FCC	Root Depth (Assumed)	Root Information	Likelihood of Occurrence
<i>Calytrix eneabensis</i>	Myrtaceae	P4	-	Moderate	Shrub, 0.3-1 m high (WAH 1998- 1998-, Craven 1987).	Moderate Habitat potentially occurs in survey area.
<i>Calytrix superba</i>	Myrtaceae	P4	-	Moderate	Shrub, 0.2-1 m high (WAH 1998- 1998-, Craven 1987)	Moderate Habitat potentially occurs in survey area.
<i>Schoenus griffinianus</i>	Cyperaceae	P4	-	Shallow	Small, tufted perennial, grass-like or herb (sedge), to 0.1 m high. (WAH 1998-) Present in previous VDT Study (Mattiske 2019)	Recorded in the North and Central Arrowsmith survey areas.
<i>Stawellia dimorphantha</i>	Hemerocallidaceae	P4	-	Shallow	Stilt-rooted perennial, herb, 0.05-0.2 m high.	Recorded in the North Arrowsmith survey area.

Shallow 0-0.5 m, Moderate 0.5-2.0 m, Deep >2.0 m (Crombie et al 1988)

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