



Government
of South Australia

Department for
Energy and Mining

15 August 2023

Ms Sarah Rye
Operations & Reporting Geologist
Quasar Resources Pty Ltd
Suite 2, Level 7, 25 Grenfell Street
ADELAIDE SA 5000
Sarah.Rye@heathgate.com.au

Dear Ms Rye,

Approval Notification - Exploration Program for Environment Protection and Rehabilitation (EPEPR 2022-011) EL 5916, EL 6033 and EL 6244

The program review for EL 5916, EL 6033 and EL 6244, final version submitted on 10 July 2023 to conduct ongoing exploration activities at the Arkaroola project area, has been approved in accordance with Section 70B(5) of the *Mining Act, 1971* (the Act).

In accordance with section 70B(7a)(b) of the Act, the approved program is subject to the conditions listed in the attached notice.

You are reminded that:

1. You must at all times implement and comply with the approved EPEPR.
2. The approved EPEPR will be made publicly available on the Mining Register.
3. Exploration operations on “native title land” (as defined in the *Native Title (South Australia) Act, 1994*) must be conducted in accordance with Part 9B of the Act.
4. In accordance with Section 70C of the Act, the licensee must review the EPEPR on request of the Minister’s Delegate within a time specified in the request and submit the revised EPEPR for approval.
5. As the operator for the approved EPEPR you must take all reasonable and practical measures to avoid undue damage to the environment and meet all the approved outcomes (when measured against the approved criteria) listed within the EPEPR.
6. In accordance with regulation 78 of the *Mining Regulations 2020* and Terms of Reference 012 (TOR 012), the licensee must submit an Exploration Compliance Report to the Mineral Exploration Branch each year, within 60 days after the anniversary of the date the licence was granted, and 60 days after the expiry or surrender of the EL, or in accordance with joint reporting requirements agreed to with the Minister.
7. In accordance with regulation 16(4) of the *Mining Regulations 2020*, drillhole and geological samples must be kept in accordance with guidelines issued by the Department for the term of the relevant tenement and for 7 years after the expiry, surrender, cancellation or forfeiture of the tenement to which the sample relates. Furthermore, samples must be retained by the tenement holder, or provided to the Director, in accordance with those guidelines (unless the Minister has authorised, on application by the tenement holder in a manner and form set out in the guidelines, the destruction or disposal of the samples).

8. The EPEPR is approved for the term of EL 5916, EL 6033 and EL 6244.

This approval does not constitute endorsement of the systems that you have in place to manage your exploration operations in compliance with the Act and licence conditions. In granting the approval, the EPEPR and your capacity to undertake the proposed activities have been considered. However, responsibility for compliance with the Act and the licence conditions, remains at all times with the licensee.

This approval relates only to the requirements of the Act. Other legislation relevant to this application includes the *South Australian Work Health and Safety Act, 2012* and Regulations. For example, Chapter 10 of the *Work Health and Safety Regulations, 2012* (SA) introduced new requirements for mine operators in South Australia. The new requirements include a notification for mining operations and the establishment of a Safety Management System. For further information on your responsibilities, including a guide to Chapter 10 and the Mine Operator Notification Form, contact SafeWork SA on 08 8303 0255 or via its website at www.safework.sa.gov.au.

The proposed program may be subject to the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Mineral exploration industry-specific information is contained in an appendix in the EPBC Matters of National Environmental Significance – Significant impact guidelines 1.1. This document is available on the Australian Government's Department for Agriculture, Water and the Environment website at <http://www.environment.gov.au/resource/significant-impact-guidelines-11-matters-national-environmental-significance>. For further information, contact the Department for Agriculture, Water and the Environment, or visit its website at www.environment.gov.au/.

Proposed changes to exploration operations stated in the approved EPEPR may require a *PEPR review* to be submitted for assessment. Where a *PEPR review* is required, implementation of the operational changes can only occur after the revised EPEPR is approved. Further information on when an exploration PEPR review is required can be found in Departmental guideline [MG22 Conducting mineral exploration](#).

If you require any further information, please contact Frank Potts on 8429 2493 or Simon Constable on 8429 2516 or email DEM.exploration@sa.gov.au.

Yours sincerely



Simon Constable
A/DIRECTOR MINERAL EXPLORATION
MINERAL RESOURCES
In accordance with delegated
Ministerial powers and functions

CC: DEW Hydrogeologist miningwatersciencereferrals@sa.gov.au

The Department's Regulatory Guidelines, Ministerial Determinations and Information Sheets are available at: http://energymining.sa.gov.au/minerals/knowledge_centre

MINERAL EXPLORATION

Level 7, 11 Waymouth Street, Adelaide SA 5000 | GPO Box 320 Adelaide SA 5001 | DX452

Tel (+61) 8 8463 3000 | ABN 83 768 683 934

Notice of Approval Conditions – EPEPR 2022-011

In accordance with section 70B(7a)(b) of the Act, the approved program is subject to the following conditions:

1. Prior to conducting exploration operations, a Program Notification must be submitted to the Department for Energy and Mining in accordance with the approved PEPR, 21 days prior to commencement of operations. Forward all Program Notifications to Mineral Exploration Branch – Attn: Exploration Regulation, email: DEM.exploration@sa.gov.au.

APPLICATION

Mining Act 1971 and Mining Regulations 2020



Government of South Australia

Department for Energy and Mining

EXPLORATION PROGRAM FOR ENVIRONMENT PROTECTION AND REHABILITATION (PEPR)

USE THIS TEMPLATE TO: Apply to conduct mineral exploration operations not covered by the Generic PEPR (Adopted Program) for an ongoing period on one or more exploration licences (ELs), retention leases (RLs) or mineral claims (MCs) in South Australia.

Refer to the Exploration PEPR [Terms of Reference](#) and to [Minerals Regulatory Guidelines MG22](#) when completing this application. Further information on exploration requirements in South Australia is available on the Department for Energy and Mining (DEM) Minerals website www.energymining.sa.gov.au.

SECTION A – GENERAL DETAILS

Operational approval period	Ongoing approval period. A program notification is required to be provided to DEM 21 days prior to the start date of each new program of works (PEPR program notification template is available from the DEM Minerals website). All rehabilitation is to be completed within 3 months after the expiry of each program notification.
Tenement details	EL 5916, EL 6033, EL 6244
Tenement holder(s) (for each tenement)	Quasar Resources Pty Ltd
Operating company	Heathgate Resources Pty Ltd
Agency agreement (if applicable)	
PEPR prepared by	Mr Anthony Hewett, Chief Geologist 08 8110 0527
Project supervisor/contact person(s)	Mr Anthony Hewett, Heathgate Resources, Chief Geologist 08 8110 0527
Project/prospect name	Arkaroola
Location details	EL 5916 Arkaroola - approximately 120km north east of Leigh Creek EL 6033 Mt Yerila – approximately 140km east of Marree EL 6244 Petermorra – approximately 160km east of Marree
Project description, commodity type and mineralisation model	The Arkaroola AEA nine target styles. <ul style="list-style-type: none">- Rollfront style uranium hosted within the Eyre and Namba formation- Rollfront style uranium hosted within decomposed Cryogenian and Proterozoic basement- Uranium hosted within Proterozoic basement- Copper at the transitional Proterozoic basement interface- Kaolin within weathered basement profile- Rare Earth Element pegmatites and ionic clays- Porphyry copper- Skarn related zinc- IOCG / ISCG

DECLARATION

I, the tenement holder, declare under regulation 84 of the Mining Regulations 2020, that I have taken reasonable steps to review the information in this PEPR/ revised PEPR to ensure its accuracy.

Name	Sarah Rye	Signature (digital allowed)	
Position	Operations & Reporting Geologist	Date	10/07/2023

Copy and paste the above table if there is more than 1 tenement holder.

Note: An authorised representative from each tenement holder must sign the declaration (e.g., in accordance with the Corporations Act 2001).

SECTION B – PROGRAM PREPARATION AND ACCESS TO LAND

Work undertaken in preparing the proposal

Summarise the research and fieldwork undertaken in preparing the proposal including:

- desktop reviews of existing information
- field visits for reconnaissance
- contractor consultation (i.e., equipment scale, type)
- other information used when planning the proposed program.

Heathgate actively explores for uranium and operates In-Situ Recovery (ISR) mining operations on the eastern side of the Flinders Ranges. Work undertaken in preparation for the proposal includes:

- Review of drilling to date, including the rotary mud and core holes drilled in the previous 12 months,
- Reprocessing and reinterpretation of geophysical data
- Review and collation of historical datasets – geological and geophysical
- Target generation using Heathgate's inhouse geology models
- Consultation with Heathgate's own drilling department which will be used for the work program
- Field reconnaissance related follow up of historical datasets and in house target generation

Extensive consultation on all exploration licences has also been undertaken with:

- Appointed representatives of the Native Title Holders to ensure Aboriginal Heritage is protected throughout tenements operated and managed by Heathgate Resources
- Local pastoralists
- Heathgate maintain an active relationship with the Native Title Holders on EL 5916, EL 6033 and EL 6244. Extensive work area clearances have been undertaken over the last 20 years; Work Area Clearances (WAC's) will continue to be undertaken in conjunction with exploration program requirements.

Consultation (r. 64)

Using the table below, provide a summary of the individual or group of similarly affected persons and summarise the results of consultation that has been undertaken on the proposed operation. Types of interested or affected parties include residents, council, government agencies etc (exclude native title groups and defence owned or controlled lands – refer to relevant sections below).

Tenement	Stakeholder	Land tenure	Land use	Date and type of NOE served	Type of exempt land	Date waiver obtained	Date consultation/access agreement and/or permits signed/authorised	Stakeholder concerns raised and how addressed
EL 6033	Mr and Mrs Gerard & Karina Sheehan – Moolawatana Pastoral Station	Pastoral	Grazing	19/05/2022 NoE	NA	NA	Notice of Entry Form 21B emailed to Sheehan's on 19 May 2022	No concerns raised, Heathgate personnel are in constant contact with Gerard and Karina Sheehan. Contact with Sheehan's was made on 10 February 2023.
EL 6033	Mr David Brook – Murnpeowie Pastoral Station	Pastoral	Grazing	19/05/2022 NoE	NA	NA	Notice of Entry Form 21B emailed to David Brook on 26 May 2022	Follow up emails re ongoing EPEPR application was sent to David Brooks on 9 February 2023.
EL 6033	Mr and Mrs Gerard & Karina Sheehan – Moolawatana Pastoral Station	Pastoral	Grazing	23/05/2022 - NoE	NA	NA	Notice of Entry Form 21B emailed to Sheehan's on 19 May 2022	No concerns raised. Heathgate personnel are in constant contact with Gerard and Karina Sheehan. Contact with Sheehan's was made on 10 February 2023.

Exploration PEPR application – ongoing

Tenement	Stakeholder	Land tenure	Land use	Date and type of NOE served	Type of exempt land	Date waiver obtained	Date consultation/access agreement and/or permits signed/authorised	Stakeholder concerns raised and how addressed
EL 6244	Mr David Brook – Murnpeowie Pastoral Station	Pastoral	Grazing	30/05/2022 - NoE	NA	NA	Notice of Entry Form 21B emailed to David Brook on 26 May 2022	Follow up emails re ongoing EPEPR application was sent to David Brooks on 9 February 2023.
EL 5916	Heathgate Resources Pty Ltd – Woollana Pastoral Station	Pastoral	Grazing and Mining	05/08/2020 – Form 21 and Form 22	NA	NA		Heathgate operate the licence on behalf of QSR.
EL 5916	G F Sprigg (deceased) Douglas Sprigg & Margaret Sprigg as Executor for R Sprigg – Arkaroola Station	Pastoral	Tourism	23/05/2022 - NoE	NA	NA	Notice of Entry Form 21B emailed to Spriggs on 23 May 2022	No concerns raised. Heathgate personnel are in constant contact with both Doug and Margaret Sprigg. Spoke with Doug on 15 Feb and sent both he, and Margaret an updated email with map.
EL 5916	Mr & Mrs Gerard & Karina Sheehan – Moolawatana Pastoral Station	Pastoral	Grazing	23/05/2022 - NoE	NA	NA	Notice of Entry Form 21B emailed to Sheehan's on 23 May 2022	No concerns raised. Heathgate personnel are in constant contact with Gerard and Karina Sheehan. Contact with Sheehan's was made on 10 February 2023.
EL 5916	Mr David Brook – Murnpeowie Pastoral Station	Pastoral	Grazing	30/05/2022 - NoE	NA	NA	Notice of Entry Form 21B emailed to David Brook on 26 May 2022	The NoE has been sent to the pastoralist with follow up emails.
EL 5916	J Redpath – Mt Freeling Pastoral Station	Pastoral	Grazing	30/05/2022 - NoE	NA	NA	Notice of Entry Form 21B emailed to Redpaths on 30 May 2022	The NoE has been sent to the pastoralist with follow up emails.
EL 5916	Carn Nominees Pty Ltd - Umberatana Pastoral Station	Pastoral	Grazing	30/05/2022 - NoE	NA	NA	Notice of Entry Form 21B emailed to Carn Nominees on 30 May 2022	The NoE has been sent to the pastoralist with follow up emails.
All licences	Adnyamathanha People No 1	Native Title		NA	NA	NA	Heathgate have a NTMA with the Adnyamathanha People which is registered against all exploration licences.	Work area clearances are conducted as required. Resultant report stipulates areas cleared for drilling purposes, and areas which are excluded from proposal.
EL 6244	Dieri No 2	Native Title		NA	NA	NA	In principle agreement reached. Now awaiting final community approval. Community meeting scheduled for Oct 2023.	Once we obtain an agreement Heathgate will conduct Work area clearances which will clear the areas for drilling. The report we receive from the WAC will stipulate areas cleared for drilling purposes, and areas which are excluded from the proposal.

If any individual or group of similar affected persons were not able to be consulted, what steps were taken to consult with them?

NA

Exploration PEPR application – ongoing

Provide any additional relevant information.

NA

SECTION C – DESCRIPTION OF THE ENVIRONMENT

Include a description of the features of the environment that are expected to be affected by the proposed operations. Each of the elements of the existing environment listed below must be described only to the extent that they may need to be considered in assessing the impacts that the proposed exploration operations are reasonably expected to have on the environment. If the element is not likely to be impacted by the operation, a statement to that effect must be included.

Where the terms and conditions of an RL include environmental outcomes, include any new baseline environmental data relevant to the control strategies or measurement criteria, and where changes to the environment are identified, provide an updated description of the environment to describe the changes.

Proximity to infrastructure and housing

Provide the following information:

- Settlements – indicate the name and distance of the nearest town, and residences within, or near the proposed exploration operations.
- Roads and tracks – indicate existing fence lines, roads and tracks, including those which are to be used in the exploration program.
- Other human infrastructure such as schools, hospitals, commercial or industrial sites, roads, sheds, bores, dams, ruins, pumps, scenic lookouts.
- Railway lines, transmission lines, gas and water pipelines, communication lines – e.g., fibre optic cables etc., if these may be impacted by the exploration operations.

Provide this information on a locality plan/map.

Settlements

The closest communities to EL 5916 Arkaroola, EL 6033 Mt Yerila and EL 6244 Petermorra include Lyndhurst, Arkaroola, the Beverley Uranium Mine, and the Aboriginal communities at Nepabunna and Iga Warta. Moolawatana homestead is also located close to our work area.

A total of approximately 80 permanent residents' lives within a 100km radius of the proposed area of drilling activities. This figure includes staff at the Arkaroola tourist resort located approximately 80km away. Actual population at Arkaroola varies with tourist demand.

Roads and Tracks

Two main roads are used for the majority of access across these tenements – Mt Hopeless Rd and the Epic Row.

Infrastructure

The South Australian dog fence crosses both EL 6033 Mt Yerila and EL 5916 Arkaroola.

The Epic gas pipeline crosses EL 6033 Mt Yerila.

Locations of infrastructure and housing are displayed in Figure 2.

Exploration PEPR application – ongoing

Land use and tenure

Using the table below, select the land tenure and land use that the proposed exploration activities will occur in. Include additional information where prompted.

Land tenure/type	Applicable	Land use	Applicable
Freehold	<input type="checkbox"/>	Grazing	<input checked="" type="checkbox"/>
Pastoral lease	<input checked="" type="checkbox"/>	Cultivated land	<input type="checkbox"/>
Perpetual lease	<input type="checkbox"/>	Residential	<input type="checkbox"/>
Crown land	<input type="checkbox"/>	Township	<input type="checkbox"/>
Mining reserve	<input type="checkbox"/>	Industrial	<input type="checkbox"/>
Aboriginal freehold/leasehold land (e.g., Anangu Pitjantjatjara Yankunytjatjara and Maralinga Tjarutja lands)	<input type="checkbox"/>	Tourism	<input checked="" type="checkbox"/>
Forestry reserve	<input type="checkbox"/>	Conservation	<input checked="" type="checkbox"/>
Marine parks	<input type="checkbox"/>	Defence activity	<input type="checkbox"/>
National parks, conservation parks, conservation reserves, regional reserves*	<input checked="" type="checkbox"/>	Road reserve	<input type="checkbox"/>
Adelaide Dolphin Sanctuary	<input type="checkbox"/>	Sites of scientific significance (geological monuments, fossil reserves etc.)	<input type="checkbox"/>
Murray Darling Basin	<input type="checkbox"/>	Orchard/vineyard	<input type="checkbox"/>
Arkaroola Sanctuary – see more detail below		*Native vegetation heritage agreements	<input type="checkbox"/>
Other*	<input checked="" type="checkbox"/>	NA	
Arkaroola Area Reserved from Mining Act 1971 which is outside of these exploration licences. The Sanctuary area which is under the NP&W Act is also outside of our exploration licence areas.		*European heritage sites	<input type="checkbox"/>
		NA	
		*Other (e.g., historic mining)	
		Arkaroola Sanctuary	

* Indicates more information required in field immediately below.

Describe any council policies (or out of council) or development plans that may impact the program area.

We are not aware of any development plans that may impact the program area.

Provide a description of any known plans for future land use changes by other parties.

We are not aware of any plans for future land use changes by other parties.

Provide any additional relevant information.

NA

Woomera Prohibited Area (WPA)

Will activities be conducted within the WPA	Yes <input type="checkbox"/>	No <input checked="" type="checkbox"/>	Do you have a resource exploration permit in place?	Yes <input type="checkbox"/>	No <input checked="" type="checkbox"/>
In which zone will activities be conducted?					
Does the Exploration Permit allow the operator to conduct exploration operations in the WPA?				Yes <input type="checkbox"/>	No <input checked="" type="checkbox"/>
What is the expiry date of the resource exploration permit?					
Identify closure periods that may impact on the exploration program.					
NA					

Other land owned or controlled by the Commonwealth Department of Defence

Lands in South Australia that are owned or controlled by the Commonwealth Department of Defence, which they manage either as a training or test area, include the Port Wakefield Proof and Experimental Establishment, Murray Bridge Training Area, and Cultana Training Area.

Exploration PEPR application – ongoing

These lands remain to be mineral land under the Mining Act 1971 (SA) and can be accessed for mineral exploration and mining subject to certain restrictions and conditions under the Defence Act 1903 (Cth) and the Defence Regulation 2016 (Cth).

Will operations be conducted within the Port Wakefield Proof and Experimental Establishment, Murray Bridge Training Area, or Cultana Training Area?	Yes <input type="checkbox"/>	No <input checked="" type="checkbox"/>
NA		
Do you have a Deed of Access with Defence?	Yes <input type="checkbox"/>	No <input checked="" type="checkbox"/>
What is the expiry date of the Deed of Access?		
Provide the date the Range Control Officer granted access permission to conduct the proposed exploration operations.		
Describe the results of consultation and how any concerns raised were addressed.		
NA		

Native title

Using the table below, describe how you have complied with the requirements of Part 9B of the Mining Act for each tenement (for further information refer to [Minerals Regulatory Guidelines MG22](#)).

Native title			
Is the proposed area of exploration located on native title land?	Yes <input checked="" type="checkbox"/> No <input type="checkbox"/> (If no, no further information in this section required.)		
Are there registered native title party/parties in the area of proposed exploration?	Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>	Adnyamathanha No. 1 and Dieri No 2	If no, an Environment, Resources and Development (ERD) Court determination is required.
Have you negotiated a native title mining agreement?	Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>	Is the agreement registered? * Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>	Instrument No 614 registered 16 Dec 2013 only for Adnyamathanha No 1. Dieri No 2 is still in progress between both parties.
Have you accepted an Indigenous land use agreement (ILUA)?	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>	Is the ILUA registered? * Yes <input type="checkbox"/> No <input type="checkbox"/>	<List the tenements covered by the ILUA>
Have you obtained ERD Court determination? †	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>	Is the determination registered? * Yes <input type="checkbox"/> No <input type="checkbox"/>	<List the tenements covered by the determination>

* The registration date refers to the date the agreement, determination or ILUA was registered with DEM.

† An ERD Court determination cannot be conjunctive (i.e., cannot apply to subsequent licences).

Provide any additional relevant information.

ATLA are currently under Special Administration and Heathgate are in frequent contact with the Administrators, so that our Work Area Clearances can continue, along with other activities relating to our work programs.
--

Landform and topography

Describe the topography of the general area affected by the exploration program. Include the susceptibility to erosion and visual attributes (steep or undulating slopes, plains, rocky outcrops, dunes, salt pans, clay pans etc.).

<p>Exploration will take place on the northern flank of the Flinders Ranges, within the Flinders and Olary Subregions (Neagle 2003). The landform and topography comprise a complex of coalescing low-angle fans, rising from 0.5m above sea level at the edge of Lake Frome to 70m near the ranges. With the exception of occasional wooded creek lines, the plains are virtually featureless.</p> <p>The Northern Flinders Ranges rise abruptly on the western margin of the plain to about 600m above sea level, falling to between 180m to 100m over the EL areas.</p> <p>The terrain consists of four main landforms:</p> <ul style="list-style-type: none"> - Level to moderately steeply sloping channels rising on the High Plain and discharging on to the Low Plain. - Flat to very gently sloping slightly elevated areas adjacent to drainage. - Gently to steeply sloping dissection of the High Plain. - Gently sloping broadly rounded foot slopes and interfluvial areas of the second order and streams forming the lower margins of the High Plain.

Exploration PEPR application – ongoing

Drill sites will be positioned on low plains, away from outcrop and drainage channels. Steep slopes, dunes and salt/clay pans will all be avoided, with all sites situated on flat and level ground to reduce risk of landform erosion. Post drilling, drill sites will be rehabilitated to ensure disturbance is minimal and returned to a pre-drilling state.

Soil and surface cover

Describe soil types and soil surface cover - e.g., gibber, rocky - in the general area affected by the exploration program. Include details on the susceptibility to compaction, erosion, dust, runoff and any other soil characteristics – e.g., acid sulphate – that may require control strategies to reduce environmental impacts during operations or rehabilitation.

The surface cover across the region is dominated by alluvial and sheet-flow outwash. Which is typically rocky immediately adjacent to the ranges and becoming more sandier / clay towards Lake Frome. Contemporary alluvial systems tend to have poor soil development within channel sands, although the flanking low-lying alluvial plains tend to have red sodosols with variable calcic components. As such, the lower parts of many of these soils tend to have dispersive properties, expressed at the land surface as “melon-hole” depressions (frequently mistakenly described as Gilgal in previous studies). The sheet-flow plains tend to have similar soils but, in some parts, the higher calcium carbonate contents define calcarosols. Erosional rises and hills both within the ranges and on the plains along the range-front mostly have thin clastic rudosols, with abundant bedrock exposure. Aeolian silt additions are significant to most soils in the area.

The soil in the project area is susceptible to bulldust creation on vehicle access tracks. Dust will be kept to a minimum by limiting vehicle movement as much as possible, regular track maintenance (on pre-existing tracks) and the use of a dust suppressing watering where possible.

Following rehabilitation of each drill site, compacted areas will be ripped / scarified across slope to create banks and troughs that both promote seed germination and minimise down-slope run-off that may cause erosion. Any existing tracks which were subject to bull dust will be graded to restore the original track condition. Any new tracks will be rehabilitated in a similar manner to drill sites and access blocked.

Surface water

Will the proposed program interfere with surface water bodies and natural drainage (e.g., drainage lines, creeks, floodplains, wetlands)?	Yes <input checked="" type="checkbox"/>	No <input type="checkbox"/>
If yes, describe the potential interference and surface water bodies and natural drainage on maps. If no, indicate why.		
Proposed drill sites have been located as such to avoid drainage channels and creeks. Collar points have been specifically placed to be close to existing access tracks and avoid crossing channels where possible. No significant earthworks are required for the proposed programs. In addition, vehicle movements will be kept to a minimum to preserve the track integrity.		
Whilst the creeks within the tenement area generally consist of dry creek beds for most of the year, they are subject to occasional flood flows. The extent of this flooding can be quite significant in the lower reaches of the catchment, as the creek topography is characterised by gentle slopes and shallow braided creek beds, in many places extending hundred of metres in width. In assessing the impact of predicted flood risk on potential operations within the floodplain, recognition must be made of the likelihood of a flood event occurring. Over a 12 month period, the probability of operations within the 1 in 100 year floodplain being inundated is 1%, while within a 1 in 10 year ARI floodplain it is 10%. Consideration of risk should also be tempered with consequence of inundation. Flow velocities within the floodplain, be it either the 1 in 10 year, or 1 in 100 year floodplain, are relatively low; generally 1 m/s or less.		
Rainfall events that result in runoff are rare in the area, while significant rainfall events generating high surface flow velocities are primarily associated with 1 in 100 year flood events.		
Following rehabilitation of each drill site compacted areas will be ripped / scarified across slope to create banks and troughs that both promote seed germination and minimise down-slope run-off that may cause erosion. Following any significant 1 in 100 year rain event an assessment of erosion in the area, resulting from surface disturbance associated with drilling activities will be made and appropriate remediation measures undertaken.		
Is the program area located within water protection areas defined under the <i>River Murray Act 2003</i> ? If yes, provide the name(s).	Yes <input type="checkbox"/>	No <input checked="" type="checkbox"/>
<If yes, provide the name(s)>		
Is the program area located within any prescribed watercourses or prescribed surface water areas under the <i>Landscape South Australia Act 2019</i> ? If yes, provide the name(s).	Yes <input type="checkbox"/>	No <input checked="" type="checkbox"/>
<If yes, provide the name(s)>		

Groundwater

Is groundwater likely to be intersected when conducting the exploration program? If yes, use the table below to describe the expected groundwater (hydrogeological) conditions, and identify groundwater aquifers in the exploration area(s) that may be affected. Indicate the approximate depth of drillholes in each area. Copy and paste a new table for each area where different groundwater conditions are expected. If no, provide evidence or any supporting information demonstrating this.	Yes <input checked="" type="checkbox"/>	No <input type="checkbox"/>
<Include text here.>		

Exploration PEPR application – ongoing

Description of the locality/area where different groundwater conditions may be encountered					
EL 5916 (Arkaroola), EL 6033 (Mt Yerila) and EL 6244 (Petermorra)					
Formation age and/or stratigraphic unit	Stratigraphic intervals (depth range) (m)	Aquifer formation name	Aquifer interval/thickness (from-to) (m)	Type of aquifer(s) intersected (e.g., unconfined, confined, artesian)	Provide aquifer salinity, depth to water level and any other relevant comments
Tertiary / Quaternary; Willawortina	100m	Willawortina	40-100m	Unconfined	Salinity; 20000, depth to water table; 60m
Tertiary / Miocene; Namba	200m	Namba	30-100m	Confined	Salinity 5000
Tertiary / Eocene; Eyre	280m	Eyre	200-300m	Confined	Salinity 2700
Mesozoic / Cretaceous; Algebuckina and Cadna – Owie Sandstone	400m	Algebuckina and Cadna – Owie Sandstone	50-100m	Artesian	Salinity 2000
Proterozoic	350m	Fractured Rock Aquifer	>5m	Confined	Salinity 3000

Provide the environmental value of each aquifer present determined according to the current Environment Protection (Water Quality) Policy.

The aquifer data for the area is limited and sparse outside of the current mining areas, however data from waterconnect.com.au provides the following:

The total dissolved solids for the Willawortina aquifer intersected in the area typically has values between 1,500 – 7,000 mg/l. The environmental value of this water falls within the Primary Industries – Irrigation and General Water Uses, water quality category.

The total dissolved solids for the Namba aquifer intersected in the area typically has values around 5,000 mg/l. The environmental value of this water falls within the Primary Industries – Irrigation and General Water Uses, water quality category.

The total dissolved solids for all of the Eyre, Algebuckina / Cadna Owie and Fracture Rock aquifers intersected in the area return values of 2,000 to 5,000 mg/l. The environmental value of this water falls within the Primary Industries – Irrigation and General Water Uses, water quality category.

Provide a description of the existence, location and value of all Groundwater Dependent Ecosystems (GDEs) within and immediately surrounding the project area.

Within the project area, multiple groundwater dependent ecosystems (GDEs) are present broadly classed as either palustrine or lacustrine wetlands. All GDEs except for one locality – Twelve Springs, are listed as Low Domain Value (LDV) for risk posed by groundwater resource development.

- The Twelve Springs mound spring is located on EL 6033 Mt Yerila and is located approximately 2km to the northwest of the Woolatchi Prospect (Figure 6) and is classed as a High-Risk groundwater dependent ecosystem (H1). No groundwater will be extracted from the Twelve Springs mound spring. With the nearest bore – Bellinger Bore, located approximately 4km to the northeast of Twelve Springs being used historically by Heathgate for drilling purposes. A key environmental management objective of Heathgate is to protect environmental assets such as groundwater dependent ecosystems. To that end, Heathgate will ensure that taking of water (if at all necessary) will not have an unacceptable impact in the mound spring ecology. All water for drilling programs will sourced from pastoral bores outside of the Zone A 5 km buffer of groundwater dependent ecosystems.
- LDV (L1 -L3) ecosystems are represented by ephemeral creek systems close to the edge of the Flinders Ranges situated on exploration licences; Arkaroola, Mt Yerila and Petermorra. Major creek systems within the project area include the Four Mile, Arkaroola, Pepegoona, Mundawatana, Yerila and Hamilton creek systems.

Additional H1 GDE's – Reedy Springs and Petermorra Springs. Reedy Springs mound spring is located 6km to the north west of EL 6244 Petermorra, outside of the project area. Petermorra Springs is located just north of EL 5916, outside of our prospect areas. All water for drilling programs will sourced from pastoral bores or dams outside of the Zone A 5 km buffer of groundwater dependent ecosystems.

Locations of all listed GDEs within and proximal to the project area are displayed in Figure 6, 7 & 8.

Exploration PEPR application – ongoing

Is the proposed program located within a prescribed wells area or prescribed water resource area? If yes, provide the name of the area.	Yes <input checked="" type="checkbox"/>	No <input type="checkbox"/>
The exploration licences are located in the Far North Prescribed Wells Area (FNPWA) and the Great Artesian Basin (GAB).		

Provide any additional information, if required.

Within the Northern Flinders Region groundwater is known to occur in several separate aquifer systems, although it should be noted that aquifers within the upper Tertiary sequences (Willawortina and Namba Formations) are not necessarily continuous or saturated. The following aquifers are found within Arkaroola AEA:

- Willawortina Formation (Tertiary and Quaternary)
- The Namba Formation aquifer (Tertiary, Miocene)
- The Eyre Formation aquifer (Tertiary, Eocene) - blanket and palaeochannel sands.
- The Great Artesian Basin (GAB) aquifer, sandstones of the Cadna-Owie Formation and Algebuckina Formation, (Mesozoic).
- Fractured Rock Aquifer (Proterozoic)

Drilling

The approximate depth of diamond drillholes will be up to 1,500 metres, with intersected stratigraphy expected to be predominantly Quaternary (Willawortina Fm.) Deep diamond drillholes target underlying Proterozoic hard rock for Cu/Au mineralisation.

The approximate depth of mud / reverse circulation drillholes will be up to 400 metres, with intersected stratigraphy expected to be predominantly Tertiary, with lesser Cretaceous sediments. Drilling within the Arkaroola, Petermorra and Mt Yerila exploration licences will target both the Namba and Eyre Formations, and Bulldog Shale equivalent aged sediments (where present) that presently host roll front style uranium mineralisation in the region.

Stratigraphy

The Willawortina Formation can be saturated at shallow depths (20m), with recharge of the aquifer thought to occur mainly through streambed infiltration. Discharge is via lateral flow and eventual evaporation from Lake Blanche / Lake Callabonna. Current Work Area Clearance (WAC) guidelines prevent Heathgate from drilling in the vicinity of current drainage lines and it is therefore unlikely for drilling to intersect saturated permeable sand(s) associates with these features.

The Namba Formation comprises Tertiary age fluvial and lacustrine sediments. The formation consists of mainly low permeability mudstones and siltstone (Callen and Telford, 1976). The Namba Formation contains some thin saturated sand units with well yields from these sand units very low. These sand units were deposited in a deltaic meandering stream environment and are generally discontinuous and limited in extent, with water quality generally poor.

The Tertiary age Eyre Formation is widespread throughout the Lake Eyre Basin (Callen et al 1995). The Eyre Formation commonly consists of mature, carbonaceous, pyritic sand, with grain size varying from silt to gravel. The permeability of this unit is quite high and is interpreted to contain the main aquifer expected to be intersected in drilling. Measured water quality in the Eyre Formation is variable, reflecting the significant extent of the formation and the available data.

The Great Artesian Basin is bound to the west by the Flinders Ranges and is hosted by the Cadna–Owie Formation and the Algebuckina Sandstone within the Eromanga basin.

The Cadna-Owie Formation is composed of heterogeneous, mainly fine-grained sandstone and pale grey siltstone. Coarser sandstone lenses occur in the upper part of the formation and were deposited within a transitional environment, from terrestrial freshwater to marine. The upper Cadna-Owie is considered a good aquifer with high yields and good water quality (Keppel et al 2013).

The Algebuckina Sandstone is a fine to coarse grained sandstone with minor siltstone shale and pebble conglomerates, deposited within a high energy braided fluvial environment. It is a high yielding aquifer with low total dissolved solids (Keppel et al 2013).

Surface geology of the project area is displayed in Figure 5.

Exploration PEPR application – ongoing

Native vegetation

Will you be working within areas of native vegetation? If yes, provide the following information: <ul style="list-style-type: none"> description of the formation and structure of vegetation in the area (e.g., woodland, shrubland, grassland) list of the dominant species. If no, indicate why you will not be working within areas of native vegetation?	Yes <input checked="" type="checkbox"/>	No <input type="checkbox"/>
Vegetation is sparse. If significant rain occurs <i>Astrebla pectinata</i> (Mitchell grass) and small shrubs may germinate, and larger Eucalyptus and Melaleuca trees in the creeks may respond to drought induced hibernation. Vegetation on gibber plains is particularly sparse in distribution.		
The area is dominated by short-lived non woody perennial forbs, particularly <i>Sclerolaena</i> spp. Around the watercourses it is supported by riparian woodland dominated by <i>Eucalyptus camaldulensis</i> and <i>Melaleuca</i> spp, particularly <i>Melaleuca glomerata</i> . The minor watercourses support shrubland or low understory vegetation to that of low open woodland with some midstory vegetation.		
A long very open woodland and low shrubland on the rockier low hills throughout the Northern Ranges includes <i>Acacia anuera</i> , <i>Mulga</i> , <i>Eremophila</i> spp., <i>Dodonaea</i> spp., shrubland over <i>Ptilotus obovatus</i> Silver Mulla Mulla and <i>Chenopodiaceae</i> spp. This group was common.		
Within the lower shale hills and valleys common within the Flinders Ranges includes <i>Acacia victoriae</i> Elegant Wattle, <i>Acacia tetragonophylla</i> Dead Finish, <i>Sida petrophila</i> Rock Sida and <i>Ptilotus obovatus</i> Silver Mulla Mulla. Where calcareous loams exist in localised areas on the Northern Flinders Ranges, <i>Eucalyptus Gillii</i> Curly Mallee, +/- <i>Eucalyptus socialis</i> Red Mallee over +/- <i>Triodia</i> spp.		
The Twelve Springs locality is a group of approximately seventy-two (72) spring vents classed as Sand Mounds in the upper catchment of the Yerila Creek. The springs are primarily vegetated with <i>C. laevigatus</i> however the site is floristically diverse, with populations of the endemic <i>Eriocaulon carsonii</i> - the salt pipewort, listed legal status as endangered under the EPBC Act (1999) and the rare <i>U. fenshamii</i> , <i>F. sieberiana</i> and <i>Glossostigma</i> sp.		
The Reedy Springs locality is a group of more than three hundred (300) spring vents classed as Sand Mounds and Erosional Channel Springs within MacDonnell Creek. The springs are primarily vegetated with <i>C. laevigatus</i> however the site is also home to the rare <i>F. sieberiana</i> and <i>S. subulatus</i> .		
The Petermorra Springs locality is a small group spring vents classed as Erosional Channel Springs in the upper catchment of Petermorra Creek. The springs are primarily vegetated with <i>C. laevigatus</i> however the site is vegetated with small populations of the endemic <i>Eriocaulon carsonii</i> - the salt pipewort, listed legal status as endangered under the EPBC Act (1999) and the rare <i>U. fenshamii</i> and <i>F. sieberiana</i>		
Observed flora sites are displayed in Figure 4.		

Significant habitats and flora

If you are working within areas of native vegetation, use the table below to list any significant habitats and any rare or endangered flora species located or reported to have been in the area that may be impacted by the proposed program. Include known sightings of listed species on a locality plan/map.

Species/habitat	Common name	NPW Act rating*	EPBC Act rating†
<i>Swainsona oligophylla</i>	Swainsona	Rare	
<i>Swainsona murrayana</i>	Slender Darling Pea	Vulnerable	Vulnerable
<i>Frankenia subteres</i>	Frankenia	Rare	
<i>Typhonium alismifolium</i>		Rare	
<i>Acacia araneosa</i>	Spidery Wattle, Balcanoona Wattle	Vulnerable	Vulnerable
<i>Acacia cameorum</i>	Needle Wattle, Dead Finish, Purplewood Wattle	Vulnerable	Vulnerable
<i>Acacia menzeli</i>	Menzels Wattle	Vulnerable	Vulnerable
<i>Caladenia gladiolata</i>	Bayonet Spider-orchid, Clubbed Spider Orchid	Endangered	Endangered
<i>Caladenia tensa</i>	Greencom Spider-orchid, Rigid Spider Orchid	Endangered	Endangered
<i>Pterostylis xerophila</i>	Desert greenwood	Vulnerable	Vulnerable
<i>Xerothamnella parvifolia</i>		Vulnerable	Vulnerable
<i>Frankenia plicata</i>		Endangered	Endangered
<i>Eriocaulon carsonii</i>	Salt Pipewort	Endangered	Endangered

Exploration PEPR application – ongoing

<i>Utricularia fenshamii</i>		Rare	
<i>Glossostigma sp.</i>		Rare	
<i>Fimbristylis sieberiana</i>	Fringe Rush	Rare	
<i>Acacia confluens</i>	Arkaroola Wattle	Vulnerable	Vulnerable
<i>Gilesia biniflora</i>	Western Tar Vine	Rare	
<i>Swainsona leeana</i>	Lee's Swainson-pea	Rare	
<i>Atriplex eichleri</i>	Eichler's Saltbush	Rare	
<i>Orobanche cernua var. Australiana</i>	Australian Broomrape	Rare	
<i>Frankenia cupularis</i>		Rare	
<i>Podolepis muelleri</i>	Button Podolepis	Vulnerable	Vulnerable
<i>Codonocarpus pyramidalis</i>	Slender Bell-fruit	Vulnerable	Vulnerable

* *National Parks and Wildlife Act 1972* (NPW Act) conservation status includes extinct, endangered, vulnerable, threatened and rare.

† *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) listings include extinct, extinct in the wild, critically endangered, endangered, vulnerable and conservation dependent.

Weeds and pathogens

Provide information of the extent the area is affected or potentially affected by weeds and pathogens (e.g., phytophthora; buffel grass *Cenchrus ciliaris*).

<p>Buffel Grass is a declared weed species in the area of all of our exploration licences therefore vehicles will be checked daily. A copy of the SA Buffel Grass Strategic Plan 2019 – 2024 will be available to all staff working on this program.</p> <p>The Heathgate exploration licences fall within the Management Zone 2 which covers the SA Arid Lands area and therefore we must contain the spread of Buffel grass.</p> <p>All vehicles will be cleaned prior to entering the drill site and again once the programme has been completed so that no new species of weeds and plant pathogens or mud will be transported in or out of the area.</p> <p>Weeds species present in the area are considered established / naturalised weeds for the northeast pastoral zone. No other declared weeds or Weed of National Significance are present.</p> <p>No plant pathogens are known to occur in the area.</p>
--

Weed Species	Common name
<i>Sisymbrium erysimoides</i>	Smooth Mustard
<i>Citrullus colocynthis</i>	Colocynth
<i>Schismus barbatus</i>	Arabian Grass
<i>Malvastrum americanum var. americanum</i>	Malvastrum
<i>Rumex vesicarius</i>	Rosy Dock
<i>Datura leichhardtii</i>	Leichhardt's Thorn-apple

Fauna

Describe the native and feral fauna that may be present in the application area, including feral species.

<p><u>Fauna Surveys</u></p> <p>No Fauna surveys have occurred within EL 6033 (Mt Yerila) or EL 6244 (Petermorra), however EL 5916 (Arkaroola) had a baseline study completed in 2014 by Environmental Biodiversity Services Pty Ltd (EBS) as part of regional studies related to the Beverley Mine Lease.</p>

Exploration PEPR application – ongoing

As a result of the survey, there are extensive datasets of fauna species known to occur in different habitats within the regional area. Therefore, detailed knowledge of the species likely to occur within the EL 5916 Arkaroola area are known and can be utilised when assessing possible impacts on fauna species, particularly those of conservation significance. The following summarises the findings of the baseline fauna survey.

Mammals

The most commonly recorded species was the Fat-tailed Dunnart (*Sminthopsis crassicaudata*) with 23 individuals detected. The least commonly detected species, with each only being detected once, were the Dingo (*Canis lupus dingo*), Euro (*Macropus robustus*) and Echidna (*Tachyglossus aculeatus*). No conservation significant species were observed.

The diversity of mammal species did not vary between the three different broad habitat groups. The minor drainage lines had a slightly higher diversity compared to other habitat groups, but the differences are seen as minor (e.g. minor drainage lines had 2-3 more species than other sites). The sites within Four Mile Creek did not exhibit the expected higher diversity of mammal species.

Mammals previously recorded or known to occur in the vicinity of the project area but were not recorded during the current baseline survey include the Sandy Inland Mouse (*Pseudomys hermannsburgensis*) and the nationally vulnerable Dusky Hopping-mouse (*Notomys fuscus*) (EBS 2007; Waudby & How 2009). The Western Grey Kangaroo (*Macropus fuliginosus*) and Feral Cat (*Felis catus*) were also recorded during the current survey.

The area is known for its Yellow-footed Rock Wallabies (*Petrogale xanthopus xanthopus*), these animals habitat is in rocky outcrops and Heathgate's exploration activities will not take place within 500 metres of these known locations, particularly the area surrounding Terrapinna waterhole, 3 km to the south of the Woolatchi work area.

Reptiles and Amphibians

The most commonly observed species were the Eyrean Earless Dragon (*Tympanocryptis tetraporophora*) with 14 individuals detected and Tree Dtellas (*Gehyra variegata*) with six individuals detected. Several species were only detected once, including the Desert Wall Skink (*Cryptoblepharus plagiocephalus*), Muller's Lerista (*Lerista muelleri*), Common Snake-eye (*Morethia boulengeri*) and Smooth Knob-tailed Gecko (*Nephurus levis*).

The diversity of reptiles was generally lower at the gibber sites compared to the minor and major drainage line sites. The diversity of habitat within the gibber sites is generally lower with very little cover present. This reduces the available refuges and promotes the species more adapted to living within relatively bare gibber plain areas. Additionally, some habitat features, such as leaf litter, are not present within the gibber plain areas, therefore reducing the number of species likely to be recorded at the gibber sites.

An additional seventeen species have been previously recorded within close proximity to the exploration area. These species include large elapids (Western Brown Snake and Mulga Snake) as well as four gecko species. Suitable habitat occurs within EL 5916 area for these species to occur; however, it is likely that either weather conditions did not promote activity in some species (e.g. large elapids and geckos) or the species occur at low densities in the area and therefore were not detected during the 2014 survey.

In addition to the species recorded or likely to occur on site, a Common Bandy-bandy (*Vermicella annulata*) was recorded, after the survey was completed, within the EL 5916 area (Hunt, D. pers.comm.). The Common Bandy-bandy is listed as being rare at the state level and has not been previously recorded within close proximity to the area.

Birds

The most commonly observed species were Galahs (*Cacatus roseicapilla*) with 98 individuals observed and Little Corellas (*Cacatus sanguinea*) with 70 individuals detected. The least observed species, with each only being detected once, were the Inland Thornbill (*Acanthiza apicalis*), Grey Shrike-thrush (*Colluricincla harmonica*), White-winged Triller (*Lalage tricolor*) and Common Bronzewing (*Phaps chalcoptera*).

Generally, the gibber plains sites had a lower diversity of bird species compared to the minor and major drainage lines. The minor and major drainage line sites have comparable bird species diversity, except for one major drainage line site which had more than double the number of bird species compared to any other survey site. It is likely that the increased bird species in the minor and major drainage lines is due to the diversity of habitat offered within these different areas.

Heathgate has very robust techniques and management systems in place to minimise disturbance to native fauna. Although the current proposal and planned activities are to be assessed as exploration activities, all drill based work sites will be accessed in line with Heathgate Resources objectives and outcomes for Beverley Mine Lease environmental practices.

Exploration PEPR application – ongoing

Significant fauna

Where possible, using the table below, list any rare or endangered fauna species located or reported to have been in the area that may be impacted by the proposed program. Include known sightings of listed species on a locality plan/map – Figure 4.

Species	Common name	NPW Act rating	EPBC Act rating
<i>Vermicella annulata</i>	Common Bandy-bandy	Rare	
<i>Notomys fuscus</i>	Dusky Hopping-mouse	Vulnerable	Vulnerable
<i>Amytornis merrotsyi</i>	Short-tailed Grasswren	Vulnerable	Vulnerable
<i>Amytornis modestus Amytornis modestus</i>	Thick-billed Grasswren Thick-billed Grasswren	Vulnerable	Vulnerable
<i>Pedionomus torquatus</i>	Plains Wanderer	Vulnerable	Critically Endangered
<i>Rostratula australis</i>	Australian Painted Snipe	Endangered	Endangered
<i>Rostratula benghalensis (sensu lato)</i>	Painted Snipe	Endangered	Endangered
<i>Notomys fuscus</i>	Dusky Hopping Mouse	Vulnerable	Vulnerable
<i>Petrogale xanthopus</i>	Yellow-footed Rock Wallaby	Vulnerable	Vulnerable
<i>Pseudomys australis</i>	Plains Rat	Vulnerable	Vulnerable
<i>Aprasia pseudopulchella</i>	Flinders Ranges Worm Lizard	Vulnerable	Vulnerable

Note: NPW Act conservation status includes extinct, endangered, vulnerable, threatened and rare.

EPBC Act listings include extinct, extinct in the wild, critically endangered, endangered, vulnerable and conservation dependent.

Exploration PEPR application – ongoing

Environmentally sensitive locations		
<p>Are there any environmentally sensitive locations within or close to the proposed exploration area (e.g., areas having particular ecological, cultural, scientific, aesthetic or conservation value)? If yes, provide a description of identified environmentally sensitive location(s). Mark these areas on a locality plan to identify any areas of conflict so that access roads or other activities can be planned and located effectively.</p>	Yes <input checked="" type="checkbox"/>	No <input type="checkbox"/>
<ul style="list-style-type: none"> - Flinders Ranges Planning Area Class A – EnA – now revoked and replaced by the Planning and Design Code on 1 July 2019 version 2022.5 date of adoption 17 March 2022 - Hamilton Creek National Estate Register - Arkaroola Conservation Park - Arkaroola Prohibited Area - Paralana High Plains Geological Monument - Mount Baggage Geological Monument - Lake Eyre Mound Springs Wetland Area - Twelve Springs Mound Springs - Reedy Springs Mound Springs - Petermorra Vent Springs - Terrapinna Gorge Yellow-footed Rock Wallaby site - Occurrence of vulnerable Button Podolepis around 200m from the Woolatchi exploration prospect <p>Heathgate, as Operator, are aware that these areas are of extremely high landscape, wilderness, environmental and scientific value, and care will be taken in and around these areas. We are also aware of the environmental and cultural significance of waterbodies in the area.</p> <p><u>Lake Eyre Mound Springs</u></p> <p>The Lake Eyre Mound Springs Wetland Area has been identified as an environmentally sensitive area in proximity to the project areas. The springs are rare but prominent, dome-shaped accumulations of largely calcium carbonate deposited by artesian springs. The isolated nature of the Lake Eyre Mound Springs has produced many plants and small animals of great ecological, evolutionary, and biogeographical significance. A large number of plants are endemic, being found only at these locations.</p> <p><u>Twelve Springs</u></p> <p>The Twelve Springs locality is a group of approximately 72 spring vents classed as Sand Mounds in the upper catchment of the Yerila Creek. The Twelve Springs mound spring is on EL 6033 Mt Yerila and is located approximately 2km to the northwest of the Woolatchi Prospect (Figure 6) and is classed as a High-Risk groundwater dependent ecosystem (H1).</p> <p><u>Reedy Springs</u></p> <p>The Reedy Springs locality is a group of more than three hundred spring vents classed as Sand Mounds and Erosional Channel Springs within MacDonnell Creek. The mound springs are classed as High-Risk groundwater dependent ecosystems (H1). Reedy Springs mound spring is located 6km to the northwest of EL 6244 Petermorra, the mound springs are outside of our project area.</p> <p><u>Petermorra Springs</u></p> <p>The Petermorra Springs locality is a small group of vent springs classed as Erosional Channel Springs in the upper catchment of Petermorra Creek. The Petermorra vent springs are located to the north of EL 5916, 24kms to the NW of Moolawatana homestead (Figure 8).</p> <p>The vegetation of the springs consists of both dryland and wetland species. Aquatic species such as reeds, sedges and rushes are common. Of particular significance is the salt pipewort (<i>Eriocaulon carsonii</i>), an endangered plant that is found within the Twelve Springs and Petermorra Springs complexes.</p> <p>Heathgate will locate any GAB springs, mound springs, vents, wetlands and any vertical leakage zones when doing reconnaissance work and new locations will be recorded and sent to either the Principal Hydrogeologist, Mining Assessments and the Far North (mark.keppel@sa.gov.au), the Senior Water Resources Officer, LSA SAAL (aaron.smith3@sa.gov.au) and/or the District Ranger Outback, National Parks and Wildlife Service (travis.gotch@sa.gov.au).</p> <p><u>Cultural Locations</u></p> <p>EL 5916 & EL 6033 lie within the Flinders Planning Areas; Environmental Zone Class A (EnA), and Environmental Zone Class B (EnB). These areas are now revoked and have been replaced by the Planning and Design Code on 1 July 2019 version 2022.5 date of adoption 17 March 2022. Heathgate, as Operator, are aware that these areas are of extremely high landscape, wilderness, environmental and scientific value.</p> <p>There are a number of property zone overlays under the Planning and Design Code 2019 which covers this area, and these include the following: Heritage Adjacency, Significant Landscape Protection, State Heritage, State Significant Native Vegetation, Water Resources and the Prescribed Wells Area.</p>		

Exploration PEPR application – ongoing

The Dog Fence occurs within EL 6033 Mt Yerila and EL 5916 Arkaroola. Access to work sites through use of infrastructure associated with the Dog Fence, is to be avoided.

The Arkaroola Conservation Park and Sanctuary are adjacent to EL 5916 Arkaroola.

The Arkaroola Prohibited Area is adjacent and outside of EL 5916 Arkaroola and under the Mining Act 1971 prohibits any mining.

Environmentally sensitive locations shown in figure 4.

Are you likely to impact on the environmentally sensitive area? If yes, detail the likely effects the proposed program may have.

Yes

No

NA

Include a statement concerning whether or not an Aboriginal heritage survey has been conducted by the proponent and if so, the results of the survey.

Aboriginal heritage surveys have been undertaken by Heathgate within EL 5916, EL 6033 and EL 6244 numerous times over the last 20 years. These surveys have enabled exploration to be undertaken across the leases within cleared areas. A spatial database of the clearances to date is maintained to ensure that exploration activities requiring an Aboriginal heritage survey clearance has been conducted prior to those exploration activities occurring. In addition, Heathgate Aboriginal Liaison Officers, undertake site specific inspections prior to any exploration activities covered by our Aboriginal heritage surveys.

SECTION D– DESCRIPTION OF PROPOSED EXPLORATION OPERATIONS

Include a description of the proposed operations. Each of the elements listed in below must be described only to the extent that they apply to the proposed exploration program.

Exploration scope

Describe the scope of the proposed exploration operations and detailing the following:

- all exploration methods to be covered by the PEPR.
- extent of exploration operations – e.g., drillhole spacing and drill line density.
- geographic extent of the area covered by the PEPR, including a general locality plan with tenement details, landowner boundaries and areas with environmental classifications or sensitivities.
- specific environments where exploration operations will not be conducted – e.g., parks, reserves, salt lakes etc.

Exploration is expected to be drilling focused across all tenements, primarily rotary mud (RM) drilling with smaller supporting program of diamond (DD), reverse circulation (RC) and aircore drilling (AC). Current prospect areas are identified in Figure 9, these are subject to change as exploration models and targeting methodology evolve.

EL Arkaroola exploration will be a combination of diamond, RC and rotary mud drilling targeting both roll front uranium within the weathered basement; supergene copper on the fresh- transitional basement contact and uranium-copper-gold mineralisation within a porphyry or fault-controlled basement setting. Drill density for this area is expected to be greater than 100m grid spacing. Infill drilling would be dependent on results and Native Title work area clearance allowances for drill density. Further exploration of roll front uranium within the Eyre formation adjacent and east of the Paralana fault. The drilling will be primarily rotary mud with some supplementary diamond drilling. Drill density for programs is planned to be greater than 50m - 100m grid spacing with infill drilling dependent on drilling results and Native Title work area clearance allowances for drilling density. The Arkaroola Protection Area lies to the west of EL 5916 and will not be impacted by exploration activities.

EL Mt Yerila exploration is targeting IOCG or ISCG style mineralisation within Proterozoic basement using a combination of rotary mud, diamond, RC methods and soil sampling. Exploration for roll front style mineralisation within the area will also be of peripheral interest. Drilling density in the area is expected to exceed 100m over the targets with line spacing in the order of 300 - 500m. The Twelve Springs Aboriginal area, groundwater dependent ecosystems, Hamilton Creek, Twelve Springs Mound Spring, Terrapinna Yellow Footed Rock Wallaby trap area and the Mount Babbage area are within EL Mt Yerila and exploration will not be conducted within these areas.

Drilling in EL Petermorra targets sediment hosted uranium within the Tertiary Namba and Eyre Formations. Similar to other mud rotary programmes, the Petermorra drill spacing is planned to be greater than 50-100m, with infill drilling dependent on drilling results and Native Title work area clearance allowances. Holes are expected to terminate within the Bulldog shale, at depths greater than 200m.

Equipment and personnel requirements

Describe the maximum composition of field crews (operator, contractors, and geologists) and proposed working hours/days for each type of activity.

Approximately eleven (11) field crew members would be undertaking work over a day shift and night shift while drilling activities are occurring. This comprises of six (6) drill crew, split over a day shift and night shift, two (2) geologists, two (2) geological field staff and one (1) site preparation and rehabilitation person. Drilling crews will be comprised of either Heathgate employees or Contractor Drilling employees. Rehabilitation and site preparation will be undertaken by either Heathgate staff or contracted to local station machinery operators. It is anticipated that this work would be offered to Moolawatana station staff as they have experience undertaking site preparation and rehabilitation for Heathgate. Geophysical logging will be undertaken by Heathgate geophysical loggers. Shifts, inclusive of travel time to site is a nominal 11.5-hour shift. Work will occur seven days per week for the duration of the programs, with drilling crews rotating on a two week on two weeks off roster.

Using the table below, describe the equipment (size, number and contractor details) required to conduct the proposed operations.

Equipment type	Owner/operator	Description/capacity	Activity/purpose
Drill Rig	Contractor Drilling	AC /RC/ RM/ DD	Drilling holes
Drill Rig	Heathgate Drilling	McCulloch DR950	Drilling holes
Geophysical Logging Truck	Heathgate		Logging of holes
Water truck	Heathgate	10,000 litre capacity	Carting of water
Backhoe	Heathgate		Digging of sumps, pads, and rehabilitation
4WD Vehicles	Heathgate	Utes	Driving to and from site and camp

Exploration PEPR application – ongoing

Low impact exploration activities

Will low impact exploration operations be conducted that are not covered by the Generic program for environment protection and rehabilitation – low impact mineral exploration in South Australia , (generic PEPR)? If yes, describe each type of low impact operations proposed.	Yes <input type="checkbox"/>	No <input checked="" type="checkbox"/>
NA		

Drilling Operations

Will exploration drilling activities be conducted? If yes, identify all the drilling methods that may be used.										Yes <input checked="" type="checkbox"/>	No <input type="checkbox"/>
AC	RAB	RM	RC	DD	AC/DD	RAB/DD	RM/DD	RC/DD	Vibracore	Auger	Other
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

AC = aircore, RAB = rotary air blast, RM = rotary mud, RC = reverse circulation, DD = diamond drilling, AC/DD = aircore with diamond tails, RAB/DD = rotary air blast with diamond tails, RM/DD= rotary mud with diamond tails, RC/DD = reverse circulation with diamond tails.

Where 'Other' drilling method is selected, provide a description of the drilling method.

NA

Drillsite preparation

If exploration drilling activities are proposed, describe the methods used to prepare sites, including vegetation clearance requirements, site levelling and digging of sumps.

<p>Holes will be pegged by Heathgate's Aboriginal Liaison Officers (ALO's), which have been cleared by Native Title Clearance surveys, and Heathgate's environmental department will conduct an environmental clearance as required. All drillhole areas will be photographed when pegged, during drilling and on rehabilitation.</p> <p>Where ground disturbance is necessary to access drill sites, the amount of vegetation removal and disturbance to the environment will be minimised, to a maximum of 40m x 40m. Where it is necessary to remove vegetation, a backhoe will be used with the blade remaining above soil level. Tracks will then be created by driving across the country and will pass around larger trees or significant vegetation. The track width will be approximate that of the drilling trucks and all vehicle movement will be minimised. Tracks will remain clear of lakebeds and potentially swampy areas.</p> <p>Drill sump construction will be completed with a backhoe, and require the separate stockpiling of topsoil, generally the top 0.5m of surface material, for later rehabilitation. Sumps and pits will be constructed to the following size dependent on drilling method.</p> <p>RC Drilling single sample pit 4m (w) by 4m (l) by 1m (d): up to 2 pits per hole. AC Drilling single sample pit 4m (w) by 4m (l) by 1m (d): up to 2 pits per hole. Rotary Mud Drilling 2-3 sumps, dependent on hole depth 3m (w) by 5m (l) by 1.5m (d). Diamond Drilling 2-3 sumps, dependent on hole depth 3m (w) by 5m (l) by 1.5m (d) (utilising pre collar Rotary Mud Sumps).</p> <p>From construction of pits and sumps, to prior to rehabilitation, all pits will be roped off to highlight their location. Escape ramps or mechanisms by which smaller animals can exit the sump safely will be installed. During drilling, a fence will be placed on the working side of the sumps to protect the site crew, with the subsoil on the rear side of the pits and sumps while drilling is being undertaken. Upon completion of the drillhole and once sumps are dry, all drill cuttings will be returned to the bottom of the sump and the sump will be backfilled with the soil which was removed when excavating the sump. The soil which was separated when excavating into subsoil and topsoil piles will be then placed back in the sump in the correct profile/order i.e. subsoil first then topsoil. The topsoil will be spread across the drillhole sites to encourage the regeneration of vegetation and will be slightly mounded to allow for natural subsidence. Visual impact of the drill sites will also be reduced by spreading vegetation matter, where available, across the drill sites.</p>

Exploration PEPR application – ongoing

Drillhole construction and decommissioning		
Have the personnel responsible for implementing the proposed program read and understood the Earth Resources Information Sheet M21, Mineral exploration drillholes – general specifications for construction and backfilling?	Yes <input checked="" type="checkbox"/>	No <input type="checkbox"/>
Describe how drillholes will be constructed, including the casing material to be used, depth of casing, if the casing will be cemented, cementing intervals and the class of driller that will install the casing.		
<p>Rotary-mud drillholes will be drilled vertically. All drillholes will be typically drilled to 6 inches in diameter and will require the construction of two (2) or three (3) drill sumps (3m (w) by 5m (l) by 1.5m (d)) dependent on drillhole depth and ground conditions. Muds and drill fluid additives used to stabilise the drillhole during the drill process are biodegradable and non-toxic to the environment. A collar casing may be installed in the first 12m of the drillhole to prevent cave in while drilling. The casing will not be cemented in place and will be removed at the completion of the drillhole.</p> <p>RC drillholes will be drilled 6 inches in diameter and will require the construction of one (1) or two (2) drill sumps dependent on drillhole depth and ground conditions. Any muds and drill fluid additives used to stabilise the drillhole during the drill process are biodegradable and non-toxic to the environment. Collar casing may be installed in the first 12 m of the drillhole to prevent cave-in while drilling. The casing will not be cemented in place and will be removed at the completion of the drillhole.</p> <p>Core holes are expected to be precollared using the above rotary mud technique with a core tail of PQ or HQ drill diameter, depending on drill conditions. Holes may be drilled on an incline to allow for structural measurements to be taken downhole. Holes will require the construction of two (2) or three (3) drill sumps (3m (w) by 5m (l) by 1.5m (d)) dependent on drillhole depth and ground conditions. Muds may be used to stabilise the drillhole to allow for post drilling geophysical logging. Muds and drill fluid additives used to stabilise the drillhole during the drill process are biodegradable and non-toxic to the environment.</p> <p>Air core holes will be drilled vertically to a 4 7/8-inch diameter. One (1) sample and dust suppression pit (4m (w) by 4m (l) by 1m (d)) will be constructed at each hole to allow for sample disposal, dust suppression and containment of any unexpected groundwater. The drilling of air core will be targeting areas considered prospective for commodities other than uranium.</p> <p>All drillholes will be constructed by Class 2 drillers who are either employees of Heathgate or Contractor Drilling.</p>		
When describing drillhole decommissioning requirements, include the materials to be used, stratigraphic intervals where cement plugs will be placed, if the casing will be removed and when decommissioning will occur after drilling is completed.		
<p>At completion of drilling, all drillholes will be abandoned in line with Department of Energy and Mining (DEM) Mineral Exploration Drillholes General Specifications for the Construction and backfilling (DEM Information Sheet M21) and within three (3) months of the end of the approved drilling program unless the drillholes are required for a longer period and Heathgate seeks future/alternative approval from DEM, via a letter to DEM with the accompanying appropriate reasons/justifications, to be agreed to in writing from DEM. Such a request, if required, will be made by submitting a Program Notification requesting a time extension.</p> <p>Rotary mud, reverse circulation and diamond holes will be backfilled and cemented with cement from base of hole to surface as the preferred method of decommissioning. After geophysical logging is completed all delineation drillholes will be backfilled and cemented in order to prevent flow between or contamination of any intersected aquifers or permeable horizons. The cementing unit will calculate the amount of grout required to cement the hole to surface, with the volume calculation determined by the depth and diameter of the hole. The cementing line is then run to the bottom of the hole and the 4.5% bentonite grout mixed and pumped to bottom. After displacing at least 200 litres of mud from the hole the cementing line is slowly withdrawn whilst continuing to pump grout down the cementing line, resulting in full length of hole grouting and sealing of possible aquifers associated with permeable layers. The operator will stop pumping when the grout appears at the surface; withdraw the cementing line, and then top up the hole with the remaining grout.</p> <p>Aircore and RC drillholes will be backfilled with drill cuttings, grouted, and plugged where required by DEM information sheet M21 requirements based on intersected aquifers. Holes will be covered with a mound of soil to allow for natural compaction in the drillhole.</p>		

Exploration PEPR application – ongoing

Where confined or artesian conditions are expected, include a schematic diagram demonstrating how drillholes will be constructed and decommissioned

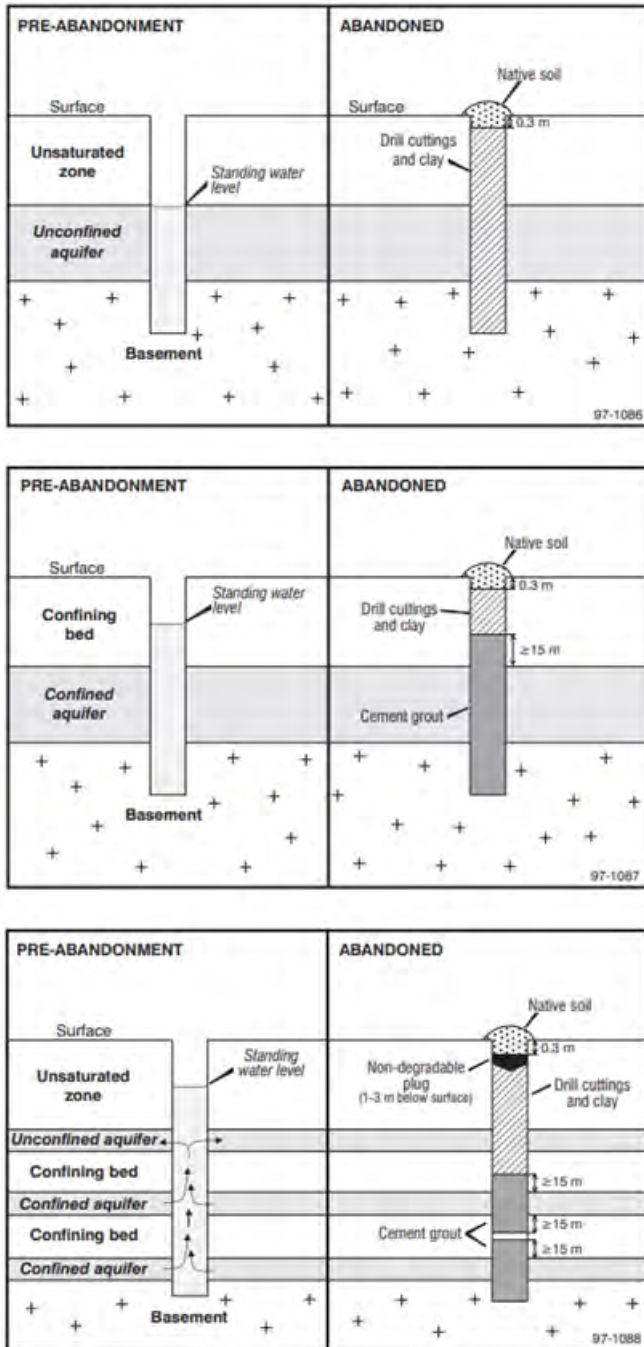


Figure 1 - DEM Information Sheet M21 figures 2-4 outlining minimum drillhole rehabilitation requirements

Costeans and bulk sample disposal pits

Will costeans/bulk sample disposal pits be required for the proposed program? If yes, indicate the maximum dimensions and size of pits and costeans.	Yes <input checked="" type="checkbox"/>	No <input type="checkbox"/>
<p>Existing sumps will be used.</p> <p>RC Drilling single sample pit 4m (w) by 4m (l) by 1m (d): 1 pit per hole AC Drilling single sample pit 4m (w) by 4m (l) by 1m (d): 1 pit per hole Rotary Mud Drilling 2-3 sumps, dependent on hole depth 3m (w) by 5m (l) by 1.5m (d) Diamond Drilling 2-3 sumps, dependent on hole depth 3m (w) by 5m (l) by 1.5m (d) (utilising pre collar Rotary Mud Sumps)</p>		
<p>Describe site preparation methods, vegetation clearance, and safety and maintenance requirements if pits and costeans are required.</p>		
<p>Drill sump construction will be completed with a backhoe, and require the separate stockpiling of topsoil, generally the top 0.5m of surface material, for later rehabilitation. Sumps and sample pits will be prepared for each hole to the size outlined above. Pits and sumps will be built with a fauna escape ramp to allow for fauna to escape prior to rehabilitation if they fall in. Prior to rehabilitation all pits will be fenced off to discourage larger animals from accessing the pit and to demarcate safe working areas.</p> <p>Rotary mud and Diamond hole sumps will be allowed to dry prior to backfilling. The soil which was separated when excavating into subsoil and topsoil piles will be then placed back in the sump in the correct profile/order i.e. subsoil first then topsoil. The topsoil will be spread across the drillhole sites to encourage the regeneration of vegetation and will be slightly mounded to allow for natural subsidence. Visual impact of the drill sites will also be reduced by spreading vegetation matter, where available, across the drill sites.</p> <p>AC and RC drill holes sumps will function both as a catchment in case of intersecting groundwater, to assist in the dust management of the drilling process, and to dispose of waste samples at the end of drilling the hole. All waste samples will be emptied from their sample bags into the drill sump prior to rehabilitation. The soil which was separated when excavating into subsoil and topsoil piles will be placed back in the sump in the correct profile/order i.e. subsoil first then topsoil. The topsoil will be spread across the drillhole sites to encourage the regeneration of vegetation and will be slightly mounded to allow for natural subsidence. Visual impact of the drill sites will also be reduced by spreading vegetation matter, where available, across the drill sites.</p>		

Sample management

Describe the size of samples collected (including drilling samples and bulk sampling), collection methods, materials used when collecting the sample, sample disposal methods (including removal of sample bags), safety management and any other sample management requirements at the exploration site (e.g., tarps or matting used to contain cuttings). Include requirements for on-site geological sample management (splitting of archive samples, bag farms, core processing and storage).

<p>Rotary mud drilling samples comprise of a small 1-2kg composite sub sample from each 1-2m downhole interval laid out on site on hessian sheets using appropriate tools (shovel or similar) to allow for geological logging and further testing if required. These sub samples will be placed at the bottom of the sump once geological logging and testing completed with the hessian sheeting and then covered with subsoil and topsoil. The remainder of any drill cuttings will remain within the drill sumps.</p> <p>Samples generated from the AC or RC drilling will be collected at either 1 or 2m intervals, dependent on the program requirements. The samples will pass through a cyclone sample collector with the full sample placed into green plastic bags, and sub samples placed into calico bags. After geological logging and pXRF scanning, samples requiring further work (laboratory geochemistry, metallurgy etc; dependent on the program requirements) will be taken to the Beverley mine geology yard for processing and distribution. Samples returned to the Beverley mine for further processing will be stored out of the weather in pallet bins until test work is completed and they are disposed of within the onsite waste disposal facility. The bulk of samples will be poured out of the green plastic bags into their drill sample pit, with the green bags being disposed of in the onsite waste disposal facility, stored calico bags will be disposed of once test work has been completed for the hole in the site waste disposal facility.</p> <p>For rotary mud, RC and AC drilling, a small sample will be retained in plastic chip trays for future reference purposes.</p> <p>For diamond core drilling, samples collected from the drill rig are placed into plastic core trays for meter marking, structural, geological, geochemical logging, and sample designation. Core will be photographed once meter marked for reference. Core samples sent off site for lab analysis will be sent as full core. Core will be retained in plastic trays at the Beverley core storage facility with representative holes retained on site. Non reference core samples will be disposed of within the onsite waste disposal facility once test work has been completed. Any core areas of potential interest will be retained and stored out of the weather at the Beverley core storage facility.</p> <p>Any samples sent off site will be returned with material stored out of the weather at the Beverley core storage facility until their disposal in the onsite waste disposal facility.</p> <p>To minimise any exposure from these pathways the following will be enforced:</p> <ul style="list-style-type: none"> • Use of gloves and work clothes while handling samples. • Wash hands and face after handling samples as well as before eating, drinking, or smoking • Keep the samples sealed in the plastic chip trays • If there is a possibility of dust inhalation from the small composite samples once dry, then it is recommended that a P1 half face mask or respirator be used.
--

Exploration PEPR application – ongoing

All plastic compartmental chip trays and diamond core samples will be stored in appropriate storage facilities at the Beverley Mine site.

Access routes to work areas

Will existing tracks require upgrading and/or maintenance? If yes, detail the work required to upgrade/maintain existing tracks.	Yes <input checked="" type="checkbox"/>	No <input type="checkbox"/>
Driving in the area will be minimised as much as possible to reduce wear and tear on existing pastoral lease tracks and temporary tracks. Existing pastoral lease tracks will be maintained by using a water truck to water the track, stabilise the track surface and minimise dust formation. Grading of existing pastoral lease tracks will be only done when necessary for safety.		
Will access off existing tracks be required? If yes, detail the method(s) for gaining access and if vegetation clearance is required. Details of the total area of disturbance (includes drill traverses and seismic lines) required off existing tracks (i.e., length (km) and width (m) of new tracks) must be provided in the program notification.	Yes <input checked="" type="checkbox"/>	No <input type="checkbox"/>
Access will principally be along existing pastoral lease station tracks.		
The majority of proposed drill activities will be readily accessible through use of current existing tracks and the creation of new tracks is minimal. Where access preparation is necessary to access drill sites these will be constructed to minimise the amount of vegetation removal and disturbance to the environment. Where it is necessary to remove vegetation, a backhoe will be used with the blade remaining above soil level. Tracks will then be created by driving across the country and will pass around larger trees or significant vegetation. The track width will be approximately that of the drilling trucks and all vehicle movement will be minimised. Tracks will remain clear of lakebeds and potentially swampy areas.		
All new access within the exploration licence will be constructed in accordance with DEM guidelines. All new access will also require clearance by an Aboriginal Liaison Officer (ALO), to ensure that no Aboriginal sites of significance are disturbed.		

Where possible, indicate planned access routes on a locality plan and distinguish between existing and proposed new access tracks and drill lines (including fence lines).

Campsites, storage, and equipment laydown areas

Provide a description of campsites and/or laydown areas required. Indicate the campsite and laydown area on a locality plan.

Campsite details		
Indicate where staff and contractors will be accommodated during the exploration program.		
Staff and contractors will stay at the existing Beverley Mine camp for most programs. Where the project is more remote, staff and contractors are expected to be accommodated within a self-contained portable camp for a program's duration.		
What is the maximum number of personnel requiring accommodation?	14	
Is a campsite required to be established? If no, no further information is required.	Yes <input checked="" type="checkbox"/>	No <input type="checkbox"/>
Provide a description and justification of the camp location (e.g., previously cleared areas etc.), and any other relevant information.		
Any site for remote accommodation will be chosen in a location which minimises environmental impact, minimising vegetation clearance, away from watercourses and will be cleared by a Heathgate ALO for any cultural sensitivities.		
What will be the total area (ha) of the campsite(s)?	0.25ha	
What will be the total area (ha) of vegetation clearance for the campsite?	Up to 0.25ha	
If vegetation clearance is required, describe the methods used to prepare the site.		
Where it is necessary to remove vegetation, a backhoe will be used with the blade remaining above soil level. Tracks will then be created by driving across the country and will pass around larger trees or significant vegetation. The track width will be approximate that of a Light Vehicle and all vehicle movement will be minimised. Tracks will remain clear of lakebeds and potentially swampy areas.		
Will any excavations be required? If yes, describe the purpose of the excavation and the maximum volume (m ³) of material to be excavated.	Yes <input checked="" type="checkbox"/>	No <input type="checkbox"/>
Two (2) small trenches will be dug, then filled with gravel for dispersing fresh and grey water from camp taps. The maximum volume will be 8m x 2m x 2m (32m ³)		
Are the proposed ablution facilities endorsed/approved for use by the Department of Health or local council, where applicable? If no, indicate why.	Yes <input checked="" type="checkbox"/>	No <input type="checkbox"/>
In accordance with the Regulation 7 of the SA Public Health (General) Regulations 2013		
Proposed infrastructure (includes caravans, tents, offices, hydrocarbon and water storage requirements etc)	Quantity	Description/capacity
Accommodation buildings	4	Accommodation for fourteen (14) people. Portable units supplied by contractor camp (QuickCamps)

Exploration PEPR application – ongoing

Kitchen building	1	Portable unit
Bathroom/Laundry building	1	Portable unit
Office building	1	Portable unit
Ablution facility	1	Portable unit

Laydown area details		
Will laydown areas be required? If no, no further information is required.	Yes <input type="checkbox"/>	No <input checked="" type="checkbox"/>
Will the laydown area(s) be located at the same location as the campsite?	Yes <input type="checkbox"/>	No <input checked="" type="checkbox"/>
What will be the maximum area (ha) required for the laydown area(s)?		ha
What will be the total area (ha) of vegetation clearance for the site?		ha
If vegetation clearance is required, describe the methods used to prepare the site.		
NA		
Will any excavations be required? If yes, describe the purpose of the excavation and volume (m ³) of material to be excavated.	Yes <input type="checkbox"/>	No <input checked="" type="checkbox"/>
NA		
Proposed infrastructure (includes hydrocarbon and water storage requirements)	Quantity	Description/capacity
		<Tab to add rows.>

Other exploration methods and/or ancillary operations

<p>Are any other proposed exploration methods (e.g., seismic) and/or ancillary exploration operations required? If yes, describe the activity(s), site preparation, vegetation clearance, and safety and maintenance requirements.</p>	Yes <input checked="" type="checkbox"/>	No <input type="checkbox"/>
<p>Low impact exploration activities are proposed across the Arkaroola AEA. These methods include:</p> <p>Sampling surveys:</p> <ul style="list-style-type: none"> - Soil and stream sediment sampling – taking a small representative sample, collected using surface grab, small auger, or rock chip from outcrop. <p>Ground and airborne geophysical surveys:</p> <ul style="list-style-type: none"> - Ground Gravity <p>Ground gravity surveys utilise small hand carried gravity stations deployed on the surface to measure variations in the earths gravitational field. Surface disturbance is limited to vehicle access, with gravity stations positioned using quadbikes or light.</p> <ul style="list-style-type: none"> - Airbourne Gravity, Magnetics and Radiometrics <p>Flight lines flown over areas of interest measuring changes in gravity gradients, magnetic susceptibility or radiation output from rocks/soils at surface– no surface impact.</p> <ul style="list-style-type: none"> - Ground Electrical Methods <ul style="list-style-type: none"> o Electrical magnetics (EM) <p>EM surveying involves inducing a magnetic field into the earth via a transmitter loop cable that sits on the surface and then the response from the earth is measured by another receiver loop cable that also sits on the surface. The actual surface disturbance associated with EM surveying is predominantly by vehicle and requires creating tracks along planned survey lines for the single use of the survey. Transmitter and receiver cables need to be dragged along the survey lines by vehicle or quadbike every few hundred metres or so. Each survey line needs to be driven on four or five times. Communication with pastoralists will occur prior to lines going in, during survey and after completion.</p> <ul style="list-style-type: none"> o Induced polarisation (IP) <p>IP surveying involves transmitting electrical current into the earth between stations on a survey line and measuring voltage response between a series of stations along the same line. In addition to vehicle access required along each line, each survey stations requires a small pit (~1 x 1 x 0.5 m) hand dug with picks and shovels, which is lined with aluminium foil and filled over with soil and water for electrical coupling. Survey stations are every hundred metres or so on each line. A remote station may also be required for the survey, which is slightly larger (~3 x 3 x 0.5m), which will be a kilometre or two from the survey area.</p> <ul style="list-style-type: none"> o Controlled Source / Audio-Frequency Magnetotellurics (CSAMT / AMT) <p>CSAMT surveys consists of emitting an electric signal with regulated frequencies into the earth from a designated transmitter location, and then detecting the resulting magnetic and electric fields in the target area. Geological resistivity values can be obtained from CSAMT data by utilizing the ratios of magnitudes of the horizontal electric, orthogonal and magnetic fields (such as Ex and Hy).</p> <p>Electromagnetic signals are transmitted using a grounded dipole that is situated remotely. To begin the CSAMT survey, this dipole requires insulated copper wire to establish connections, and two current electrodes that are grounded and separated by around 1.5km. here are two ways to construct grounded current electrodes - either by driving multiple galvanized steel stakes into the ground or by building small mud pits lined with aluminium foil. Typically, salt water is used to ensure optimum electrical contact.</p> <p>Surface disturbance associated with CSAMT surveying is predominantly by vehicle and requires creating tracks along planned survey lines for the single use of the survey. Transmitter and receiver cables need to be dragged along the survey lines by vehicle or quadbike every few hundred metres or so. Each survey line needs to be driven on four or five times. Communication with pastoralists will occur prior to lines going in, during survey and after completion.</p> <ul style="list-style-type: none"> - Ambient Noise Tomography (ANT) / Passive Seismic <p>ANT / Passive seismic involves the passive recording sub surface seismic velocity changes using background noise from vibrations within the earth. The surveys consist of small geophone nodes, set in an array to record these changes. The nodes are typically left in place for up to a week. Nodes are set by hand and transported to location on quadbikes or on foot. A small pit may be required to be dug at each site to make sure correct coupling with surround soil.</p>		

Exploration PEPR application – ongoing

Water supply and management

Will camp and/or drilling water be required? If yes, describe how and where water will be sourced for drilling, track maintenance and camping purposes (e.g., groundwater, surface water, mains). Indicate how wastewater and/or runoff water will be managed.	Yes <input checked="" type="checkbox"/>	No <input type="checkbox"/>
Water for drilling purposes will be sourced from an existing network of water lines and storage dams. Water may also be sourced from existing water bores. Permission for use of any source for drill water will be determined in consultation with landowner and or stakeholder prior to use of the water source. Water may be carted from the Beverley Uranium Mine.		
Will surface water and/or mineral drillholes be used as a water source/supply? If yes, indicate if a licence for water extraction/usage is required (refer to relevant Natural Resources Management water allocation plan available on the <i>Department for Environment and Water</i> (DEW website). If a licence is required and has been obtained, please attach a copy. Where a licence has not been obtained, include a statement confirming that a licence will be obtained before the extraction and/or usage of water.	Yes <input checked="" type="checkbox"/>	No <input type="checkbox"/>
A determination of the need for an additional / alternate water source nearer to the drill areas will be made based on the progress of the drill programs and the amenability of these areas as a drilling water source. If this is required a license for the extraction / use of the water will be obtained prior to the extraction and/or usage of the water.		

Groundwater and drilling investigation activities

Will any water bores be required and/or water investigation activities (e.g., pump testing, water monitoring sites, water storage, turkey nests/dams) be conducted? If yes, describe the water drilling and investigation activities, including site preparation, vegetation clearance, and safety and maintenance requirements.	Yes <input checked="" type="checkbox"/>	No <input type="checkbox"/>
If required, water bores may be converted from existing exploration holes and will follow the same procedures and ground disturbance activities outlined in Section D of this application. Investigation methods will comprise of the following methods:		
<ul style="list-style-type: none"> - Screening select aquifers - Piezometer installation - Screened well converted into a water source 		
Water investigation holes will be PVC cased with casing grouted in place to isolate intercepted aquifers. Drill sites will require the standard two (2) sumps (3m (w) x 5m (l) x 1.5m (d)). Where ground disturbance is necessary, the amount of vegetation removal and disturbance to the environment will be minimised. Any muds and drill fluids used to stabilise the drillhole are biodegradable and non-toxic to the environment.		
Any wells converted to a water source will have a water licence applied prior to the conversion. The water from these wells will be used as a water source for drilling if required.		
Data from these wells, is used for continued uranium exploration. Primarily water pressures from targeted/host formations within these wells, are used to provide insight into ground water gradients and potential redox front orientation. Additionally, to provide elemental analysis of ground water conditions for uranium exploration and set baseline aquifer properties.		
Indicate if well permits have been obtained and whether or not a water extraction licence is required in accordance with the Landscape South Australia Act 2019. If yes, attach a copy of the permit(s)/licences. If no, provide a statement confirming that permits/licences will be obtained prior to commencement of water investigation activities.	Yes <input type="checkbox"/>	No <input checked="" type="checkbox"/>
Permits/licenses will be obtained prior to the commencement of water investigation activities.		

Water affecting activities

Will any water affecting activities, other than drilling a water well, be undertaken (refer to s. 127 of the Landscape South Australia Act 2019)? If yes, attach a copy of the permit. If a permit has not been obtained, provide a statement confirming that a water affecting activity permit(s) will be obtained and provide a description of the site preparation, vegetation clearance, and safety and maintenance requirements.	Yes <input type="checkbox"/>	No <input checked="" type="checkbox"/>
NA		

Management of hazardous materials

Will activities be conducted in areas of known uranium and thorium mineralisation? If yes, attach a Radiation Management Plan and confirmation of endorsement of the plan by the Environment Protection Authority South Australia (EPA).	Yes <input checked="" type="checkbox"/>	No <input type="checkbox"/>
Will any other hazardous material be encountered when exploring in the area? If yes, list the types of hazardous materials and provide a management plan on how these materials will be managed.	Yes <input type="checkbox"/>	No <input checked="" type="checkbox"/>
NA		

Exploration PEPR application – ongoing

Rehabilitation

Detail all the activities and strategies relating to the remediation of all impacts associated with the proposed exploration operations (includes exploration camps and laydown areas, tracks).

Completion of rehabilitation must be achieved within 3 months after the expiry of each program notification.

At completion of drilling all drillholes will be abandoned in line with Department for Energy and Mining (DEM) Mineral Exploration Drillholes General Specifications for the Construction and backfilling (DEM Information Sheet M21) and within three (3) months of the end of the approved drilling program unless the drillholes are required for a longer period and Heathgate seeks future/alternative approval from DEM through a letter to DEM with the accompanying appropriate reasons/justifications, and to be agreed to in writing from DEM. If such a request is required, it will be made by submitting a Program Notification requesting a time extension.

Existing station tracks are used as much as possible for all Heathgate exploration. Minimise vehicle movement and track construction to preserve the track integrity. Drill tracks are put in place when driving across country to eliminate or minimise the need of clearing vegetation. Where vegetation clearing is required, it is trampled/flattened above the surface to preserve the root stock. The seed bank is not removed during the process. The recommendation for gibber plain is not to rip these tracks. Access to any temporary drill tracks will be disguised at their entrance during the final rehabilitation of drill sites.

Removal of contaminated soil and waste/rubbish will be taken to an approved EPA disposal site with the nearest one being at Beverley Uranium Mine.

State the estimated budget required to rehabilitate all impacted sites.

Recent contractor exploration rehabilitation has worked out to approximately \$300 per hole.

Vegetation Clearance

Will any area of cleared native vegetation be unrehabilitated after the authorised period? If yes, provide a map and description of the vegetation present in the application area, the extent of any proposed vegetation clearance and the likelihood of the presence of threatened flora.	Yes <input type="checkbox"/>	No <input checked="" type="checkbox"/>
State the estimated quantum of significant environmental benefit (SEB) to be gained in exchange for the proposed native vegetation clearance and describe how the SEB will be provided.		
NA		

SECTION E – LEASE CONDITIONS

Retention leases

Where the retention lease includes specific conditions that are not environmental outcomes, demonstrate where these have been addressed in the PEPR (if relevant) or demonstrate how otherwise they have or will be complied with.

NA

SECTION 6 – MANAGEMENT OF ENVIRONMENTAL IMPACTS

Use the table below (instructions provided) to identify all of the potential environmental, social and economic impact events that are likely to occur as a result of the proposed exploration operations, how each of the identified impacts will be managed, and the residual risk, i.e., the level of risk remaining after implementing control and management strategies. Identified potential impact events should be developed based on the aspects of the environment that may be impacted on and the proposed operational details. Potential impact events must have corresponding outcomes and measurement criteria.

Where the terms and conditions of an RL include environmental outcomes, list them (where different) in the table below and complete all sections (receptor, potential impacts, control strategies, risk assessment and measurement criteria).

Environmental management – potential impacts/events, outcomes, measurable criteria and monitoring plan

			Likelihood of consequence (LH)				
			1	2	3	4	5
			Rare	Unlikely	Possible	Likely	Almost certain
Severity of consequence (CQ)	A	Insignificant	Low	Low	Low	Low	Low
	B	Minor	Low	Low	Moderate	Moderate	Moderate
	C	Moderate	Moderate	Moderate	High	High	High
	D	Major	High	High	Extreme	Extreme	Extreme
	E	Catastrophic	High	Extreme	Extreme	Extreme	Extreme

How to fill out the table

- Based on the description of the environment and exploration operations, indicate which potential impacts are applicable to the proposed program. Note that some potential impacts are applicable to all programs.
- For each applicable potential impact (and corresponding receptor), describe control strategies that will reduce the risk of the potential impact to an acceptable level, and achieve the corresponding environmental outcomes.
- Conduct an impact assessment to determine if the control strategies address the potential impact (i.e., reduce the risk to an acceptable level). Indicate where there is uncertainty pertaining to the likely effectiveness of the control strategies. Where the risk is not considered low, provide justification that the risk is acceptable, or consider additional strategies to reduce the risk to an acceptable level.
- For each applicable potential impact, the corresponding outcome and outcome measurement criteria are required.
- Based on the description of the environment and proposed exploration activities, determine if any other potential impacts are applicable. For each new potential impact, describe proposed control and rehabilitation strategies, conduct an impact assessment, and develop corresponding outcomes and outcome measurement criteria.

Use the above matrix to conduct an impact assessment for each potential impact.

Impact assessment							Outcomes	Outcome measurement criteria (inc. monitoring plan)
Receptor	Potential impacts	Is the potential impact applicable (Yes/No)	Control strategies	Risk assessment				
Lists are not exhaustive.	Lists are not exhaustive.	Some potential impacts are applicable to all programs.	Indicate where there is uncertainty pertaining to the likely effectiveness of the control strategies. Where the risk is not considered low, provide justification that the risk is acceptable, or consider additional strategies to reduce the risk to an acceptable level. – refer to Minerals Regulatory Guidelines MG22 for more information.	LH	CQ	Risk		
Stakeholders: <ul style="list-style-type: none"> freehold land owners perpetual lease holders pastoral lease holders Aboriginal land (Anangu Pitjantjatjara Yankunytjatjara and Maralinga Tjarutja lands) Department of Defence state government departments. local government (councils) federal government native title parties. 	Interference to: <ul style="list-style-type: none"> existing or permissible land use (includes loss of income, noise, dust, light and other emissions). buildings, structures, existing tracks or other infrastructure. aesthetic values of an area. Noncompliance with legislative requirements.	Yes (Applicable to all programs.)	<ul style="list-style-type: none"> All statutory forms have been issued to the stakeholders. Geologist will consult with all stakeholders prior to, during and after execution of the program. Undertake heritage clearance to ensure heritage is not disturbed and acquire stakeholder approval prior to undertaking program. Supervision by Heathgate's Aboriginal Liaison Officers (ALO's) with respect to pegging of drill locations. Consultation during program approval. Compliance with drillhole construction, rehabilitation, and site access in accordance with DEM and DEW guidelines and requirements. 	2	B	Low	Stakeholders are fully informed and satisfied with the proposed methods used to conduct exploration activities on their land, and all prescribed forms are served, and agreements obtained in accordance with the Mining Act.	Provide the information requested within the 'Complaints' section of the annual exploration compliance report demonstrating that all reasonable complaints from stakeholders are resolved to the satisfaction of both parties prior to and ongoing during the course of exploration program, without the involvement of DEM. Provide the information requested within the 'Landowner details and liaison' section of the annual exploration compliance report demonstrating that prescribed forms were served, and agreements obtained in accordance with the Mining Act prior to the commencement of exploration activities.
Stakeholder: DEW	Interference to: <ul style="list-style-type: none"> existing or permissible land use. buildings, structures, existing tracks or other infrastructure. aesthetic values of an area. Noncompliance with legislative requirements.	No (Applicable to programs located adjacent to or within parks and reserves.)	<If the potential impact is applicable, list the control and rehabilitation strategies>				For activities located within or adjacent to regional reserves, national, conservation and marine parks only: <ul style="list-style-type: none"> no unauthorised interference with park management activities. 	Provide confirmation that: <ul style="list-style-type: none"> Park access notification forms were submitted to DEW and DEM at least 10 days prior to entry into regional reserves, national, conservation and marine parks, or Program notifications for PEPRs approved for an ongoing period of time, were submitted to DEW and the DEM at least 21 days prior to entry into regional reserves, national, conservation and marine parks.

Exploration PEPR application – ongoing

Impact assessment						Outcomes	Outcome measurement criteria (inc. monitoring plan)	
Receptor Lists are not exhaustive.	Potential impacts Lists are not exhaustive.	Is the potential impact applicable (Yes/No) Some potential impacts are applicable to all programs.	Control strategies Indicate where there is uncertainty pertaining to the likely effectiveness of the control strategies. Where the risk is not considered low, provide justification that the risk is acceptable, or consider additional strategies to reduce the risk to an acceptable level. – refer to Minerals Regulatory Guidelines MG22 for more information.	Risk assessment LH = likelihood of consequence CQ = severity of consequence				
				LH	CQ			Risk
Flora and fauna and their habitats; includes Commonwealth and state scheduled species.	Loss/modification of native vegetation and associated habitats through the clearance of vegetation.	Yes (Applicable to exploration programs located within or impacting on native vegetation.)	<ul style="list-style-type: none"> All personnel and contractors are inducted prior to commencement of the drilling program. Access tracks / drill sites are planned in a manner that avoids significant vegetation. Use of existing tracks where possible. Avoidance of excessive track making by limiting access to and from sites with one track. Supervision by Aboriginal Liaison Officers (ALO's) with respect to drillhole location and pegging and clearing of access tracks. Heathgate has a Bushfire Response Procedure and team. 	2	B	Low	<p>No permanent loss/modification of native flora and fauna populations and their habitats through:</p> <ul style="list-style-type: none"> clearance fire other <p>unless prior approval under the relevant legislation is obtained.</p>	<p>Maintain before, during and after photographic evidence of all exploration sites (e.g., drillsites, new track exit/entry points off existing tracks, costeans, campsites) demonstrating that:</p> <ul style="list-style-type: none"> The area and method of disturbance is consistent with that described in the PEPR. No uncontrolled fires* occurred as a result of exploration activities. <p>Representative photos to be included within the annual exploration compliance report.</p>
All flora and fauna, especially listed species.	Loss/modification of the environment (biological, social and economic) through the introduction of weeds and pathogens.	Yes (Applicable to all programs.)	<ul style="list-style-type: none"> All personnel and contractors are inducted prior to commencement of the program. All vehicles to be washed prior to arriving on site and on departure from site to remove any weeds, plant, soil, and mud. Supervision by Aboriginal Liaison Officers (ALO's). A copy of the SA Buffel Grass Strategic Plan 2019 – 2024 will be on the drill site. 	2	B	Low	<p>No introduction of new species of weeds and plant pathogens, nor increase in abundance of existing weeds species.</p>	<p>Provide a statement within the 'Compliance with approved programs' section of the annual exploration compliance report, confirming that:</p> <ul style="list-style-type: none"> Vehicle logs were kept during the exploration program, demonstrating that all vehicles are clean and free of plant and mud material prior to entering properties' within the tenement areas, unless otherwise agreed to with the relevant landowners. Photographic evidence before and during exploration operations and after rehabilitation of disturbed sites was captured, demonstrating that no new weeds and plant pathogens were introduced, nor an increase in abundance of existing weeds recorded.
All fauna	Entrapment of fauna through open drillholes and excavations.	Yes (Applicable to exploration programs that involve drilling and/or require excavations.)	<ul style="list-style-type: none"> All personnel and contractors are inducted prior to commencement of the program. An ALO will supervise location of pegging for drillhole. Avoidance of excessive track making by limited access to and from sites with one track and use of existing tracks where possible. Drill holes to be permanently or temporarily capped/plugged prior to leaving the drill site. Drillhole pits will be fenced off and ramps built into the construction to enable fauna to exit pits. 	2	B	Low	<p>No fauna traps created as a result of exploration activities.</p>	<p>Maintain before, during and after photographic evidence of all drillholes and/or excavations demonstrating that:</p> <ul style="list-style-type: none"> All drillholes were permanently or temporarily capped/plugged immediately upon completion. No fauna and livestock became trapped in drillholes and/or excavations throughout the duration of the program. All rehabilitation was completed within 3 months of expiry of the PEPR approval (for PEPRs approved for a period of 12 months), or 3 months after the expiry of a program notification (for PEPRs approved for an ongoing period), unless otherwise authorised. <p>Representative photos are to be included within the annual exploration compliance report.</p> <p>Provide the information requested within the 'Rehabilitation' section of the annual exploration compliance report.</p>
Aboriginal heritage sites	Disturbance to Aboriginal heritage.	Yes (Applicable to all programs.)	<ul style="list-style-type: none"> A Work Area Clearance to be conducted prior to the commencement of the drilling program. Will keep away from any areas of Aboriginal Heritage. Heathgate's ALOs will be on site at all times. All staff to be inducted into Heathgate's Native Title policies. Aboriginal Heritage sites which are identified during the exploration program will be appropriately avoided, recorded, and reported to the correct authorities. 	2	B	Low	<p>No disturbance to Aboriginal artefacts or sites of significance unless prior approval under the relevant legislation is obtained.</p>	<p>Maintain a database and provide a statement within the 'Compliance with approved programs' section of the annual exploration compliance report demonstrating that:</p> <ul style="list-style-type: none"> Heritage sites were not impacted during the conduct of the exploration program, unless prior approval was obtained under the appropriate legislation. Work ceased on discovery of a significant site and recommenced only after authorisation. Aboriginal heritage sites identified during the exploration program were appropriately recorded and reported to authorities, if not previously known.
European heritage sites and sites of scientific and environmental significance	Disturbance to European heritage sites and sites of scientific and environmental significance (e.g., geological monuments, fossil reserves).	No (Applicable to exploration programs located close to or within European heritage sites and sites of scientific and environmental significance.)					<p>No disturbance to European heritage sites and to sites of scientific and environmental significance unless prior approval under the relevant legislation is obtained.</p>	<p>Demonstrate no impact to heritage sites and sites of scientific and environmental significance by:</p> <ul style="list-style-type: none"> Maintaining evidence, including detailed maps showing sites compared to the location of exploration activities, and photographic evidence of sites before and after the conduct of the exploration program. Providing a statement within the annual exploration compliance report confirming sites were not impacted during the conduct of the exploration program.

Exploration PEPR application – ongoing

Impact assessment							Outcomes	Outcome measurement criteria (inc. monitoring plan)
Receptor Lists are not exhaustive.	Potential impacts Lists are not exhaustive.	Is the potential impact applicable (Yes/No) Some potential impacts are applicable to all programs.	Control strategies Indicate where there is uncertainty pertaining to the likely effectiveness of the control strategies. Where the risk is not considered low, provide justification that the risk is acceptable, or consider additional strategies to reduce the risk to an acceptable level. – refer to Minerals Regulatory Guidelines MG22 for more information.	Risk assessment LH = likelihood of consequence CQ = severity of consequence				
				LH	CQ	Risk		
Soil/vegetation/fauna	Soil/vegetation contamination (e.g., hydrocarbons, rubbish, drill samples/cuttings, ablutions, other sources).	Yes (Applicable to all programs.)	<ul style="list-style-type: none"> Spill kits will be available in all vehicles this includes light and heavy. Drill rigs will have a bund placed around the areas where spillages may occur. Removal of contaminated soil and waste / rubbish to an EPA approved disposal site the nearest one being at the Beverley Uranium Mine. Staff to be inducted into the Radiation Management Procedure. 	2	B	Low	<p>No contamination of soil and vegetation as a result of exploration activities.</p>	<p>Demonstrate that all domestic or industrial waste (includes general rubbish and hydrocarbons) is disposed of in accordance with the <i>Environment Protection Act 1993</i> within 3 months of the expiry of the PEPR approval (for PEPRs approved for a period of 12 months), or 3 months after the expiry of a program notification (for PEPRs approved for an ongoing period), and that all fuel and chemicals are stored in accordance with EPA requirements, by providing:</p> <ul style="list-style-type: none"> The name, location and contact details of the authorised waste disposal facility. A statement within the 'Compliance with approved programs' section of the annual exploration compliance report confirming domestic and industrial waste was removed from all exploration sites and disposed of at an authorised waste disposal facility. Photographic evidence within the annual exploration compliance report demonstrating that all fuel and chemical storage facilities were managed in accordance with EPA requirements. <p>Maintain photographs of all exploration sites and provide representative photos within the annual exploration compliance report demonstrating that drill cuttings are:</p> <ul style="list-style-type: none"> removed from site and disposed of at a licensed facility buried under a minimum of 30 cm of soil, or in accordance with EPA guideline, Radiation protection guidelines on mining in South Australia: mineral exploration, available on the EPA website, or backfilled down the drillhole, within 3 months of the expiry of the PEPR approval (for PEPRs approved for a period of 12 months), or 3 months after the expiry of a program notification (for PEPRs approved for an ongoing period), unless otherwise authorised. <p>Provide the information requested within the 'Rehabilitation' section of the annual exploration compliance report.</p>
Soil	Disturbance to the soil profile and topography, and accelerated soil erosion caused by exploration activities (e.g., construction of sumps, new tracks and drill pads; ground compaction at laydown areas and camps).	Yes (Applicable to all programs.)	<ul style="list-style-type: none"> Minimise vehicle movement and track construction to preserve the track integrity. No significant earthworks required. Frequent monitoring of drill sites by Heathgate's Health, Safety, Security and Environment (HSSE) Department. Stockpiling of the topsoil separately during sump/pit excavation. Educate all site employees and contractors on the importance of remaining on existing tracks. Personnel to drive only on existing tracks. Additional fencing in areas with repeated unauthorised off-road tracks. Ripping / scarification across compacted areas to control excessive run-off during high rainfall events. 	2	B	Low	<p>Where soil disturbance occurs as a result of exploration activities, ensure that:</p> <ul style="list-style-type: none"> topsoil quality and quantity are maintained the soil profile and topography is reinstated to original conditions there is no accelerated soil erosion. 	<p>Maintain before, during and after photographic evidence of all excavations, drillsites, camps, laydown areas and new tracks demonstrating that:</p> <ul style="list-style-type: none"> The soil profile and topography is reinstated to original conditions and is consistent with natural surroundings within 3 months of the expiry of the PEPR approval (for PEPRs approved for a period of 12 months), or 3 months after the expiry of a program notification (for PEPRs approved for an ongoing period), unless otherwise authorised. Where required, sufficient topsoil is removed (depending on soil profile), stored separately from subsoil and reinstated (in the correct order) within 3 months of the expiry of the PEPR approval (for PEPRs approved for a period of 12 months), or 3 months after the expiry of a program notification (for PEPRs approved for an ongoing period), unless otherwise authorised. There are no signs of accelerated soil erosion during and post rehabilitation of disturbed sites. <p>Representative photos to be included within the annual exploration compliance report.</p> <p>Provide the information requested within the 'Rehabilitation' section of the annual exploration compliance report.</p>
Surface water	Alteration to surface water – interference to surface drainage.	Yes (Applicable to exploration programs that are likely to impact on surface drainage channels.)	<ul style="list-style-type: none"> Ripping / scarification across compacted areas to control excessive run-off during rainfall events. Move drill sites to avoid modification of existing drainage. No significant earthworks required. 	2	B	Low	<p>No permanent modification to hydrological features caused by exploration activities without obtaining a water affecting permit from the relevant Landscape Board (under Landscapes Act SA 2019).</p>	<p>Provide before, during and after photographic evidence within the annual exploration compliance report demonstrating that original drainage contours (watercourses and lakes) are consistent with the natural relief post rehabilitation within 3 months of the expiry of the PEPR approval (for PEPRs approved for a period of 12 months), or 3 months after the expiry of a program notification (for PEPRs approved for an ongoing period).</p> <p>Alternatively, provide copies of water affecting permits within the annual exploration compliance report.</p>

Exploration PEPR application – ongoing

Impact assessment						Outcomes	Outcome measurement criteria (inc. monitoring plan)	
Receptor Lists are not exhaustive.	Potential impacts Lists are not exhaustive.	Is the potential impact applicable (Yes/No) Some potential impacts are applicable to all programs.	Control strategies Indicate where there is uncertainty pertaining to the likely effectiveness of the control strategies. Where the risk is not considered low, provide justification that the risk is acceptable, or consider additional strategies to reduce the risk to an acceptable level. – refer to Minerals Regulatory Guidelines MG22 for more information.	Risk assessment LH = likelihood of consequence CQ = severity of consequence				
				LH	CQ			Risk
Groundwater/aquifer	Groundwater contamination: <ul style="list-style-type: none"> contamination of aquifers through entry of pollutants from the surface interconnection between aquifers degradation of natural hydrostatic conditions (maintain pre-drilling pressures). 	Yes (Applicable to all exploration programs that may intersect groundwater.)	<ul style="list-style-type: none"> All drillholes will be drilled by Class 2 drillers. All drillholes to be abandoned and rehabilitated in accordance with DEM guidelines Earth Resources Information Sheet M21. Separate aquifer systems isolated by cement plugs. Cementing holes from top to bottom. No drilling within a 2km radius of mound springs. 	2	B	Low	Drillholes restored to controlling geological conditions that existed before the hole was drilled or, where it is intended to re-enter the hole, the hole must be completed with casing of adequate strength and the casing cemented so that all aquifers are isolated to prevent the movement of any fluids behind the casing.	Maintain evidence demonstrating that drillholes are decommissioned in accordance with Earth Resources Information Sheet M21, Mineral exploration drillholes – general specifications for construction and backfilling , and/or specific conditions from DEW (Groundwater) within 3 months of the expiry of the PEPR approval (for PEPRs approved for a period of 12 months), or 3 months after the expiry of a program notification (for PEPRs approved for an ongoing period), unless otherwise authorised. Provide the information requested within the 'Groundwater' section of the annual exploration compliance report.
Soil/vegetation/fauna	Discharge of groundwater into the surrounding environment.	Yes (Applicable to all exploration programs that may intersect groundwater or where activities require the discharge of groundwater into the surrounding environment.)	<ul style="list-style-type: none"> All drill rigs will have a bund placed around the area. All discharge of groundwater will be controlled through the use of drill sumps of an adequate size. Drill sumps are constructed in order to prevent discharge of groundwater into the surrounding environment. All drillholes will be decommissioned and rehabilitated in accordance with DEM guidelines Earth Resources information Sheet M21. 	2	B	Low	No discharge of groundwater outside of the exploration site (e.g., drillsite) into the surrounding environment and no discharge of water into a watercourse, unless prior approval under the relevant legislation is obtained.	Maintain photographic evidence of all drillsites demonstrating that groundwater was not discharged into the surrounding environment, unless water affecting activity permits were obtained allowing the discharge of groundwater into watercourses and/or lakes. Representative photos and water affecting activity permits (where applicable) to be included within the annual exploration compliance report.
Groundwater users	Interference to existing water users when extracting water from existing dams, water bores or mineral drillholes.	Yes (Applicable to all exploration programs that may require the use of water from existing dams, water bores or mineral drillholes.)	<ul style="list-style-type: none"> An agreement on the amount of water taken will be pursued before any water is extracted from existing bores / dams Agreement will be reached with stakeholders on the use of existing pumps / tanks and whether Heathgate will supply their own pumps and tanks for taking and storing water. Consultation with all stakeholders prior to and during execution of the program. Minimise disturbance to areas or livestock surrounding bores and dams. 	1	B	Low	No public nuisance impacts resulting from the extraction of water for exploration purposes, unless prior approval under the relevant legislation is obtained.	Provide the information requested within the 'Complaints' section of the annual exploration compliance report demonstrating that all reasonable complaints from stakeholders were resolved to the satisfaction of both parties, prior to and ongoing during the course of the exploration program without the involvement of DEM. Where permits are required for the extraction and/or usage of groundwater, provide copies of the licence or permit within the annual exploration compliance report.
Soil/vegetation/fauna	Degradation of rehabilitated access tracks caused by third party access (includes previously closed and rehabilitated access tracks).	Yes (Applicable to exploration programs that create new access tracks.)	<ul style="list-style-type: none"> All new access tracks will be decommissioned and rehabilitated at the end of the work program, as per SA Earth Resources Information Sheet M33. Rehabilitation of all new access tracks will be closed and rehabilitated within 3 months of the Program Notification expiry. Photographs of new access tracks will be taken before, during and after work program activity. 	2	A	Low	Rehabilitated access tracks remain permanently closed, unless prior approval under the relevant legislation is obtained.	Maintain before and after photographic evidence demonstrating that all tracks are closed and rehabilitated within 3 months of the expiry of the PEPR approval (for PEPRs approved for a period of 12 months), or 3 months after the expiry of a program notification (for PEPRs approved for an ongoing period), unless otherwise authorised. Representative photos are to be included within the annual exploration compliance report. Provide the information requested within the 'Rehabilitation' section of the annual exploration compliance report.
Community/landowners	Damage to infrastructure and loss of income through fire.	Yes (Applicable to all programs.)	<ul style="list-style-type: none"> No fires on fire ban days. All vehicles will be fitted with fire extinguishers. All staff and contractors will be inducted and trained in fire management. A copy of Heathgate's Bushfire response procedure document will be at the drill site for staff and contractors to access. 	1	C	Mod	No loss of infrastructure or income through fire as a result of exploration activities.	Provide a statement within the 'Compliance with approved programs' section of the annual exploration compliance report confirming that no uncontrolled fires* occurred. Alternatively, provide a report on the independent investigation of all uncontrolled fires* demonstrating that the licensee could not have reasonably prevented the fire through the implementation of precautionary measures.
General public	Injury or death to members of the public as a result of exploration activities.	Yes (Applicable to all programs.)	<ul style="list-style-type: none"> Drill rig / drilling warning signs to be placed 100 metres either side of drill rig when working on an access road. Flagging, bunting, and fencing to be used around areas that public can access. All staff to be inducted on drillsites. All staff and contractors to be trained in first aid. All vehicles to have mine flashing lights on them and working so they can be seen in the distance. 	1	D	High	No accidents involving the public that could have been reasonably prevented by the licensee.	Provide a statement within the 'Compliance with approved programs' section of the annual exploration compliance report confirming no accidents occurred involving the public during and after the exploration program. If an accident involving the public did occur, provide a copy of the independent investigation report within the annual exploration compliance report demonstrating that the licensee could not have reasonably prevented the accident through the implementation of precautionary measures.

Exploration PEPR application – ongoing

Impact assessment						Outcomes	Outcome measurement criteria (inc. monitoring plan)	
Receptor Lists are not exhaustive.	Potential impacts Lists are not exhaustive.	Is the potential impact applicable (Yes/No) Some potential impacts are applicable to all programs.	Control strategies Indicate where there is uncertainty pertaining to the likely effectiveness of the control strategies. Where the risk is not considered low, provide justification that the risk is acceptable, or consider additional strategies to reduce the risk to an acceptable level. – refer to Minerals Regulatory Guidelines MG22 for more information.	Risk assessment LH = likelihood of consequence CQ = severity of consequence				
				LH	CQ			Risk
General public, employees, contractors and the environment	Contamination of the environment when exploring for known uranium and thorium deposits. Public and employee/contractor exposure to low level radiation.	Yes (Applicable to exploration programs located within known uranium or thorium deposits.)	<ul style="list-style-type: none"> Use of appropriate tools which handle high grade drill cutting / samples. Minimise the time spent near high grade drill cutting/samples. Use of appropriate PPE gear. Maintain good personal hygiene. Disposal of drill cuttings and mud into the pits and covering them with sufficient thickness of subsoil and topsoil. Inducting and training personnel in working with high grade drill cuttings / samples. 	2	A	Low	<p>No increase in background radiation levels, and employee/contractor exposure levels during the exploration program are within safe limits.</p> <p>Maintain a database and provide a statement within the 'Compliance with approved programs' section of the annual exploration compliance report demonstrating that:</p> <ul style="list-style-type: none"> Radiation levels post exploration and rehabilitation are consistent with pre-existing background levels. Employee and contractors' exposure levels were within safe limits during the exploration program. 	
Other (if applicable)								

* Uncontrolled fires = fires that escape outside of the work area (e.g., drillsite).

† Properties = freehold (cropping and grazing land); perpetual/pastoral lease land; council land; regional reserves; national, conservation and marine parks; Aboriginal land; Commonwealth land etc.

SECTION G - OPERATOR CAPABILITY

Provide information demonstrating that the tenement holder and operator (where applicable) has the capability to conduct the program in a manner that consistently ensures ongoing achievement of the environmental outcomes. This may be demonstrated within the PEPR by providing an overview of the following:

- Manuals or standard operating procedures that outline the safe and environmentally sound operation of all critical operations associated with the exploration program that ensure compliance with the PEPR.
- Systems in place to monitor, audit and assess compliance against the criteria approved in the PEPR.
- Systems in place to identify and report any noncompliance with regulatory requirements or relevant environmental outcomes (e.g., measures in place to report incidents in accordance with regulation 79(3)).
- Practices and procedures in place to provide appropriate communication of regulatory requirements to employees and contractors (e.g., induction programs).
- Practices and procedures in place to respond to, and communicate with landowners and external parties on the proposed program and compliance matters (e.g., complaints)

Prior to commencing exploration work, all Heathgate staff and contractors undertake a Heathgate site induction, this induction covers; the use of STAR cards, Hazard cards, incident reporting, and Job Safety Analysis and Risk Assessment forms. This induction also addresses the regulatory requirements related to working for Heathgate as both a staff member and contractor.

In addition to the site induction, exploration programs will include a pre commencement meeting to discuss the program scope with the team members to assist with the planning of the program and to identify any unique considerations (safety, environmental, cultural, social etc) so these issues can be documented, and a management plan can be prepared.

Any equipment arriving on site is inspected prior to commencing work to assess for safety compliance. Any non-compliant components are required to be remedied prior to commencing work.

SOPs have been prepared to ensure activities are being undertaken by licensed and competent people. SOPs cover the steps required to undertake activities in a safe and effective manner and control environmental risks in accordance with the PEPR.

SOPs are reviewed for updates annually with the competencies of staff assessed against the SOPS on a 12-month rolling review period.

Any activity that is not covered by an SOP is managed through the use of the Heathgate Job Safety Analysis and Risk Assessment form. This form is completed by staff undertaking the tasks and reviewed by the department supervisor, and the senior person undertaking the task, prior to the task being undertaken.

Prior to undertaking any tasks, the Heathgate STAR card system is undertaken by all staff and contractors to assess any potential risks and document controls put in place to manage these risks.

Regular site safety and environmental visits are undertaken by geology and drill supervisors as well as by supervisors of departments independent of the exploration process. Results of the safety and environmental visits are recorded digitally within the INX InControl system where any safety and environmental improvements are documented to ensure they are followed up and resolved.

Hazard cards are used to identify and report any pre-incident issues. These hazard cards are entered into the InControl system to ensure the hazards are addressed prior to being closed out.

Incident reports where required are recorded digitally within the InControl system with supporting documentation attached for reference. Incidents reported entail any safety, environmental, cultural or any other non-compliant incident that is required to be reported. These incidents are reported to supervisors and departments required to address the incident.

Heathgate maintains an active communication with landholders on and around EL 5916, EL 6033 and EL 6244. Prior to the commencement of any program, communication, either by telephone, email, or letter, is made. This communication includes the serving a notice of entry form and notice of use of declared equipment form 42 days prior to the commencement of exploration activities. Exploration activities take into consideration the activities of other landholders to minimise the impact on their activities through variations in the timing of programs or modification of the program where possible.

SECTION H –ADDITIONAL INFORMATION

List any other supporting information and/or documents submitted with the application, including land access approvals/permits required to conduct the proposed exploration program.

<Include text here.>

SECTION I – PHOTOS

Include photographs in this section:

- that have been obtained during site visits
- that help describe relevant environmental and operational aspects in the PEPR.

To insert photos, copy and paste the photo into the template below. Resize photos to fit page width. Ensure that all information about each photo is completed and refer to the photo number in the relevant section of the PEPR.

Site identification	Date taken	Photo number & PEPR section reference	Easting (GDA94)	Northing (GDA94)	Zone	Details and Comments
FSD0089	28/10/2019	1	350690	6651296	54	General landscape of Four Mile South



Exploration PEPR application – ongoing

Site identification	Date taken	Photo number & PEPR section reference	Easting (GDA94)	Northing (GDA94)	Zone	Details and Comments
Woolatchi	5/12/2019	2	372652	6695971	54	General Landscape of Woolatchi from foot of Northern Flinders Ranges



Exploration PEPR application – ongoing

Site identification	Date taken	Photo number & PEPR section reference	Easting (GDA94)	Northing (GDA94)	Zone	Details and Comments
Yadglin Point C4	28/07/2019	3	372906	6678563	54	Yadglin general landscape image



SECTION J – MAPS

Provide a map(s) showing the following information that is located adjacent to or within the proposed area of operations, where applicable:

- tenement boundaries,
- cadastral information,
- existing surface contours,
- existing vegetation,
- location of the proposed exploration operations (includes drillholes, existing and new access tracks, drill traverses, campsites, laydown areas and other applicable information) and/or the target exploration area(s),
- location of existing ephemeral and permanent rivers, creeks, swamps, streams or watercourses and water management structures,
- location of towns, houses and homesteads, existing roads, rails, fences, transmission lines, buildings, dams and pipelines
- known sightings of listed species,
- location and extent of all environmentally sensitive areas,
- any relevant land use types (e.g., parks and reserves, Aboriginal freehold land, Woomera Prohibited Area).

All maps and sections must conform to the standards outlined in the Exploration PEPR Terms of Reference.

SECTION K – PUBLIC RELEASE

PEPR documents will be registered on the mining register and publicly released in full without the need to request consent from the tenement holder(s). Ultimately, it is the applicant's responsibility to ensure that confidential, or commercially sensitive, information is not included within the PEPR application.

SECTION L – SUBMISSION OF THE APPLICATION

An application for an Exploration PEPR or PEPR review, must be submitted in the following form, unless otherwise specified by the Director of Mines or an authorised officer:

- an electronic version of the PEPR must be submitted using the exploration PEPR template(s) provided on the DEM Minerals website,
- the electronic version must be submitted online through the DEM Minerals website using the exploration PEPR submission form,
- the electronic version must be submitted in one single Acrobat PDF file, and
- Microsoft Word-compatible files must be submitted if requested by the Director of Mines (or delegate), or other authorised officers.

200000

300000

400000



Wahlgate Pty Ltd
8, 11, 13, 15, 17, 19, 21, 23, 25, 27, 29, 31, 33, 35, 37, 39, 41, 43, 45, 47, 49, 51, 53, 55, 57, 59, 61, 63, 65, 67, 69, 71, 73, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 119, 121, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, 161, 163, 165, 167, 169, 171, 173, 175, 177, 179, 181, 183, 185, 187, 189, 191, 193, 195, 197, 199, 201, 203, 205, 207, 209, 211, 213, 215, 217, 219, 221, 223, 225, 227, 229, 231, 233, 235, 237, 239, 241, 243, 245, 247, 249, 251, 253, 255, 257, 259, 261, 263, 265, 267, 269, 271, 273, 275, 277, 279, 281, 283, 285, 287, 289, 291, 293, 295, 297, 299, 301, 303, 305, 307, 309, 311, 313, 315, 317, 319, 321, 323, 325, 327, 329, 331, 333, 335, 337, 339, 341, 343, 345, 347, 349, 351, 353, 355, 357, 359, 361, 363, 365, 367, 369, 371, 373, 375, 377, 379, 381, 383, 385, 387, 389, 391, 393, 395, 397, 399, 401, 403, 405, 407, 409, 411, 413, 415, 417, 419, 421, 423, 425, 427, 429, 431, 433, 435, 437, 439, 441, 443, 445, 447, 449, 451, 453, 455, 457, 459, 461, 463, 465, 467, 469, 471, 473, 475, 477, 479, 481, 483, 485, 487, 489, 491, 493, 495, 497, 499, 501, 503, 505, 507, 509, 511, 513, 515, 517, 519, 521, 523, 525, 527, 529, 531, 533, 535, 537, 539, 541, 543, 545, 547, 549, 551, 553, 555, 557, 559, 561, 563, 565, 567, 569, 571, 573, 575, 577, 579, 581, 583, 585, 587, 589, 591, 593, 595, 597, 599, 601, 603, 605, 607, 609, 611, 613, 615, 617, 619, 621, 623, 625, 627, 629, 631, 633, 635, 637, 639, 641, 643, 645, 647, 649, 651, 653, 655, 657, 659, 661, 663, 665, 667, 669, 671, 673, 675, 677, 679, 681, 683, 685, 687, 689, 691, 693, 695, 697, 699, 701, 703, 705, 707, 709, 711, 713, 715, 717, 719, 721, 723, 725, 727, 729, 731, 733, 735, 737, 739, 741, 743, 745, 747, 749, 751, 753, 755, 757, 759, 761, 763, 765, 767, 769, 771, 773, 775, 777, 779, 781, 783, 785, 787, 789, 791, 793, 795, 797, 799, 801, 803, 805, 807, 809, 811, 813, 815, 817, 819, 821, 823, 825, 827, 829, 831, 833, 835, 837, 839, 841, 843, 845, 847, 849, 851, 853, 855, 857, 859, 861, 863, 865, 867, 869, 871, 873, 875, 877, 879, 881, 883, 885, 887, 889, 891, 893, 895, 897, 899, 901, 903, 905, 907, 909, 911, 913, 915, 917, 919, 921, 923, 925, 927, 929, 931, 933, 935, 937, 939, 941, 943, 945, 947, 949, 951, 953, 955, 957, 959, 961, 963, 965, 967, 969, 971, 973, 975, 977, 979, 981, 983, 985, 987, 989, 991, 993, 995, 997, 999

Arkaroola AEA Ongoing PEPR

AEA Locality

Requested By: Anthony Hewett	Drawn By: Anthony Hewett
Scale: 1:1,600,000	Datum: GDA94 / MGA zone 54
Date: 01/03/2022	Plan No: Figure 1.

6700000

6700000

6600000

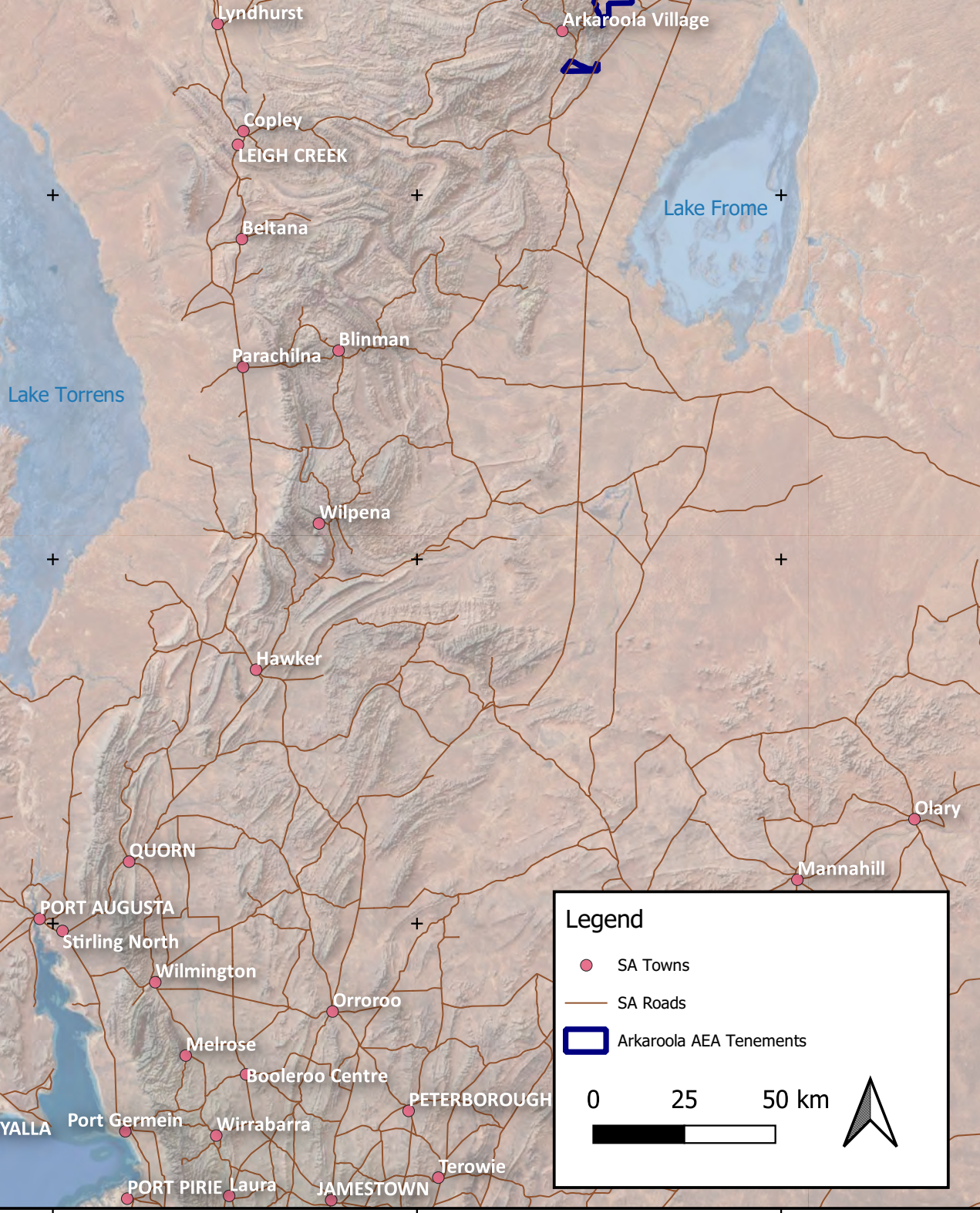
6600000

6500000

6500000

6400000

6400000



Legend

- SA Towns
- SA Roads
- Arkaroola AEA Tenements

0 25 50 km

325000

350000

375000



Heathgate Resources Pty Ltd
Suite 1, Level 4
25 Ordman Street
Adelaide SA 5002

Arkaroola AEA Ongoing PEPR

Tenement Locality

Requested By:
Anthony Hewett

Drawn By:
Anthony Hewett

Scale:
1:400,000

Datum:
GDA94 / MGA zone 54

Date:
11/01/2023

Plan No:
Figure 2.

6725000

6700000

6675000

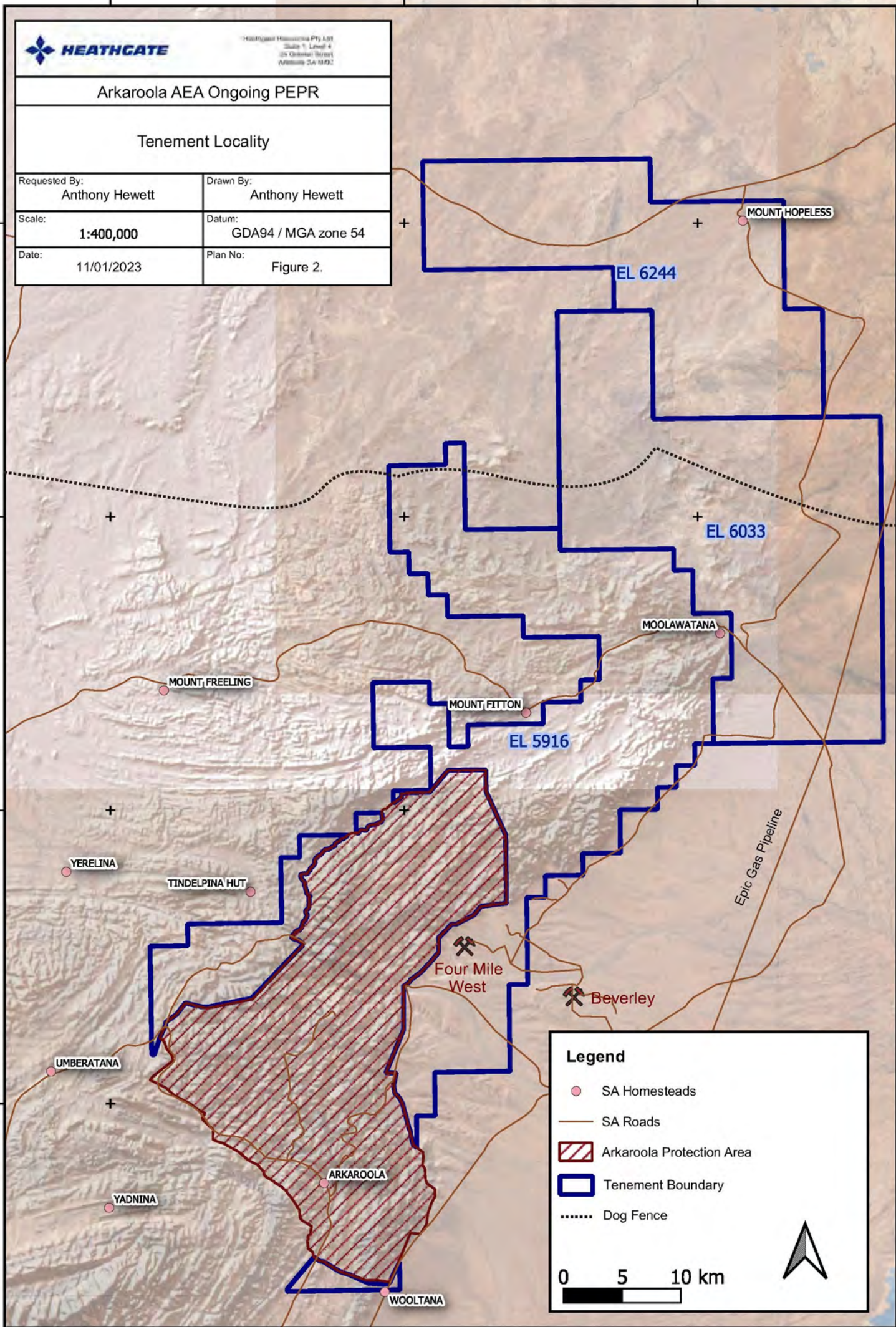
6650000

6725000

6700000

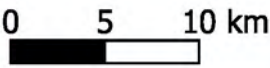
6675000

6650000



Legend

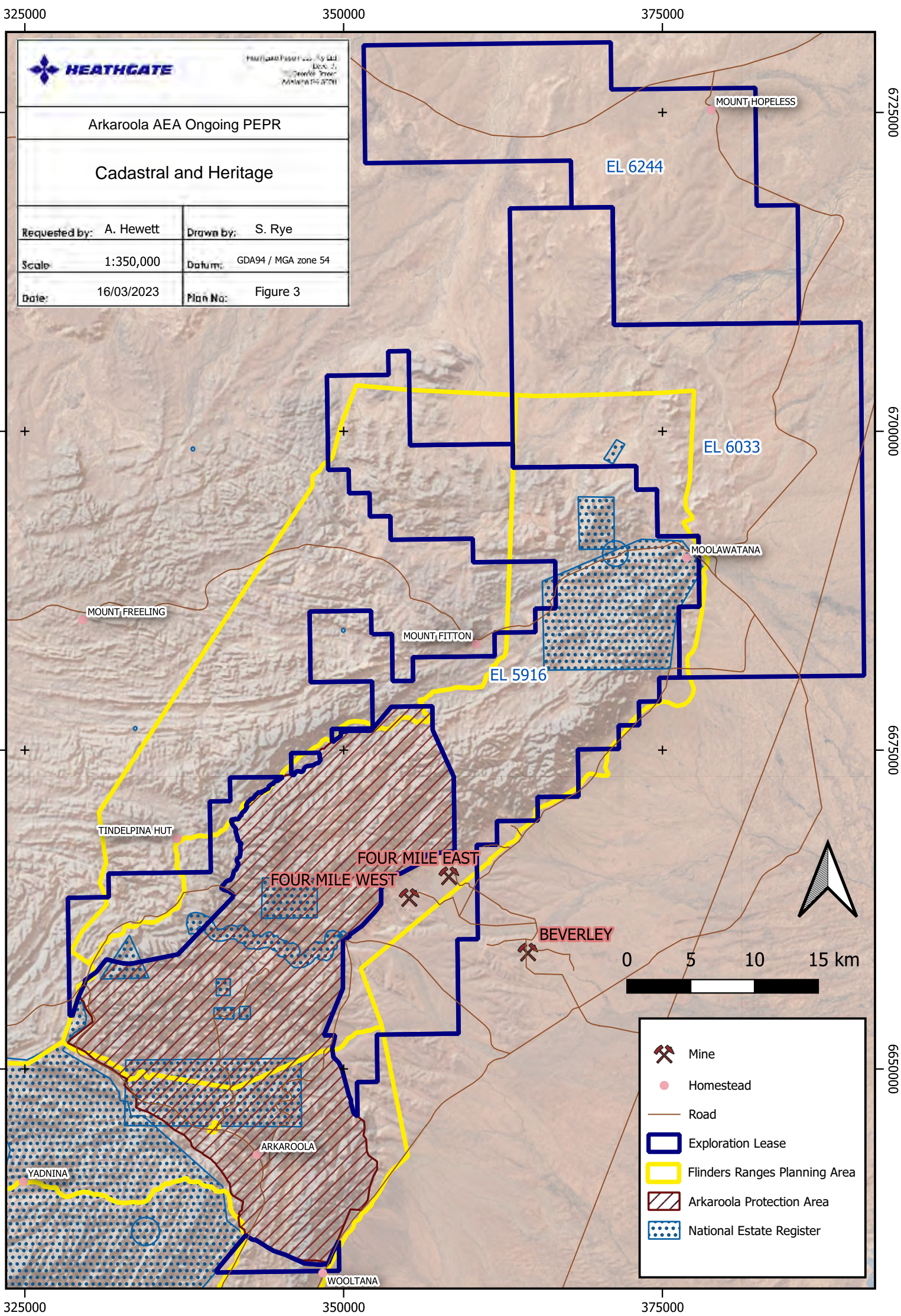
- SA Homesteads
- SA Roads
- Arkaroola Protection Area
- Tenement Boundary
- Dog Fence



325000

350000

375000



325000

350000

375000



Heathgate Resources Pty Ltd
Suite 1, Level 4,
23 Grenfell Street
Adelaide SA 5000

Arkaroola AEA Ongoing PEPR

Environmentally Sensitive Areas

Requested By: Anthony Hewett	Drawn By: Anthony Hewett
Scale: 1:400,000	Datum: GDA94 / MGA zone 54
Date: 11/01/2023	Plan No: Figure 4

6725000

6700000

6675000

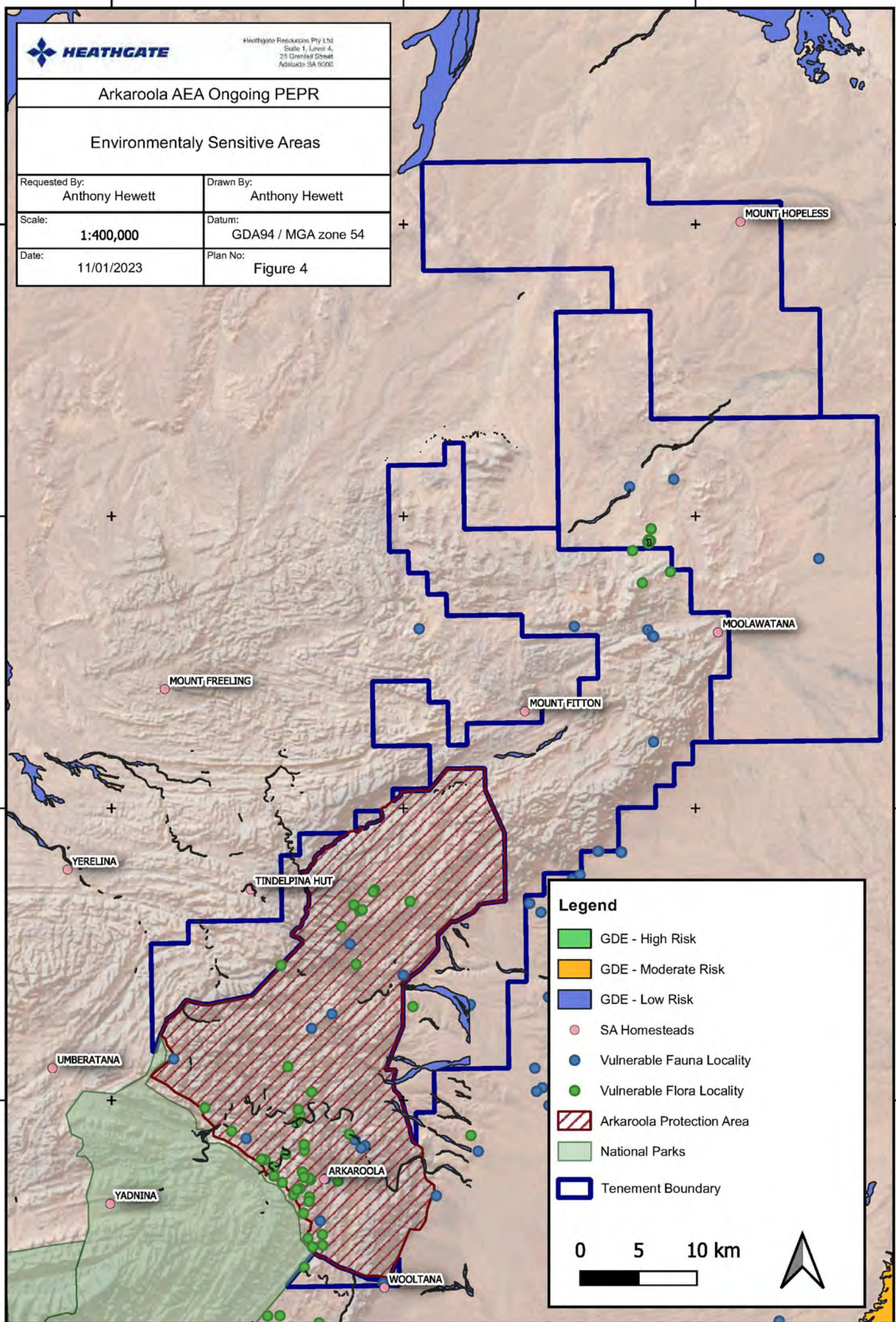
6650000

6725000

6700000

6675000

6650000



Legend

- GDE - High Risk
- GDE - Moderate Risk
- GDE - Low Risk
- SA Homesteads
- Vulnerable Fauna Locality
- Vulnerable Flora Locality
- Arkaroola Protection Area
- National Parks
- Tenement Boundary

0 5 10 km

325000

350000

375000

325000

350000

375000

6725000

6700000

6675000

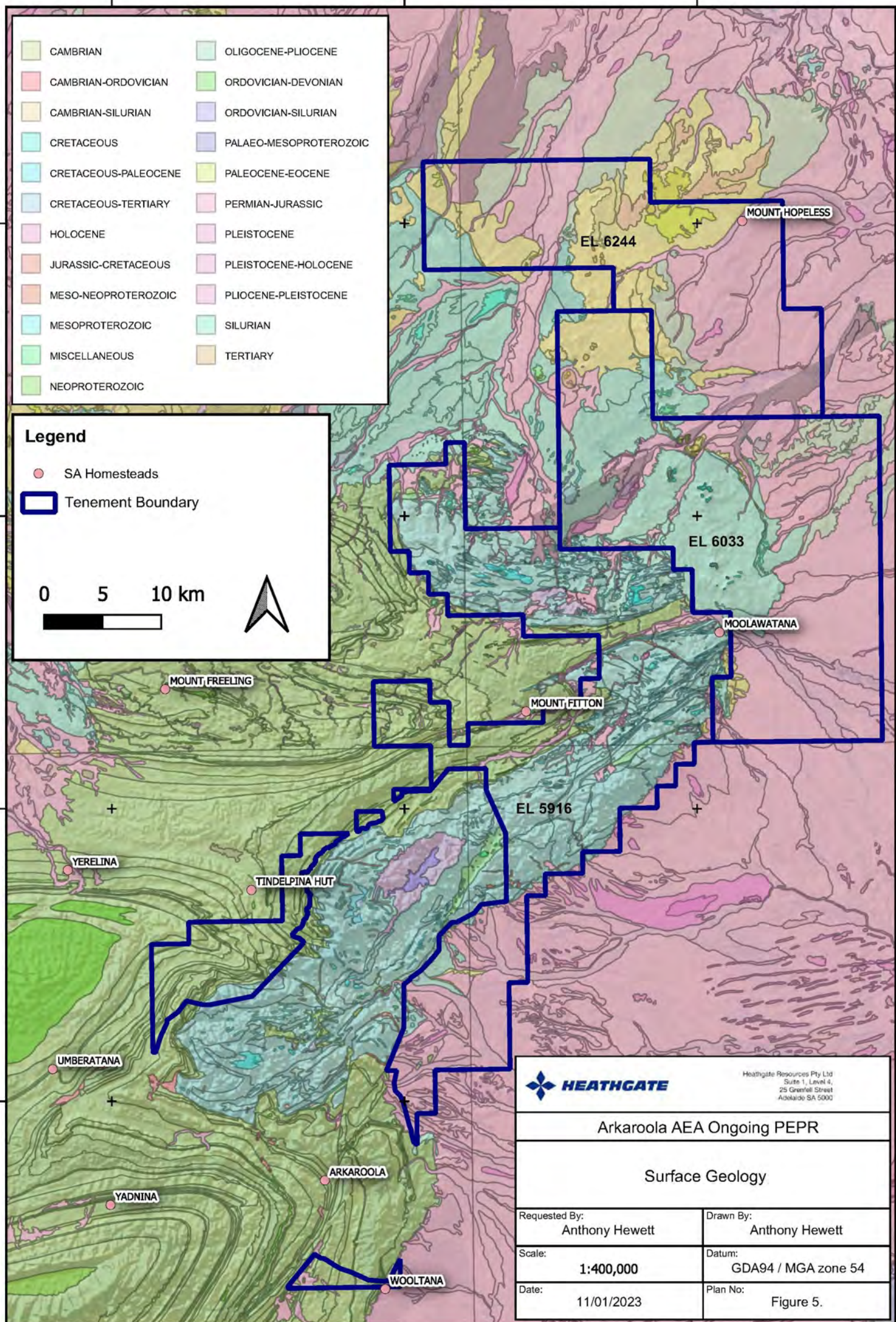
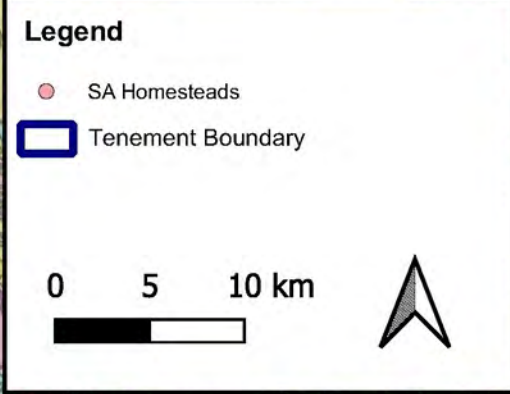
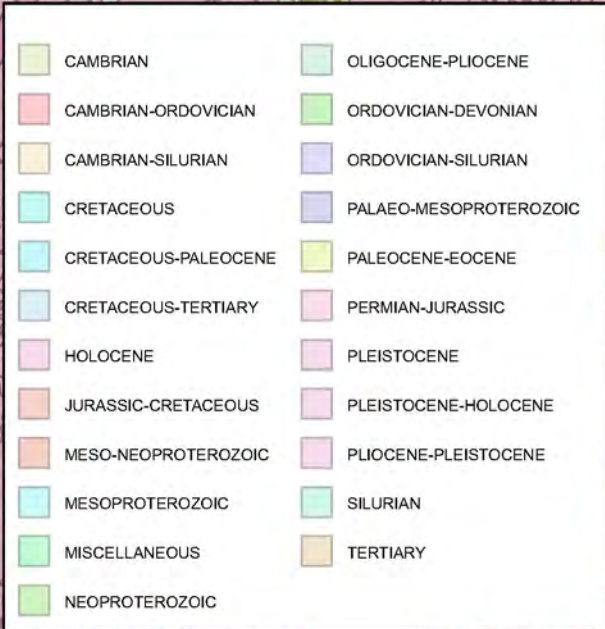
6650000

6725000

6700000

6675000

6650000



<p>Heathgate Resources Pty Ltd Suite 1, Level 4, 25 Grenfell Street Adelaide SA 5000</p>	
<p>Arkaroola AEA Ongoing PEPR</p>	
<p>Surface Geology</p>	
Requested By:	Drawn By:
Anthony Hewett	Anthony Hewett
Scale:	Datum:
1:400,000	GDA94 / MGA zone 54
Date:	Plan No:
11/01/2023	Figure 5.

325000

350000

375000

365000

370000

375000



Heathgate Resources Pty Ltd
Suite 1, Level 4,
25 Grenfell Street
Adelaide SA 5000

Arkaroola AEA Ongoing PEPR

Twelve Springs - High Risk
Groundwater Dependant Ecosystem

Requested By:
Anthony Hewett

Drawn By:
Anthony Hewett

Scale:
1:100,000

Datum:
GDA94 / MGA zone 54

Date:
02/03/2022

Plan No:
Figure 6.

6705000

6705000

6700000

6700000

6695000

6695000

6690000

6690000

6685000

6685000

6680000

6680000

365000

370000

375000

Twelve Springs

EL 6033

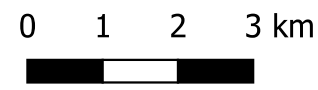
Woolatchi Prospect

MOOLAWATANA

EL 5916

Legend

- GDE - High Risk
- GDE - Low Risk
- SA Homesteads
- SA Roads
- National Estate Register
- Tenement Boundary
- Woolatchi Prospect



- GDE - High Risk
- GDE - Low Risk
- SA Roads
- Tenement Boundary
- National Estate Register

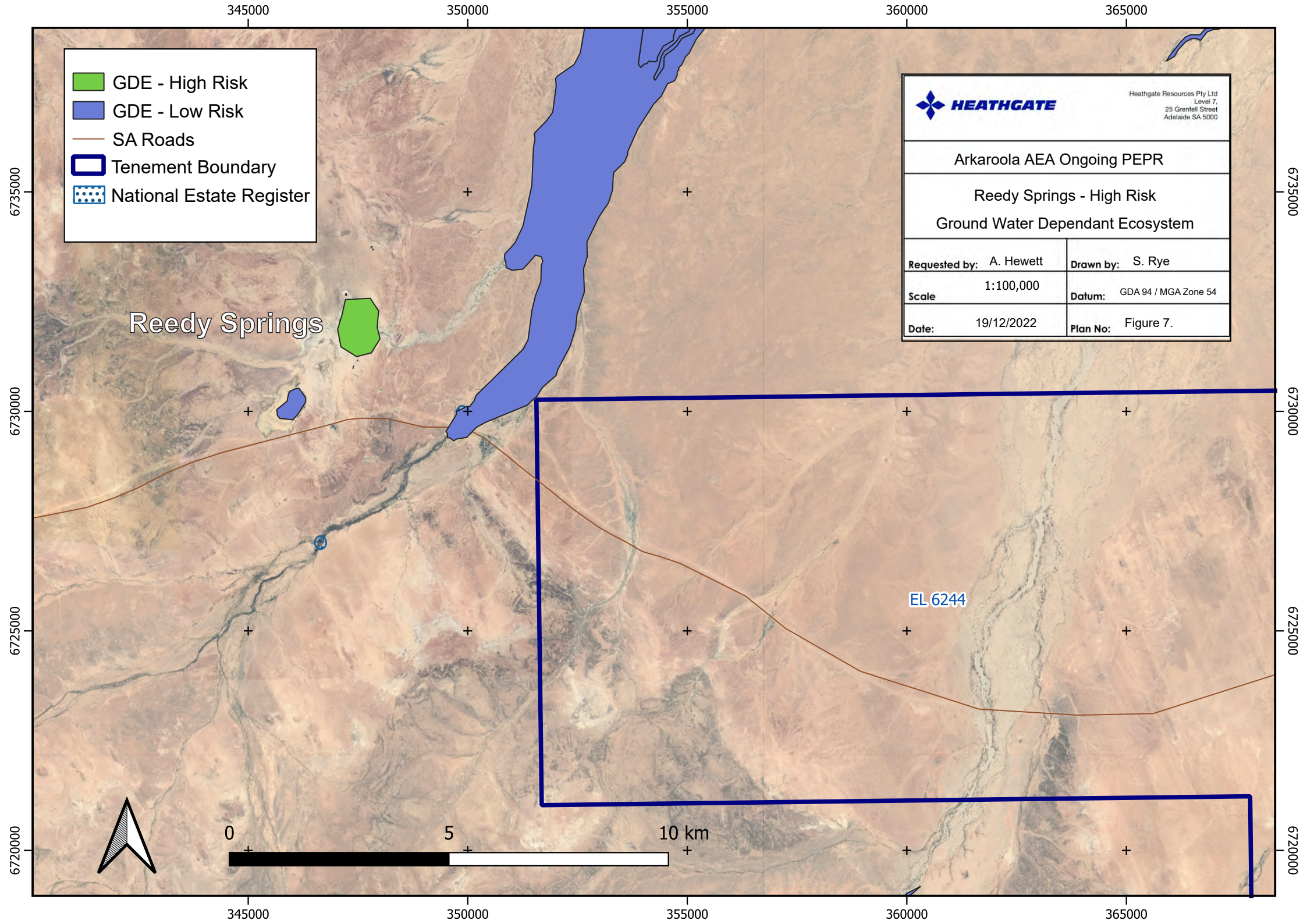
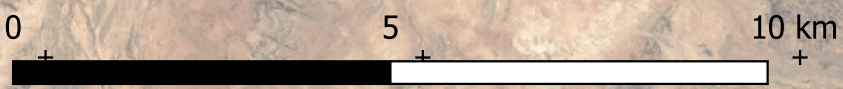


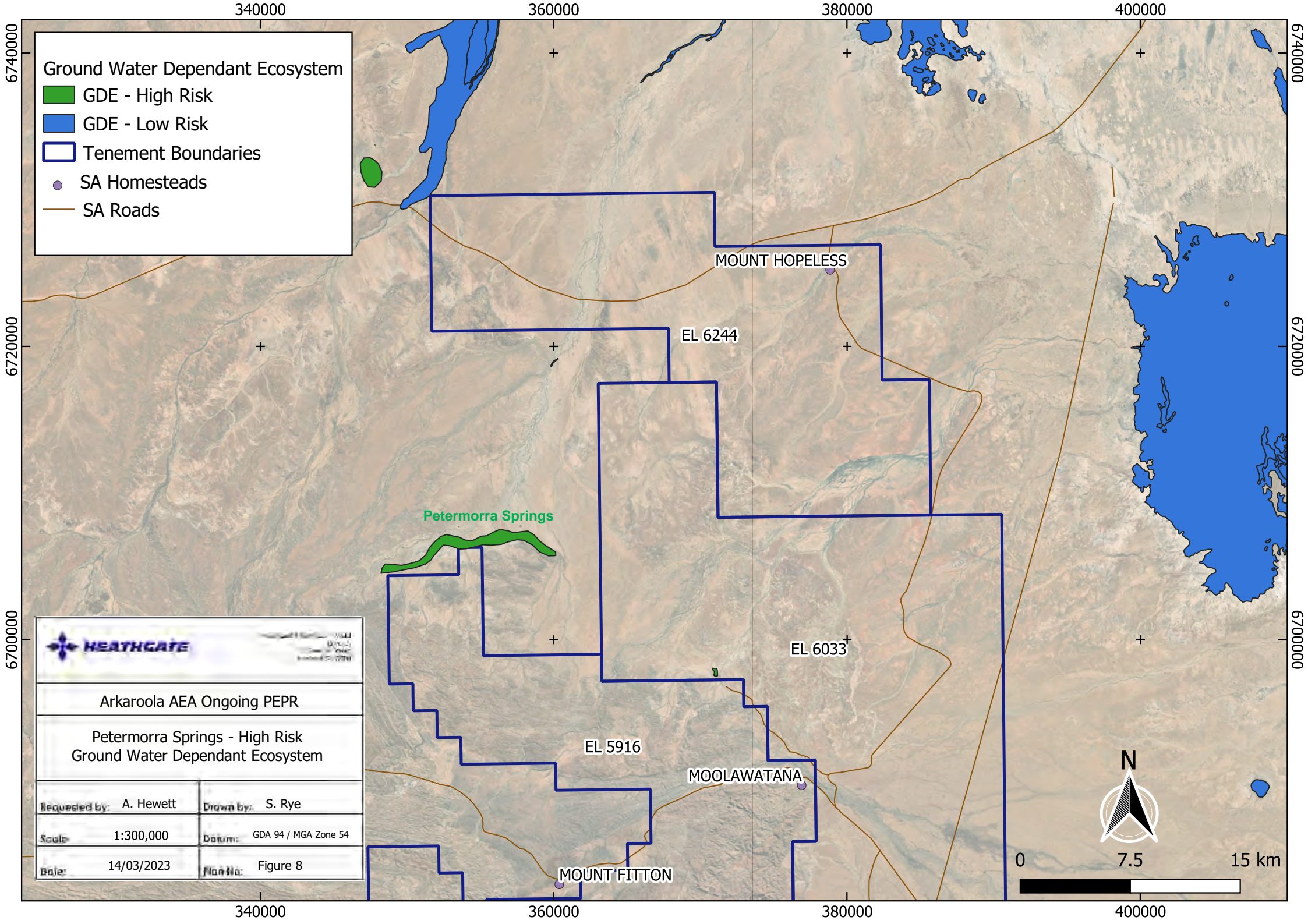
Heathgate Resources Pty Ltd
Level 7,
25 Grenfell Street
Adelaide SA 5000

Arkaroola AEA Ongoing PEPR	
Reedy Springs - High Risk Ground Water Dependant Ecosystem	
Requested by: A. Hewett	Drawn by: S. Rye
Scale: 1:100,000	Datum: GDA 94 / MGA Zone 54
Date: 19/12/2022	Plan No.: Figure 7.

Reedy Springs

EL 6244





Ground Water Dependant Ecosystem

- GDE - High Risk
- GDE - Low Risk
- Tenement Boundaries
- SA Homesteads
- SA Roads

HEATHGATE

Arkaroola AEA Ongoing PEPR

Petermorra Springs - High Risk Ground Water Dependant Ecosystem

Requested by: A. Hewett	Drawn by: S. Rye
Scale: 1:300,000	Datum: GDA 94 / MGA Zone 54
Date: 14/03/2023	Plan No: Figure 8

N

0 7.5 15 km

340000

360000

380000

400000

Legend

-  Arkaroola Protection Zone
-  Gammon Ranges Nat Park
-  Homesteads
-  Active Mines
- Arkaroola AEA
 -  EL 5916 Arkaroola
 -  EL 6033 Mt Yerila
 -  EL 6244 Petermorra
 -  Arkaroola AEA Prospects

6720000

6720000

6700000

6700000

6680000

6680000

6660000

6660000

6640000

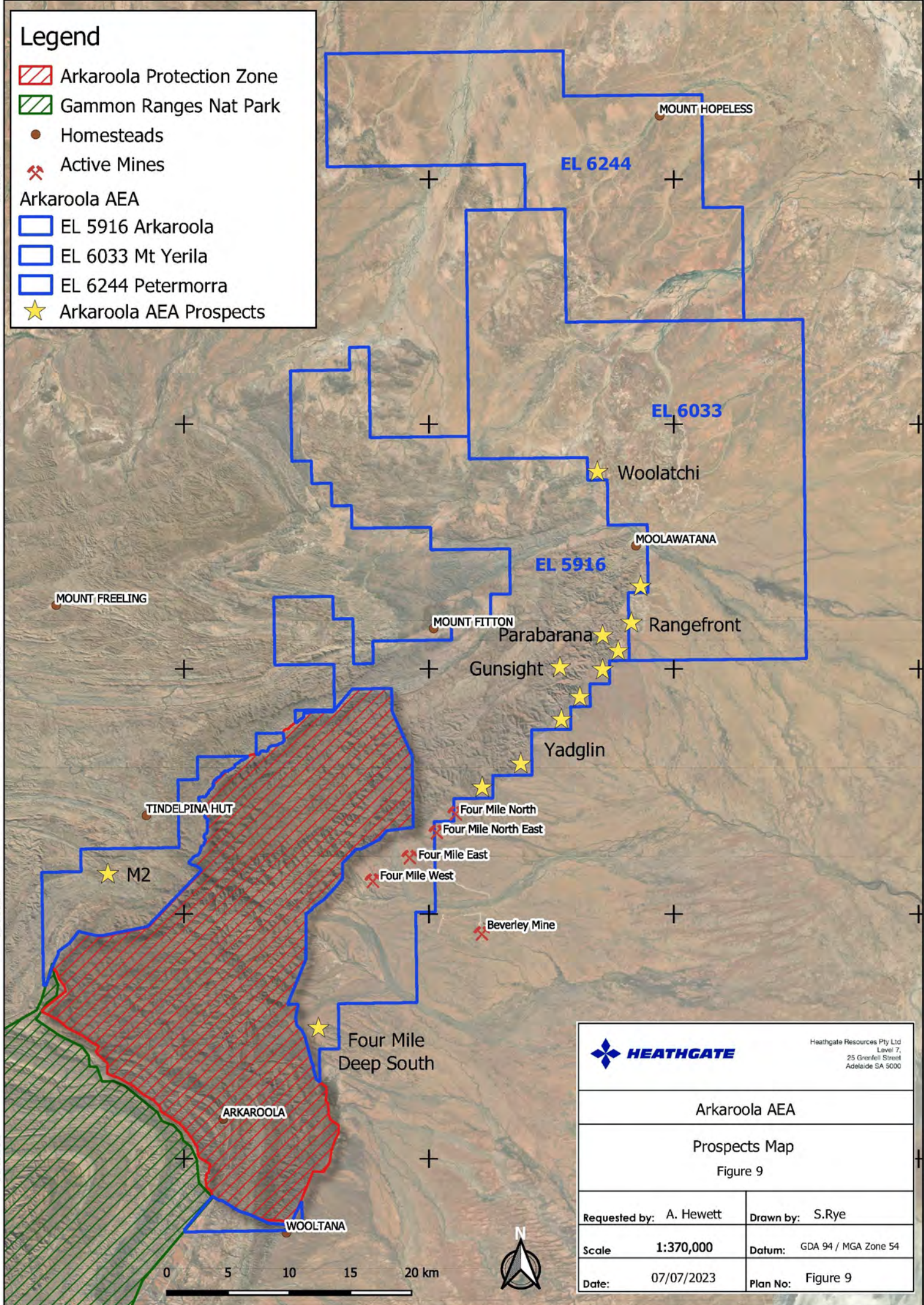
6640000


340000

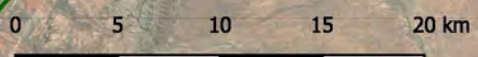
360000

380000

400000



		Heathgate Resources Pty Ltd Level 7, 25 Grenfell Street Adelaide SA 5000	
Arkaroola AEA			
Prospects Map Figure 9			
Requested by: A. Hewett	Drawn by: S.Rye		
Scale: 1:370,000	Datum: GDA 94 / MGA Zone 54		
Date: 07/07/2023	Plan No: Figure 9		





SOUTH AUSTRALIA

Buffel Grass Strategic Plan

2019–2024



Government
of South Australia



Suggested citation: Biosecurity SA (2019) South Australia Buffel Grass Strategic Plan 2019–2024: A plan to reduce the weed threat of buffel grass in South Australia. Government of South Australia.

Edited by: Troy Bowman, David Cooke and Ross Meffin, Biosecurity SA (Department of Primary Industries and Regions South Australia).

Contributors:

Tim Reynolds, Ben Shepherd (editors 2012 Strategic Plan).

Mark Anderson, Brett Backhouse, Doug Bickerton, Troy Bowman, David Cooke, Dwayne Godfrey, Kym Haebich, Michaela Heinson, Paul Hodges, Amy Ide, Susan Ivory, Rob Langley, Glen Norris, Greg Patrick, John Read, Grant Roberts, Ellen Ryan-Colton, Andrea Schirner, Carolina Galindez Silva, Jarrod Spencer, Clint Taylor (Buffel Grass Taskforce).

Cover photo: Dense buffel grass infested hills and plains near Umuwa, APY Lands, Troy Bowman, PIRSA





Foreword

Buffel grass can affect biodiversity, natural and cultural heritage, communities and infrastructure. Through changes in vegetation structure and the loss of native flora and fauna, it can transform rangeland landscapes. By degrading the environment it can threaten natural, Aboriginal and European cultural heritage; remote communities and infrastructure can be impacted through the increased risk of bushfire.

South Australia took the lead in 2015 as the first jurisdiction in Australia to declare buffel grass under its weed management legislation. Our response to buffel grass in South Australia requires a delicate balance between its use as a pasture grass across state and territory boundaries, and the need to protect our environment, cultural landscapes and infrastructure.

The South Australian Buffel Grass Strategic Plan for 2019–24 presents a coordinated statewide approach to buffel grass management, building on the success of the 2012–2017 plan and further developing the existing zoning scheme and management strategies.

Primary Industries and Regions SA, through its Biosecurity SA division has facilitated the development of this Strategic Plan with input from local communities, regional boards, industry bodies, staff of other South Australian government agencies and researchers.

We are fortunate that many areas of South Australia remain free of buffel grass, and while management of buffel grass will continue in the northern rangelands, a strategy to reduce its spread can protect other valuable areas such as the Flinders Ranges.

The negative impacts of buffel grass in South Australia can be minimised through a collaborative approach between land managers, industry, traditional owners and the broader community making responsible decisions about how they maintain their environment.

Contents

1 EXECUTIVE SUMMARY	6
2 INTRODUCTION	7
2.1 Strategic plan development	7
2.2 Principles underpinning the Strategic Plan	9
2.3 Scope of Strategic Plan.....	9
2.4 Linkages to other plans	9
2.5 Legislative context.....	10
3 STRATEGIC GOALS AND ACTIONS.....	11
3.1 Vision	11
3.2 Management zones	13
3.3 Goals and actions.....	16
3.4 Stakeholder challenges/opportunities.....	24
3.5 Monitoring and evaluation	29
4 TECHNICAL BACKGROUND	30
4.1 Description	30
4.2 Taxonomy	30
4.3 Reproduction	30
4.4 Preferred habitat.....	31
4.5 Dispersal and persistence	31
4.6 Impacts and uses	31
4.7 History of spread	35
4.8 Current distribution.....	36
4.9 Potential distribution.....	36
4.10 Risk assessment.....	38
4.11 Control options	40
5 REFERENCES	44
6 APPENDICES	46

Acronyms

AMLR NRMB	Adelaide and Mt Lofty Ranges Natural Resources Management Board
APVMA	Australian Pesticides and Veterinary Medicine Authority
APY Lands	Anangu Pitjantjatjara Yankunytjatjara Lands
AW NRMB	Alinytjara Wilurara Natural Resources Management Board
BHA	Bush Heritage Australia
Biosecurity SA	Biosecurity South Australia, Primary Industries and Regions SA
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DEM	Department for Energy and Mining
DEW	Department for Environment and Water
DPTI	Department of Planning, Transport and Infrastructure
EP NRMB	Eyre Peninsula Natural Resources Management Board
GVD	Great Victoria Desert
MT Lands	Maralinga Tjarutja Lands
NRMB	Natural Resources Management Board
NY NRMB	Northern and Yorke Natural Resources Management Board
PIRSA	Department of Primary Industries and Regions South Australia
SAAL NRMB	South Australian Arid Lands Natural Resources Management Board



1 Executive Summary

Buffel grass (*Cenchrus ciliaris* and *Cenchrus pennisetiformis*) has been listed among species of 'extensive continental distribution' that are 'capable of destroying' Australian ecosystems (Humphries *et al.* 1991). Buffel grass is arguably the single biggest invasive species threat to biodiversity across the entire Australian arid zone, and without active management it will continue to invade a wide range of native habitats to the extent that it could replace many native species in those habitats.

Buffel grass is a perennial tussock grass native to Africa, India and Asia. Since its introduction into central Australia last century for dust control and livestock production, buffel grass has spread widely across many new landscapes causing significant problems. Although it has been planted for livestock production in other states, productivity of buffel grass dominated pastures can decline in the longer term, particularly in arid areas such as northern South Australia.

Buffel grass forms dense monocultures, increases the frequency and intensity of fires, and displaces native plants and the animals that depend on them, including bush foods and many culturally significant species. It imposes economic costs through the need to manage fire risk, and to protect biodiversity, Aboriginal culture and infrastructure. Accounting for these factors, a state-level risk assessment has determined the weed risk posed by buffel grass to be very high for both grazing rangelands and native vegetation in South Australia.

In South Australia buffel grass is now widely distributed across northern regions as populations of varying size, with extensive infestations in the far north-west. Once established, there is no single control method available for the successful management of buffel grass over extensive areas. Buffel grass has several qualities that enable it to survive and persist in arid conditions. In addition to prolific seed production and opportunistic germination, buffel grass accumulates carbohydrates at the base of its stems for slow release when needed, and has a deep root system that enables it to access water supplies faster and for longer than most native herbs and forbs. Individual tussocks have long lifespans and can readily re-sprout following fire. As a result of these traits and the extensive distribution of buffel grass, the feasibility of its containment has been risk assessed as low in native vegetation and negligible in grazing rangelands.

As such, in line with the South Australian Weed Risk Management Guide, the focus of this strategy is to reduce the overall economic, environmental and/or social impacts of buffel grass through targeted management, and to prevent spread of the weed species to key sites and assets of high economic, environmental and/or social value. In a

state-wide context, with buffel grass primarily established in the north, this means protecting key environmental assets and attempting to minimise broad-scale impacts in infested regions, and preventing range expansion southwards into uninfested areas.

At a finer scale, management of buffel grass may include the destruction of localised infestations where feasible and strategically important. The potential success of management is higher if buffel grass is controlled during the early stages of invasion. A range of management options may be considered, and success will be greatest if these can be implemented in a coordinated and sustained manner at a broad scale. It is vital that decision making be evidence-based and outcomes-focused.

The strategic approach to the management of buffel grass across the state is based on three management zones: the far north-west (Zone 1); the far north, north-east and upper mid-north (Zone 2); and the far-west, lower mid-north and south (Zone 3). The aim, state-wide, is to contain buffel grass and reduce its impact. This will be achieved through the Plan's four goals:

- Goal 1 - Exclude the entry of buffel grass into SA and prevent its movement within the state
- Goal 2 - Manage impacts of buffel grass in Zone 1
- Goal 3 - Protect priority assets from buffel grass in Zone 2, and destroy infestations in Zone 3
- Goal 4 - Build capacity to manage buffel grass.

Significant partnerships and resourcing are required to work towards achieving the four goals of this Strategic Plan. Cooperation, commitment and funding are sought from industry, community and government stakeholders at the local, regional and state levels to manage this weed.

2 Introduction

Buffel grass (*Cenchrus ciliaris* and *Cenchrus pennisetiformis*) is a perennial tussock grass native to Africa, India and Asia. Since its introduction into central and northern Australia for pasture improvement and dust control, buffel grass has spread widely. It has been identified as a 'transformer weed' of the Australian rangelands (Bastin *et al.* 2008) due to its ability to fundamentally alter ecosystem structure and function.

Buffel grass is widely distributed across northern arid South Australia with infestations varying widely in size and density. Most known large infestations occur in the far northwest of the state and along roads. However, much of the land where buffel grass is likely to occur is remote and difficult to access. The actual distribution of buffel grass is likely to be wider than is currently known, and its distribution is expanding.



Cenchrus ciliaris, buffel grass.

Cenchrus ciliaris has highly varied morphological and physiological characteristics, resulting in adaptation to different climates and habitats. Many forms of buffel grass have been imported to Australia from across its native range; programs of pasture introduction have brought in approximately 580 accessions, with many informal and formal releases in central, tropical and sub-tropical Australia (Hall 2000). In addition, there are at least three other exotic *Cenchrus* species that have naturalised in South Australia and which could expand their distributions, including *Cenchrus pennisetiformis*, also called Cloncurry buffel grass. For the purposes of declaration under the *Natural Resources Management Act 2004* (NRM Act), buffel grass includes both *C. ciliaris* and *C. pennisetiformis*. Modelling suggests over 60% of mainland Australia is suitable for buffel grass establishment (Lawson *et al.* 1994). This is likely in large part due to the genetic diversity of buffel grass present in Australia.

Buffel grass is considered one of Australia's worst environmental weeds (Humphries *et al.* 1991). Many of the attributes which contribute to the success of buffel grass as a pasture species also make it a serious environmental weed. These include ease of establishment, rapid growth rate, fast maturation, prolonged flowering periods, prolific production of easily dispersed seeds with considerable seed bank longevity (Franks 2002). Buffel grass is tolerant of drought, fire and grazing. It can generate positive fire invasion feedbacks in central Australian woodlands (Miller *et al.* 2010) and has been shown to affect fire regimes in native plant communities (Butler and Fairfax 2003). It has a wide climatic tolerance and establishes on a range of soil types under a various disturbance regimes, quickly forming self-sustaining populations (Franks 2002).

Buffel grass is recognised as a major threat to country – the term commonly used to explain the land or waters with which an Aboriginal person, persons, community or homeland family has a traditional or contemporary association. This is particularly the case within the Alinytjara Wilurara Natural Resources Management Region (Alinytjara Wilurara NRM Board 2011) where buffel grass infestations are most extensive.

The perceived value of buffel grass for livestock production is offset by its serious environmental and social impacts. Furthermore, there is growing evidence that it may be nutritionally inadequate for adult dry stock and could lead to pasture degradation in the long term (NRM SAAL 2017).

Despite these challenges, South Australia clearly has an opportunity to continue to implement a strategic management approach to the weed to prevent or mitigate its impacts. Extensive areas of the state, such as the Great Victoria Desert bioregion, are still largely free of buffel grass. To maintain and build on the gains made under the previous State Buffel Grass Strategic Plan 2012–2017, and prevent buffel grass from becoming a dominant feature of our arid landscapes, significant ongoing management intervention will be required.

This plan guides state level prioritisation and coordination to deliver a strategic approach to buffel grass management, as well as development of regional weed management plans. Partnerships are required to find solutions to the conflicting perceptions of buffel grass among stakeholders, and resource communication, extension, on ground activities and applied research to fill remaining knowledge gaps.

2.1 Strategic plan development

The 2012–17 Buffel Grass Strategic Plan was based on a draft State Operational Plan that was prepared following a workshop held in Port Augusta in September 2010. The aim of the workshop was to initiate and guide the development of a state-wide strategic approach to minimising the impacts of buffel grass in South Australia. The workshop was instigated by Biosecurity SA with support funding from the 2010/11 State NRM Program,

and involved representatives of state agencies (PIRSA, DEWNR, DPTI), regional NRM Boards, and research organisations (CSIRO, University of Adelaide).

The current updated plan was prepared by the SA Buffel Taskforce in consultation with the key stakeholders identified in section 3.4. It recognises the important outcomes achieved through the first iteration of the plan and aims to sustain and build upon these. Achievements aligned with the 2012- 2017 plan were mostly delivered through a project funded by the Native Vegetation Council with supporting contributions from NRM Regions and PIRSA: the Buffel Grass Control in Arid Rangelands project. These included:

- strategic control of over 300ha of buffel grass outlier infestations
- herbicide research and a report identifying best practice options for control
- five fact sheets developed to communicate best practice management
- over 4,600km of roadsides surveyed, documenting distribution and spread of buffel grass
- a GIS distribution database and control prioritisation tool
- community engagement activities involving well over 270 stakeholders
- awareness building through media articles and interviews
- technical advice to stakeholders throughout South Australia and nationally

Despite this, much remains to be done. The Buffel Grass Control in Arid Rangelands project made a number of recommendations to guide future buffel management.

These are summarised below, and further details can be found in the project final report (available at pir.sa.gov.au/buffel-grass):

- continuation of the SA Buffel Grass Taskforce and pursuing options to fund a dedicated buffel grass coordinator
- further engagement of a range of stakeholders including the mining industry, road and rail corridor managers, National Parks rangers and pastoralists
- annual strategic responses to target key on ground works and support capacity and coordination at regional level
- follow-up surveillance and control in areas treated through the 2015 and 2016 strategic responses, and in key dispersal nodes such as Port Augusta and Coober Pedy
- surveillance and mapping to identify priority infestations for control and improve understanding of buffel distribution.

With best practice materials developed and a range of control options to suit most situations, future activities will be refocussed to fill gaps identified during the process of updating this plan. Key challenges include improved and expanded stakeholder engagement, maintaining funding and momentum for on-ground action and containment, better mapping and knowledge of distribution, and developing strategies and tools for managing buffel grass in remote areas with widespread, extensive infestations.

This strategic plan will be reviewed in five years (2024). In addition, an update of legislative aspects of the plan (particularly section 2.5) will be required following the replacement of the NRM Act by the *Landscape South Australia Act*, currently planned for mid-2020.



Aerial herbicide trial, Mambray Creek.

2.2 Principles underpinning the Strategic Plan

The following principles underpin this strategic plan:

1. Weed management is an essential and integral part of sustainable management of natural resources and the environment and requires an integrated, multi-disciplinary approach
2. Evidence-based decision making should underpin weed management activities
3. Prevention and early intervention are the most cost effective techniques that can be deployed against weeds
4. Successful weed management is a responsibility shared among landholders, community, industry and government and coordination amongst these stakeholders is essential to manage weeds at a landscape scale.

2.3 Taxonomic scope of Strategic Plan

The main focus of this Plan is the management of *Cenchrus ciliaris* in South Australia, due to its current and potential impact. However, three other exotic *Cenchrus* species with weed potential and the ability to expand their current distribution in the state are also noteworthy. *Cenchrus pennisetiformis* is declared along with *C. ciliaris* as buffel grass under the NRM Act, and is within the scope of the plan. *Cenchrus setiger* and *Cenchrus echinatus* have restricted distributions and are not declared. However, in keeping with principle three of this plan, consideration should be given to prevention activities, i.e. the early detection of incipient populations and rapid response to prevent widespread establishment. This could likely be achieved opportunistically alongside buffel grass management.

2.4 Linkages to other plans

National

This strategic plan is consistent with the vision of the Australian Weeds Strategy, to ‘protect Australia’s economic, environmental and social assets from the impacts of weeds’, and in particular Goal 2: *Minimise the impact of established weeds*.

State

Priority element 3 of the State Biosecurity Policy 2017/2021 is relevant to buffel grass: *Minimising the economic, social and environmental impacts of pests and diseases, - in particular, developing and implementing management plans and programs to contain spread and reduce the impacts of established priority pests and diseases*.

Section 4(b) (ii), an Object of the *Pastoral Land Management and Conservation Act*, 1989, is the legislative basis of the aforementioned policy. This Object provides for “the prevention of degradation of the land and its indigenous plant and animal life”.

Regional

Buffel grass is recognised in regional pest management strategies for the AW, EP, SAAL and SAMDB NRM Boards, including the *Alinytjara Wilurara Buffel Grass Operational Strategy 2018-2023*.

Buffel grass is noted for its impact on threatened species in the Threatened Species Recovery Plan, and the Rare and Threatened Flora Management Plan, for the APY Lands (Paltridge *et al.* 2009).

Species	Description	Comment
<i>C. pennisetiformis</i> (Buffel/Cloncurry grass)	Perennial grass, easily confused with <i>C. ciliaris</i>	Used for pasture in Australia. Appears to have similar invasive properties as <i>C. ciliaris</i> . Few herbarium records for SA (< 15: Flinders Rgs & Far North) – may greatly under-estimate its true prevalence.
<i>C. setiger</i> (Birdwood grass)	Perennial grass, similar to smaller types of <i>C. ciliaris</i>	Has been planted for pasture in Australia. Adapted to a wider range of soils and more drought tolerant than <i>C. ciliaris</i> . A serious weed of watercourses in WA. Only three records for SA (far NW).
<i>C. echinatus</i> (Mossman River grass)	Annual grass, clump-forming, spiny attachable burrs	Not deliberately cultivated in Australia – a pest of pastures and some crops. Less than 20 records for SA (far NW incl. APY Lands).

2.5 Legislative context

Buffel grass is currently declared under the *NRM Act*, providing a legislative basis for management as specified in this strategic plan and regional NRM plans.

From late 2020, the new *Landscape South Australia Act 2019* will become fully operational and will replace the *NRM Act*. The *Landscape South Australia Act* continues to provide for the control of weeds, including through some improved and simplified provisions. Buffel grass will remain a declared weed, and this plan will remain relevant in its intent and utility as a high-level strategic document.

The following provisions of the *NRM Act* apply:

Currently no other Australian states or territories have regulated the management of buffel grass under their respective legislative frameworks. However, it is unclear what actions are required under a ‘general biosecurity duty of care’ system such as is in effect in Queensland and New South Wales. In New South Wales buffel grass is included in the key threatening process listed under the *Threatened Species Conservation Act 1995*, Invasion of native plant communities by exotic perennial grasses.

As one of the greatest single threats to biodiversity by an invasive species within the Australian arid zone, buffel grass was nominated as a Key Threatening Process under the terms of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Although it was considered that this is already recognised in the overarching key threatening process ‘Novel biota and their impact on biodiversity’, the nomination resulted in the issuing of a threat abatement advice (Department of the Environment 2015).

Section	Requirement	Control Area
75(1)(2)	Prohibiting movement on public roads and entry into SA	Whole of state
177(1)(2)	Prohibiting sale of the plants or their seeds, or contaminated material	Whole of state
180(1)(2)(3)	Requires landholders to notify the presence of buffel grass on their land	The areas of the Kangaroo Island, South Australian Murray-Darling Basin, and South East NRM Regions.
182(1)	Requiring landowners to destroy the plants on their properties	The areas of the Adelaide and Mount Lofty Ranges, Eyre Peninsula, Kangaroo Island, South Australian Murray-Darling Basin, and South East NRM Regions
182(2)	Requiring landowners to control - as far as reasonably achievable - the plants on their land	The areas of the Alinytjara Wilurara, Northern and Yorke, and South Australian Arid Lands NRM Regions
185	NRM authorities may recover certain costs from owners of land adjoining road reserves	Whole of state

The associated declared plant policy can be found at pir.sa.gov.au/buffel-grass



Rocky hill with pristine *Tridodia* grassland.



Rocky hill heavily invaded by buffel grass.

3 Strategic Goals and Actions

3.1 Vision

Buffel grass is no longer spreading throughout South Australia, and through increased awareness and action the impacts of buffel grass are minimised, especially at sites of environmental, cultural and economic significance.

Case study:

Buffel Grass Program on Bon Bon Station Reserve

Bon Bon Station Reserve, a former sheep station south of Coober Pedy in South Australia, is owned and managed by Bush Heritage Australia (BHA) as a private conservation reserve. The 217,000 ha reserve is managed to protect ephemeral wetlands and surrounding western myall (*Acacia papyrocarpa*) and mulga (*Acacia aneura*) woodlands and chenopod shrublands associated with Lake Puckridge. Buffel grass threatens the woodlands and shrublands through changed vegetation structure and increased fire risk.

The buffel grass control program is currently focused along the old and new alignments of the Stuart Highway, a total distance of 130 km. Movement of vehicles along the transport corridor is the main vector for the spread of buffel grass seeds throughout the reserve.

Additionally, there are a few drainage lines that are being actively managed to eliminate the threat of these sensitive systems becoming severely infested with buffel grass.

Our strategy

A buffel grass management strategy has been developed and is being implemented. A key focus of the strategy is to progressively reduce buffel infestations from the relatively clean north and eastern parts of the reserve, working south and west. This strategy was initiated in 2013 and it was estimated it will take four-five years to do initial treatments while undertaking annual control of regrowth.

Funding for the work has come from Bush Heritage Australia, an environmental grant from the Native Vegetation Council as well as additional support from the South Australian Arid Lands Natural Resources Management Board (SAAL NRM) and the Department of Planning, Transport and Infrastructure (DPTI).

Fire was also used to treat four sites along the Stuart Hwy road verge early in April 2014. This project was instigated by DPTI and undertaken using DPTI, Country Fire Service (CFS) and BHA resources. Four small sites were burnt over two days (as weather conditions were unfavourable).



Buffel grass on Stuart Hwy before treatment.



Same site post treatment.



Regeneration after buffel grass control.

The burning was successful at reducing dry matter and seed banks, but needed a large amount of resources (two CFS water tankers, five CFS staff, one DPTI vehicle and staff for traffic control plus BHA staff and vehicle). Following burning, herbicide was applied to all four sites.

After four years of buffel grass treatment all of the 130 km of highway verge has been treated at least once with other areas with higher infestations being treated up to five times. Surveillance for buffel grass infestations will be maintained indefinitely by BHA, especially along main transport corridors.

Challenges faced in controlling buffel grass at Bon Bon Station Reserve are the sheer size of the task, resources required and the need for a quick response during the short growing season. The development of effective control strategies beyond the growing season will greatly assist the management plan.

Key Learnings

1. Glyphosate/flupropanate mix has consistently delivered good knockdown and good regrowth control for at least two years.
2. Flupropanate alone gave mixed results on mature plants.

3. Soil applied chemicals are good for isolated detctions.
4. Fire is a very useful tool for reducing dry matter and seed banks, but requires significant resources.
5. Achieving at least 95% kill at first treatment is necessary.
6. Diligent retreatment is imperative and requires as much time as the first treatment but may only require a fraction of the herbicide.
7. To get best regrowth control with residual herbicides, complete ground spray is necessary.

Acknowledgements

Although buffel grass management on Bon Bon Station Reserve is an ongoing program, the control actions that have been undertaken to date would not have been possible without the assistance of the Native Vegetation Council, Department of Planning, Transport and Infrastructure, Biosecurity SA, South Australian Arid Lands Natural Resource Management including the Kingoonya NRM group, Country Fire Service, Roxby Buffel Busters, Friends of the Gawler Ranges, Mike Chuk and Julia Harris (BHA Bon Bon Station Reserve managers 2013-2017). A special thanks to Glenbarr weed and pest control to their dedication to the BHA Buffel grass management strategy.



Hand removal of buffel grass by volunteers.

3.2 Management zones

A key component of reducing the impacts of buffel grass in South Australia is a management strategy based on a zonal system reflecting the gradient of invasion and establishment of buffel grass from the far north-west to the southern regions of the state. Management zoning is a tool that can be used to guide planning and management at a broad scale. It does not prescribe what must occur at a local scale, which should be determined on the basis of local issues. The use of a management zone approach recognises that while management of an invasive plant depends on local actions, these will be much more effective and efficient when they are part of a broader scale strategic approach (e.g. Grice *et al.* 2011).

A state buffel grass workshop in 2010 identified a state containment line that divided the north of the state from the south at 29 degrees latitude (i.e. near the township of Coober Pedy, largely within the SAAL NRM region). Although buffel grass is well established south of this line, efforts should be made to maintain this line, both in terms of on-ground control and as a symbolic statement of intent. It should be noted that these efforts are directed at achieving benefits not only for the SAAL NRM region, but broader benefits for the state as a whole. As such, and in line with principle four of this plan, it is appropriate that resourcing these activities should not be the sole responsibility of the SAAL NRM Board, and other private and public beneficiaries should contribute where possible. It should also be recognised that there are other containment lines of state significance, such as our north-eastern borders with other jurisdictions, as well as dispersal nodes of strategic importance to the state, such as Port Augusta. Managing these too should be considered in the context of wider benefit and resourced accordingly.

In this strategic plan, management zone boundaries are delineated broadly on the basis of current knowledge of the weed's extent, having implications for the feasibility of eradication. These boundaries can be reviewed in the future as the extent of buffel grass across the state is monitored. The state weed risk assessment determined a "manage weed" management action for the 'Rangelands Grazing' land-use, and "manage weed/protect sites" action for the 'Native Vegetation' land-use. The goals for the management zones broadly align with this risk assessment.

The state management zones (Figure1) should also be considered in developing Regional Weed Management Plans for individual NRM Boards:

Zone 1 – Manage buffel grass

NRM Boards: Alinytjara Wilurara - Anangu Pitjantjatjara Yankunytjatjara (APY) Lands; SA Arid Lands - Marla-Oodnadatta NRM District.

Status: Numerous, extensive, widespread infestations, particularly in the far north-west.

Management aim: To reduce the overall impacts of buffel grass through targeted management, including protection of sites of cultural and environmental significance and control of outlier populations

MANAGE WEED

- aims to reduce the overall economic, environmental and/or social impacts of the weed species through targeted management
- research and develop integrated weed management (IWM) packages for the species, including herbicides and biological control where feasible
- promote IWM packages to landholders
- monitor decrease in weed impacts with improved management
- identify key sites/assets in the management area and ensure adequate resourcing to manage the weed species

Zone 2 - Protect sites

NRM Boards: SA Arid Lands (SAAL) excluding Marla-Oodnadatta NRM Group; Northern and Yorke - Upper North sub-region

Status: Large and small, widely distributed infestations, with some larger infestations challenging to contain or control, for example:

- townships along major roads, in particular Port Augusta, Pimba, Copley, Glendambo, Kingoonya, Tarcoola and Coober Pedy
- National Highway 1 road reserve and adjoining land between Port Augusta and Port Pirie
- the rail corridor (Interstate Main Line) between Port Augusta and Wynbring (SAAL and AW NRM)
- the North Flinders District (SAAL)
- parts of Innamincka Regional Reserve (SAAL).

Management aim: To prevent the ongoing spread of buffel grass into clean or priority areas within or beyond Zone 2, aiming for a significant reduction in all infestations.

PROTECT SITES

- aims to prevent spread of the weed species to key sites/assets of high economic, environmental and/or social value
- surveillance and mapping to locate all infested areas
- identification of key sites/assets in the management area
- control of infestations in close proximity to key sites/assets, aiming for a significant reduction in weed density
- limits on movement and sale of species within management area
- monitor change in current distribution within and in close proximity to key sites/assets.

Zone 3 - Destroy infestations

NRM Boards: Alinytjara Wilurara - Maralinga Tjarutja (MT) Lands south of the northern boundaries of Mamungari and Tullaringa Conservation Parks); rail corridor west of Tarcoola within SA Arid Lands; Eyre Peninsula; Northern and Yorke - Lower North sub-region and Yorke sub-region; SA Murray-Darling Basin; Kangaroo Island; South East.

Status: Predominantly small, widely scattered localised infestations, currently known to occur in EP, NY, AMLR, SAMDB and the MT Lands of the AW NRM Board. Not yet recorded in KI.

Management aim: To significantly reduce the extent of buffel grass in Zone 3, locating and destroying all infestations aiming for local eradication at feasible sites.

DESTROY INFESTATIONS

- aims to significantly reduce the extent of the weed species in the management area
- detailed surveillance and mapping to locate all infestations
- destruction of all infestations, aiming for local eradication at feasible sites
- prevention of entry to management area and movement and sale within
- monitor progress towards reduction.

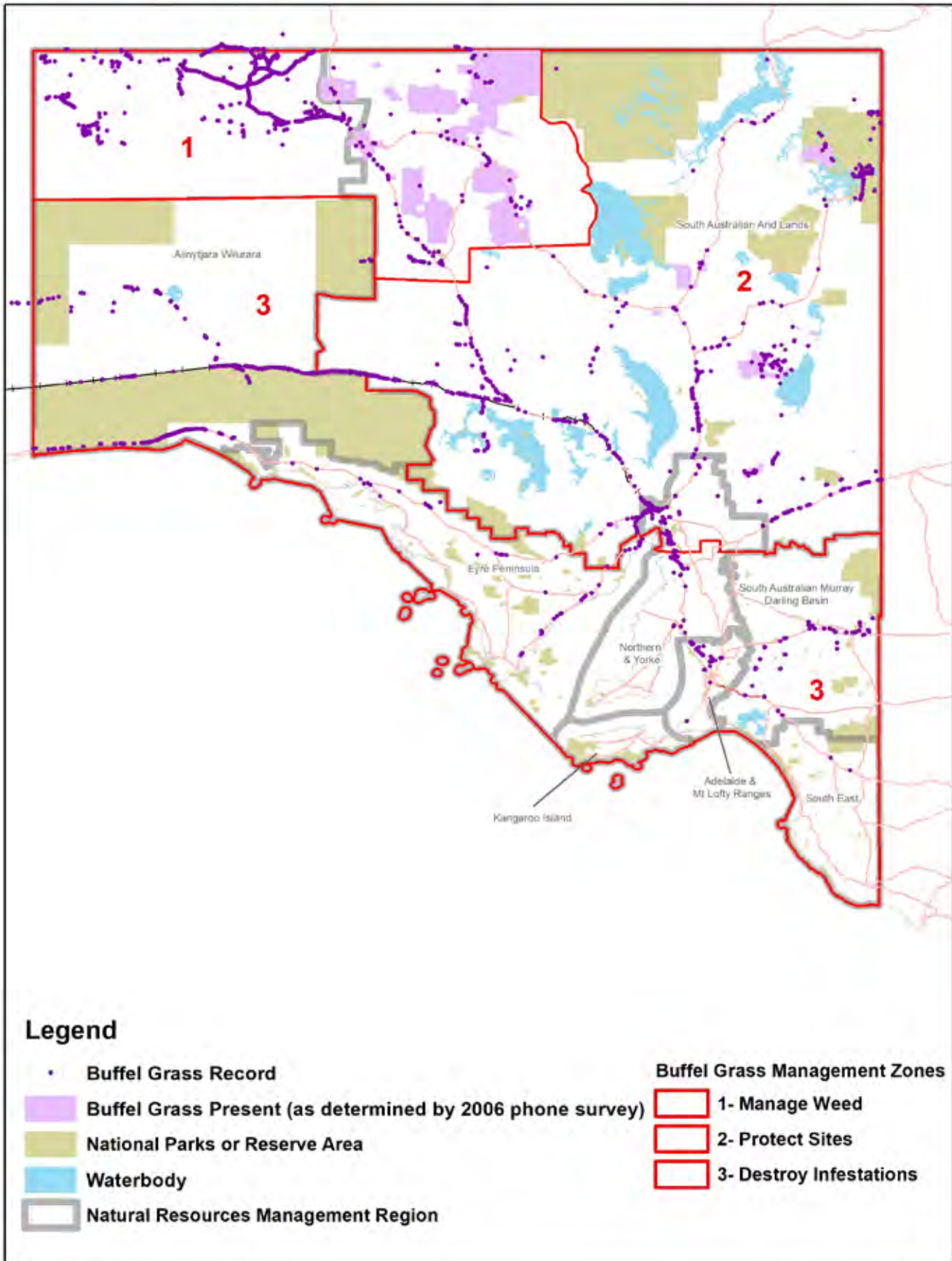
Figure 1. Buffel Grass Management Zones and records in South Australia, 2018. Note, the map displays cumulative records of buffel grass collated from a variety of sources. It does not account for infestations that are being actively controlled and the current status of each population is not known. Given known seed longevity, infestations must not have set seed within the last five years for an infestation to be considered as eradicated, therefore regular mapping and monitoring are important in producing a map showing only currently extant infestations.

The majority of infestations in Zone 3 are situated along roadsides and are subject to ongoing management. Intensive buffel grass management commenced in many regions in 2013 and if this continues it is expected that many outlier infestations in Zone 3 may be considered eradicated in 2019-2020.

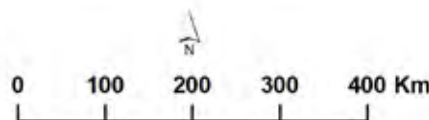
Buffel grass distribution as determined by the 2006 phone survey is an indicator of presence within the parcel only, it does not provide any indication of the distribution or density contained within.

The map also contains a bias towards roadside data collection and is likely not representative of buffel grass occurrence away from roads. The actual distribution of buffel grass is likely to be much more widespread than is currently recorded in the northern half of the state due to its widespread distribution and a lack of survey data on private property and in inaccessible areas.

Buffel Grass Management Zones and Records in South Australia



Produced By: Troy Bowman
 Invasive Species Unit- PIRSA (July 2016)
 Data Source: Weed data from Rural Solutions SA, DEW,
 DPTI, Biosecurity SA, Topo 250K from PIRSA,
 NRM regions and National Parks from DEWNR.
 Projection: Lambert Conformal Conic
 Datum: Geocentric Datum of Australia 1994 (GDA 94)



Disclaimer
 PIRSA and its employees
 do not warrant or make any representation
 regarding the use or results of the use of the
 information contained herein.



3.3 Goals and Actions

Goal 1 - Prevent

Exclude the entry of buffel grass into SA and prevent its movement within the state (all zones)

Background

Vast areas of South Australia are susceptible to buffel grass invasion and impacts. A key means of minimising the impacts of buffel grass across the state is the early detection of plants in areas where it is absent or sparse, and preventing the establishment of new populations. Priority should be given to areas where there is a significant risk of incursion and to important assets that would be threatened by establishment of buffel grass. Effort should focus on the routes by which buffel grass is likely to spread, principally transport corridors.

Industries and communities are encouraged to assist, particularly in the northern parts of the state, to prevent spread and to detect new infestations. Mining industries are users of some remote areas of the state, with movement of workers and machinery through these areas presenting risks of inadvertent spread. Any future growth in exploration, mining, petroleum or geothermal industries would need to be done in an appropriate manner to ensure the prevention of the spread and effective management of buffel grass. Earthworks such as roadside grading can spread seed, starting new infestations or expanding existing infestations. Road managers need to be aware of the risks of spreading the weed in this way and adopt appropriate hygiene practices. A range of education and awareness activities will be required including protocols

to reduce seed spread, and more effective awareness campaigns. Resources need to be available when new infestations are detected to enable timely responses.

Increasing public and community awareness of what buffel grass looks like, its impacts and the benefits of control, is essential to building community willingness and capacity to prevent, monitor for, and control new buffel grass occurrences (Pitt 2004). Landholders should be provided with information regarding the negative ecological and economic effects of buffel grass, as well as restrictions and obligations under the NRM Act. Signage on roadsides, in rest stops at sites of cultural and environmental significance is an effective method that could be employed by the SAAL NRM Board to raise public awareness and reduce the risk of spread into uninfested areas.

Buffel grass hygiene is a critical component of preventing the spread of this highly invasive weed, either from interstate or within South Australia. Due to its prolific seed production, small seed size and presence of fine seed hairs, it has the ability to spread long distances via vehicles, earth moving and other machinery, stock, wind, water and other human activities.

Avoidance is the best method of reducing the potential spread of buffel grass seed so where possible people should stay on tracks and avoid driving or walking through buffel grass infestations.

To minimise the risk of inadvertent spread, members of the public should ensure vehicles, machinery and personal items are free of buffel grass seed through thorough decontamination and on-farm biosecurity measures.

For more information on buffel grass hygiene visit pir.sa.gov.au/buffel-grass

ACTION	Activities	Responsibility	Priority
1.1 Minimise inadvertent spread of buffel grass by human activity	<ul style="list-style-type: none"> develop Codes of Practice with reference to containment for road and rail infrastructure managers conduct community extension activities to promote awareness of impacts, mode of spread, hygiene and control options public signage at strategic locations to promote awareness of the risk of inadvertent spread work with graziers to minimise the risks associated with stock movements from infested parts of Australia to parts of SA where eradication has been declared the principal management objective seek a cross-jurisdictional approach to preventing the further spread of buffel grass into SA from other states and territories (i.e. WA, NT, Qld, NSW) through national committees and working groups. 	<p>NRMBs DPTI, councils, industry</p> <p>Biosecurity SA, NRMBs, Community, NGOs</p>	High

ACTION	Activities	Responsibility	Priority
1.2 Develop and maintain early detection and eradication mechanisms	<ul style="list-style-type: none"> • identify new entry pathways for buffel grass seed in SA • undertake systematic surveys to ascertain the distribution status of buffel grass in SA and across state borders, particularly along high risk spread pathways • undertake research into options to enable cost effective mapping of remote and outlier infestations. 	Biosecurity SA and NRMBs	Medium



Shrubs killed by buffel grass fire, surrounded by a sea of buffel grass regrowth, APY Lands.

Goal 2 – Manage buffel grass in Zone 1

Reduce the overall impacts of buffel grass in ZONE 1 through targeted management (NRM Boards: AW - APY Lands; SAAL - Marla-Oodnadatta NRM District)

Background

Control within Zone 1 should focus first on limiting further spread. The conventional approach is to concentrate on the small, outlying patches at the edges of an infestation, working back towards the core. However, a combined approach of destroying outliers and limiting seed production in large patches may be more effective in the longer term. Building capacity for on-ground work is essential to continue to manage infestations in Zone 1.

This zone includes areas where only limited management activities are currently economically and technically feasible. These sites include dense, inaccessible infestations that

may be lower priority because they are a long distance from infrastructure, key ecological assets, and/or organised management groups.

Mapping is important to determine where infestations are located, the area infested within a region, which infestations are eradicable, and where buffer/control zones should be located. Identifying priority areas for control should therefore consider:

- size and density of infestations
- distribution of infestations (isolated/scattered/widespread)
- proximity to natural and cultural assets at risk
- pathways of spread (roads, drainage lines, towns, etc.)
- accessibility.

Where resources are constrained, the need to delimit more accurately known infestations may need to be reconciled with a more urgent need to control infestations threatening Priority Assets¹.

ACTION	Activities	Responsibility	Priority
2.1 Improve knowledge of buffel grass distribution in Zone 1	<ul style="list-style-type: none"> • survey and map areas where buffel grass presence is unknown • undertake surveillance and mapping of key priority areas, in particular high risk pathways (e.g. roads, rail, towns) • map sources and the invasion fronts of priority infestations and determine the ongoing control requirements • maintain databases of buffel grass distribution throughout the state. 	AW, SAAL	Medium
2.2 Identify and prioritise areas for management	<ul style="list-style-type: none"> • include buffel grass management in regional plans • liaise with Traditional Owners and pastoral lessees • identify and prioritise infestations according to proximity to Zone 2. Determine localised containment lines for larger infestations • develop criteria for prioritising other areas, including the establishment of clean areas within the core areas of infestation, and the protection of priority assets. Identify roadside and non-roadside destruction targets based on isolation and feasibility of control. Plan actions according to risk of spread. • develop and implement management plans for buffel grass on public lands • ensure buffel grass management is included in regional, industry and property planning • monitor and evaluate all management programs. 	AW, SAAL, DEW DEW AW, SAAL, land managers	High

ACTION	Activities	Responsibility	Priority
2.3 Contain or reduce established infestations in Zone 1 to prevent their spread into Zone 2 or 3	<ul style="list-style-type: none"> • treat infestations using appropriate control techniques • involve landholders and community in the control of priority infestations • regularly inspect treated areas for regrowth after significant rainfall events • provide assistance and resources for effective follow-up • record infestations treated 	AW, SAAL, land managers	High
2.4 Destroy and monitor outliers, new incursions and infestations threatening Priority Assets in Zone 1 where feasible	<ul style="list-style-type: none"> • treat infestations using appropriate control techniques • involve landholders and community in the control of priority infestations • regularly inspect treated areas for regrowth after significant rainfall events • provide assistance and resources for effective follow-up • record infestations treated • monitor control sites to confirm eradication. 	AW, SAAL, land managers	High

¹ Priority assets may be considered in the following broad categories:

- Social (e.g. cultural sites, dwellings, settlements at risk of buffel grass-fuelled fire)
- Environmental (e.g. species or ecological communities of conservation significance; specific habitats)
- Economic (e.g. native pastures and pastoral or mining infrastructure at risk of buffel grass-fuelled fire)



Buffel grass invasion in native shrubland.

Goal 3 – Protect Sites (Zone 2) or Destroy (Zone 3)

PROTECT SITES: Protect priority assets from buffel grass in ZONE 2 aiming for a significant reduction in priority infestations (NRM Boards: SAAL excluding Marla-Oodnadatta NRM Group; Northern & Yorke’s Upper North sub-region)

DESTROY: Significantly reduce the extent of buffel grass in ZONE 3, locating and destroying all infestations aiming for local eradication where feasible (NRM Boards: EP, NY – Mid North and Yorke sub-regions, SAMDB, AMLR, SE, KI; AW - MT Lands south of northern boundaries of Mamungari and Tullaringa Conservation Parks)

Background

There are significant areas of South Australia that are free of buffel grass or have only scattered populations. With committed and sustained action, these areas can be protected from the establishment or further spread of the plant.

Mapping is an important first step in planning an eradication program. New infestations of buffel grass are often associated with roads, railway corridors and watercourses. Buffel grass establishes readily in these disturbed environments and human activities such as roadworks spread seeds further along these pathways from which

natural dispersal into the surrounding landscape can occur. Roadside surveys may be undertaken to indicate infested and un-infested areas on a regional scale. GPS should be used for accurate mapping and sharing of data. Data collected by various sources should be collated prior to new surveys. Focusing on high-risk sites for buffel grass is one basis for planning surveys. Where resources are constrained the need to delimit known infestations more accurately may need to be reconciled with a more urgent need to control infestations threatening Priority Assets¹.

The best opportunities to control buffel grass are in areas where it is confined to transport corridors and verge areas in townships (e.g. Appendix 2). Once it disperses from these areas into the surrounding landscape control becomes significantly more difficult and costly.

Although many buffel grass infestations in Zone 2 are relatively small and isolated, there are some locations where control is likely to be more difficult. This may be due to the density, size and remoteness of the infestations, and the economic incentive to control, for example:

- townships along major roads, in particular Port Augusta, Pimba, Copley, Glendambo, Kingoonya, Tarcoola
- the rail corridor (Interstate Main Line) between Port Augusta and Tarcoola (SAAL NRMB)
- North Flinders District (SAAL NRMB)
- Innamincka Regional Reserve (DEW).

In Zone 3 where destruction of infestations is the principal management aim, enforcement of control should be considered as a last resort, with primary emphasis on encouraging landholders through involvement in weed management to provide ownership of the issues and consequent outcomes or problems.



Buffel grass invading spinifex grassland.



Controlled burn of buffel grass, Umuwa, APY Lands.

ACTION	Activities	Responsibility	Priority
3.1 Improve knowledge of buffel grass distribution in Zones 2 and 3	<ul style="list-style-type: none"> • survey and map areas where buffel grass presence is unknown • undertake surveys of high risk pathways (e.g. roads, rail, towns) where there are current knowledge gaps • undertake delimiting surveys of each infestation • undertake landholder surveys to identify distribution on private land. 	NRMBs, DEW	Medium
3.2 Prioritise infestations for treatment	<ul style="list-style-type: none"> • map known infestations in Zone 3 by 2023. • determine the feasibility of eradication of these infestations • prioritise activities based on: <ul style="list-style-type: none"> ◦ assets at risk (“Priority Assets”) ◦ high risk source infestations (e.g. townships) ◦ invasion pathways, and ◦ isolated occurrences (e.g. Appendix 2). 	NRMBs, DEW	Medium
3.3 Develop and maintain early detection and eradication capability	<ul style="list-style-type: none"> • establish state-level procedures for receiving and responding to reports of new infestations, including specimens in State Herbarium • improve communication and reporting networks between agencies • increase the capacity of stakeholders to recognise, detect and report new incursions - develop community surveillance networks • monitor high risk invasion pathways (e.g. roads, towns) during the growing season / undertake surveys of high risk areas following significant rainfall events. 	Biosecurity SA, NRMBs, DEW	Medium
3.4 In Zone 2, protect priority assets from buffel grass aiming for a significant reduction in all infestations	<ul style="list-style-type: none"> • treat infestations using appropriate control techniques • involve landholders and community in the control of priority infestations • regularly inspect treated areas for regrowth after significant rainfall events • provide assistance and resources for effective follow-up • record infestations treated. 	SAAL , NY, land managers	High
3.5 In Zone 3, destroy infestations where feasible	<ul style="list-style-type: none"> • treat infestations using appropriate control techniques • involve landholders and community in the control of priority infestations • regularly inspect treated areas for regrowth after significant rainfall events • provide assistance and resources for effective follow-up • record infestations treated. 	All stakeholders	High

Goal 4 – Build capacity

Ensure SA has the capability and commitment to manage buffel grass (all zones)

Background

Capacity building is a key part of buffel grass management, and in most of the state has been below the level required for effective management.

The current and potential distributions of buffel grass in South Australia are large: the resources required to prevent the spread of buffel grass and minimise the impacts are therefore large, and effective management of the weed requires a coordinated approach involving all key stakeholders. Management on government land, as well as on privately managed land, is required as this species occurs in protected areas and other Crown lands. Control programs are expensive and will require on-going landholder commitment to follow-up. Education activities to promote community awareness of the buffel grass threat will need to be ongoing.

Some research has been conducted on the ecological impacts and control of buffel grass, both interstate and through the Buffel Grass Control in Arid Rangelands Project. This has fulfilled the most pressing needs, but some gaps still remain. While the focus should be on stakeholder engagement and on-ground management, there is still a need to undertake targeted, prioritised research that will contribute towards improved buffel grass management in this state. Research into the economic impacts of buffel grass, alternatives to its use in productive rangelands, and options for mitigating the impacts of widespread, remote infestations should be encouraged.

The capacity of the state to manage buffel grass effectively will require the commitment and cooperation of key stakeholders in particular public land managers (DEW), road managers (e.g. councils, DPTI), Aboriginal landowners, the mining, pastoral, transport and tourism industries and the Australian Government.

Regional authorities and landowners should incorporate strategic buffel grass management in regional and local planning in accordance with this Strategic Plan. Regional planning may require the development of plans specific to buffel grass, particularly where the threat is recognised as a high regional priority.

ACTION	Activities	Responsibility	Priority
4.1 Coordinate and maintain buffel grass management at a state level	<ul style="list-style-type: none"> maintain the State Buffel Grass Taskforce facilitate the inclusion of strategic buffel grass management in pest management planning by regional authorities seek funding for a state coordinator to coordinate control activities and deliver extension services. 	Biosecurity SA, NRMBs	High
4.2 Promote awareness of buffel grass to land managers and the community	<ul style="list-style-type: none"> develop a strategic communications and engagement plan to be coordinated by the Taskforce conduct extension activities to promote awareness of impacts, mode of spread, hygiene and control options disseminate regular updates to weed managers on the progress of buffel grass management across the state maintain best practice management information and provide in a variety of media formats. 	NRMBs Biosecurity SA	Medium
4.3 Consolidate and centralise existing distribution and control data across SA	<ul style="list-style-type: none"> maintain a state database of buffel grass distribution and control make data available to NRM Boards and regional weed managers to aid in priority setting. 	NRMBs Biosecurity SA	Low

ACTION	Activities	Responsibility	Priority
4.4 Guide and support research on buffel grass biology and control	<p>Key research areas (refer Appendix 1 for further details):</p> <ul style="list-style-type: none"> o ecology o impacts o taxonomy o management / control o distribution – current and potential. 	Research, organisations Biosecurity SA	Medium
4.5 Develop and promote integrated weed management to maximise benefits of buffel grass control	<ul style="list-style-type: none"> • establish best practice demonstration sites and conduct training in management techniques • promote best practice options for buffel management and alternatives to its use. 	NRMBs Biosecurity SA Universities	Medium
4.6 Actively involve land managers and the community in buffel grass management	<ul style="list-style-type: none"> • seek support and engagement for the management of buffel grass from community, industry and government. • establish and maintain networks with relevant agencies, groups and individuals • encourage the reporting of new infestations • investigate funding opportunities for landholder incentives • long-term capacity building for community groups. 	NRMBs Land managers Community	High



Buffel grass strategic response team, Coober Pedy.

3.4 Stakeholder opportunities and challenges

Effective management of buffel grass in South Australia can be achieved with the following contributions by key stakeholders. In addition, each of these stakeholders has a general duty of care to take reasonable precautions to ensure that their actions do not harm the environment, for example by spreading a declared weed.

Australian Government

The Australian Government is responsible for the management of Commonwealth lands, including Department of Defence lands, and for the administration of the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act).

This includes:

- undertaking strategic buffel grass control on Australian Government managed lands in South Australia.
- supporting the protection of Matters of National Environmental Significance (as defined by the EPBC Act) threatened by buffel grass within South Australia through national funding programs.
- continuing to support the recognition of buffel grass under the 'Novel biota and their impact on biodiversity' key threatening process.
- continuing to support the buffel grass threat abatement advice.

Biosecurity SA (Department of Primary Industries and Regions South Australia)

Biosecurity SA provides technical, policy and scientific expertise for the control of declared plants under the NRM Act. It develops state policies, provides legislative recommendations to the Minister for Environment and Water, and works closely with NRM Boards and other stakeholders to implement policies for the management of weeds in SA.

This includes:

- reviewing current state policy and where required provide legislative recommendations to the Minister to achieve state level objectives for managing buffel grass
- contributing to buffel grass control and coordination at the state level through continued representation on the State Taskforce to complement the management and delivery of the Strategic Plan
- promoting consistency with this Strategic Plan in NRM Board regional weed management plans and future Landscape Plans
- providing advice to stakeholders on the inclusion of strategic buffel grass management, and recommended control methods, in pest management planning

- contributing to priority research initiatives
- sourcing funding for strategic management programs and research
- continuing to facilitate state level mapping.

State Buffel Grass Taskforce

The State Taskforce has provided guidance, direction and policy advice for the management of buffel grass across SA through the delivery of the Strategic Plan.

This includes:

- ensuring a diversity of community and agency views are maintained on the taskforce for effective implementation of the revised strategic plan
- advising stakeholders on strategic buffel grass management and recommended control methods in pest management planning
- continuing to monitor and evaluate the implementation of the strategy and refine as appropriate
- assisting in the support, development and implementation of programs and initiatives that deliver strategic actions
- coordinating and facilitating the exchange of information on control initiatives around the state
- reviewing and improving communication and extension plans where appropriate
- monitoring and evaluating success of the plan
- maintaining and strengthening partnerships with key stakeholders to improve strategic buffel grass management
- developing and implementing communication and extension plans where appropriate
- contributing to a greater national recognition and understanding of the threat posed by buffel grass to natural, economic and social systems
- identifying funding sources and provide independent advice for prospective applicants for projects consistent with the needs of the Strategic Plan.

Regional Natural Resources Management Boards

Eight regional NRM Boards provide strategic oversight for local and regional control programs for weeds. The role of NRM boards is to lead regional natural resources management through developing regional NRM plans, investing in weed management projects, advising government and connecting government to communities on relevant issues.

Regional NRM boards are supported by DEW staff, with a regional manager who is responsible to both the Chief Executive DEW and the NRM board.

This includes:

- reviewing regional NRM plans and weed management plans and prioritising buffel grass management in accordance with the Strategic Plan
- controlling buffel grass on road corridors and other lands for which they have responsibility for declared plants
- monitoring and evaluating success of buffel grass management
- promoting and supporting local and regional control programs in partnership with relevant stakeholders
- facilitating a coordinated approach to encourage stakeholders to include the strategic management of buffel grass in weed management planning
- initiating or sponsoring buffel grass funding submissions in line with state priorities
- in partnership with DEW, guiding local and regional mapping initiatives and contributing to state map production
- promoting awareness and best practice management through event coordination and product distribution.

Aboriginal land management authorities

Aboriginal land management authorities have been established across SA to assist traditional land owners to manage their land, including Anangu Pitjantjatjara Yankunytjatjara (APY) Land Management, Maralinga Tjarutja, and Yalata Aboriginal Community Council (Alinytjara Wilurara NRM Region), and the Aboriginal Lands Trust. The authorities work with Traditional Owners to ensure their cultural values are maintained and the ecological health of the land is retained.

This includes:

- improving knowledge of the identification, impacts and best practice control of buffel grass
- identifying priority sites for buffel grass control according to cultural values
- incorporating buffel grass management into Healthy Country plans in accordance with strategic management objectives (e.g. regional weed management plans)
- practicing good weed hygiene to minimise the spread of buffel grass
- implementing best practice management to reduce and / or remove buffel grass where possible and desirable
- monitoring and evaluating success of buffel grass management
- considering agreements across state borders to cooperatively manage buffel grass.

Private landholders

With the declaration of buffel grass under the NRM Act, landholders have a legislated requirement to control and manage it on their own lands in accordance with regional pest priorities.

This includes:

- improving knowledge of the identification, impacts and best practice control of buffel grass
- incorporating buffel grass management into property plans in accordance with strategic management objectives (e.g. regional weed management plans)
- practicing good weed hygiene to minimise the spread of buffel grass
- implementing best practice management
- monitoring and evaluating success of buffel grass management.

State government landholders

As the NRM Act binds the Crown, State government agencies with landholdings (e.g. DEW, DPTI, SA Water) have the same duty of care as private landholders in the control and management of buffel grass.

Department for Environment and Water (DEW)

DEW provides integrated environmental and natural resources services including management of the public land estate (parks, reserves and crown lands). DEW's role in managing the state's natural resources ranges from policy leadership to on-ground delivery with regional Natural Resources Management Boards, including issues relating to climate change, sustainable land management, and biodiversity conservation.

DEW has a supporting role for NRM boards to provide an integrated service delivery in each region on environment and NRM matters. Each region is led by a regional manager who is responsible to both the Chief Executive DEW and the regional NRM board.

This includes:

- including buffel grass in the development, implementation and/or review of management plans for the public land estate in accordance with the Strategic Plan
- monitoring and evaluating the success of buffel grass management
- facilitating the inclusion of strategic buffel grass management in pest management planning by stakeholders
- promoting and supporting local and regional control programs in partnership with relevant stakeholders
- supporting and/or developing buffel grass funding submissions in line with state priorities

- participating in local and regional mapping initiatives and contribute to state map production
- promoting awareness and best practice management through event coordination and product distribution.

Pastoral Program (PIRSA)

The Pastoral Board has a key role in preventing the introduction of buffel grass as a pasture species under the provisions of the Pastoral Land Management and Conservation Act, 1989. The introduction of plants not locally indigenous for the purpose of improving pasture values is not permitted without the written approval of the Board.

This includes:

- encouraging lease-holders to identify buffel grass and other weeds threatening the property
- facilitating the inclusion of strategic buffel grass management in property planning in accordance with this Strategic Plan and regional weed management plans
- encouraging lease-holders to implement good weed hygiene and other control measures to minimise the spread of buffel grass

SA Department of Planning, Transport, and Infrastructure (DPTI)

Buffel grass is commonly introduced into new areas along transport corridors from which it can spread into the surrounding landscape. Road managers therefore need to be aware of this risk, including the potential for a rapid build-up of buffel grass fuel in road reserves and the fire threat to infrastructure and the wider landscape. DPTI carries out vegetation control on roadside verges primarily for road safety (e.g. to provide sight distance) and for the maintenance of road infrastructure along state arterial and many outback roads. This maintenance can include management of weeds and other vegetation. While management of declared plants is the responsibility of the relevant NRM Board, improved outcomes and efficiency can be achieved by communication and coordination of roadside maintenance and weed control activities.

This includes:

- liaising with NRM Boards to facilitate effective and efficient buffel grass management on DPTI controlled land
- establishing local management protocols that contribute to strategic management objectives
- including weed hygiene and other prevention measures in work specifications and contractor inductions
- contributing to regional strategic control programs as part of road maintenance programs.

Local government

Within local government districts, councils are vested with care and control of most road reserves, with the exception of state arterial roads where DPTI typically assumes maintenance responsibility for a portion of the road reserve (see above). On state arterial roads the maintenance responsibility of councils is therefore reduced to the portion of road reserve between the road formation and the adjacent property boundary. Buffel grass is commonly introduced into new areas along transport corridors from which it can spread into the surrounding landscape. Local government authorities therefore need to be aware of this risk including the potential for a rapid build-up of buffel grass fuel in road reserves and other council-controlled land and the threat of fire to infrastructure and the wider landscape.

This includes:

- liaising with NRM Boards to facilitate effective and efficient buffel grass management on council-controlled land
- establishing local management protocols (e.g. weed hygiene) that contribute to strategic management objectives
- including weed hygiene and other prevention measures in work specifications
- contributing to strategic control programs as part of road maintenance programs
- improving community and industry awareness of impacts and identification, and promoting early detection.

Railway and service easement managers

Buffel grass is commonly introduced into new areas along transport corridors, rights of way and service easements (e.g. pipelines, transmission lines, Dog Fence) from which it can spread into the surrounding landscape. Managers therefore need to be aware of this risk including the potential for a rapid build-up of buffel grass fuel within the easement and the fire threat to infrastructure and the wider landscape.

This includes:

- establishing local management protocols (e.g. weed hygiene) that contribute to strategic management objectives
- managing buffel grass on rights of way and service easements
- monitoring and evaluating success of buffel grass management
- including weed hygiene and other prevention measures in work specifications
- contributing to strategic control programs and support NRM Boards undertaking control in rail corridor easements.

SA Department for Energy and Mining (DEM) and the Exploration, Mining, Petroleum and Geothermal Industries

As resource exploration and extraction are major activities across the state (including regions where buffel grass is prevalent) the exploration, mining, petroleum and geothermal industries have a duty of care to prevent the spread of weeds, including buffel grass. DEM issues licences, leases and work/activity approvals to the resource sector with conditions that ensure compliance with the control of weeds declared under the NRM Act.

This includes:

- establishing management policies to contribute to strategic management objectives
- including buffel grass management (e.g. weed hygiene to prevent introduction of buffel grass to new sites) in environmental approvals in accordance with the State Strategic Plan and regional weed management plans
- where appropriate, undertaking environmental approvals under the *Mining Act 1971* and the *Petroleum and Geothermal Energy Act 2000* including environmental outcomes or objectives that require exploration, mining, petroleum and geothermal companies to ensure no introduction of new weed species nor a sustained increase in abundance of existing weeds. Exploration, mining, petroleum and geothermal companies must then adopt management strategies to achieve those outcomes, including buffel grass management (e.g. weed hygiene to prevent introduction of buffel grass to new sites) in accordance with the State Strategic Plan and regional weed management plans
- improving community and industry awareness of impacts and identification, and promote early detection and rapid response.

Community Groups and Volunteers

Volunteer groups are making essential contributions to the detection and control of buffel grass infestations.

This includes:

- managing volunteer efforts that contribute to strategic management objectives.
- encouraging capacity building in volunteer networks.
- practicing good weed hygiene to minimise the spread of buffel grass.

Interstate government agencies

South Australia is the only state or territory to date that has declared buffel grass, and as such, no other jurisdiction has responsibility to control or remove buffel grass. However, the cooperation of other states and territories will help to

reduce the ongoing invasion pressure of buffel grass into South Australia. A Buffel Free Great Victoria Desert Working Group has been formed to co-ordinate management in this desert which is shared between two states and the Northern Territory.

This includes:

- supporting South Australian declaration prohibiting the movement of contaminated goods, machinery livestock and materials into the state
- cooperating with South Australian agencies in determining the distribution of buffel grass across common state borders
- avoiding the release of new cultivars where there is a high risk of natural or inadvertent human spread into and establishment within South Australia.

Research institutions

Universities are the key research bodies that can fill knowledge gaps in the control of buffel grass. South Australia's three universities (Adelaide, South Australia and Flinders) should be encouraged and empowered to source funding and resources for researchers in support of this task. Contribution from interstate and overseas (e.g. USA) universities is also encouraged.

This includes:

- identifying research gaps and seeking innovative solutions for the management of buffel grass
- seeking new and on-going funding and support for research requirements.

Case study:

Working across borders

The Great Victoria Desert (GVD) is the largest desert in Australia and contains significant biodiversity and cultural values. One of the key threats to the GVD includes the encroachment of buffel grass which is transforming arid landscapes and fire behaviour across outback Australia.

Buffel grass has limited distribution across the GVD but if left unmanaged, it is predicted to spread across vast areas of this relatively intact bioregion. Buffel grass threatens habitat and places further pressure on threatened and vulnerable species that live in the GVD including:

Vertebrates listed under the Environment Protection Biodiversity Conservation Act (EPBC Act)

- Sandhill dunnart, *Sminthopsis psammophila* (endangered)
- Southern marsupial mole, *Notoryctes typhlops* (endangered)
- Malleefowl or nganamara, *Leipoa ocellata* (vulnerable)
- Black footed rock wallaby or warru, *Petrogale lateralis* (vulnerable)
- Bilby, *Macrotis lagotis* (vulnerable)
- Western quoll or chuditch, *Dasyurus geoffroii* (vulnerable)
- Crest-tailed mulgara, *Dasyercus cristicauda* (vulnerable)

- Princess parrot, *Polytelis alexandrae* (vulnerable)
- Great desert skink, *Liopholis kintorei* (vulnerable)
- Greater stick nest rat, *Leporillus conditor* (vulnerable).

Plant species listed under the EPBC Act:

- Victoria desert smoke bush, *Conospermum toddii* (endangered)
- Ponton creek mallee, *Eucalyptus articulata* (vulnerable)
- Ooldea guinea-flower, *Hibbertia crispula* (vulnerable)
- Yellow Swainson-pea, *Swainsona pyrophila* (vulnerable)
- Bead samphire, *Tecticornia flabelliformis* (vulnerable).

The buffel grass free GVD (BFGVD) project was initiated in 2015, with the goal to eradicate buffel grass from the GVD. It is now a part of the 10 Deserts Project. To work towards achieving a buffel free GVD the project aims to:

- identify and map existing buffel grass infestations within the GVD
- improve the capacity and capability of land managers to manage buffel grass
- reduce buffel grass infestations through active management
- prevent new infestations of buffel grass from establishing in the GVD
- implement a more coordinated approach across the GVD
- test buffel grass control strategies for broader application in other desert regions



Rangers from the APY Lands spraying buffel grass

Indigenous land management organisations are leading collaborative action against buffel grass across the GVD, supported by a number of land and resource management organisations – they make up the *BFGVD Working Group*. The BFGVD working group includes partners from across the GVD including:

- Anangu Pitjantjatjara Yankunytjatjara Lands Management (SA)
- Arid Lands Environment Centre (NT)
- Charles Darwin University (NT)
- Desert Support Services (WA)
- Great Victoria Desert Biodiversity Trust (WA)
- Maralinga Tjarutja Land Management (SA)
- Natural Resources Alinytjara Wilurara (SA)
- Rangelands NRM (WA)
- Ngaanyatjarra Land Management (WA)
- Primary Industries and Regions South Australia (PIRSA)
- Spinifex Land Management (WA)

The working group meets quarterly to share updates, data and organise on-country workshops to build capacity and implement the management plan across the GVD. The first Southern Desert Ranger Forum (SDRF) in Ilkurlka Spinifex Country, Western Australia in 2017 was initiated through the BFGVD working group. The SDRF has become an annual event for Indigenous rangers to learn skills, build capacity and share knowledge across and surrounding the GVD.

The working group has developed an *Integrated Buffel Grass Management Plan for the Great Victoria Desert*. The plan identifies key priority management actions across the six sub-regions of GVD with key introduction pathways into the GVD including the Trans-Continental rail line and key roads, tracks and communities. It also provides the basis for standardised data collection and analysis across the bioregion.

The plan identifies opportunities for sustained gains in the battle against buffel grass through developing culturally appropriate communication products to highlight the risks of its spread and how important vehicle hygiene is in protecting culturally and ecologically important areas.

Building a long-term sustainable model is critical to this project's success. The 10 Deserts Project provides a solid base to support collaboration across the GVD in the short term. In the medium to long-term, leadership like that shown by the South Australian Government's listing of buffel grass is needed. This leadership combined with cross-border commitments of state governments to support key bioregions like the GVD to manage *mamu tjanpi* (devil grass) will ensure future generations experience the wonder of these desert landscapes and not be subjected to vast, flammable monocultures of buffel grass.

3.5 Monitoring and evaluation

Monitoring and evaluation are important to the continued development of the State Strategic Plan to improve the effectiveness of management actions. This strategic plan is subject to a five year review.

The national NRM Monitoring, Evaluation, Reporting and Improvement (MERI) Framework has been adopted by the South Australian government for monitoring natural resource management targets. Applied to this strategic plan, the MERI Framework should measure the effectiveness of specific management actions on achieving measurable outcomes.

The implementation of the plan will be monitored by the State Buffel Grass Taskforce, via biennial reports. These will comprise an assessment of progress against the goals of the plan, as set out in section 2, identifying which have been achieved, are underway or have not been achieved. For the latter category, the reasons for not achieving them should be identified and recommendations made for facilitating attainment of these goals.



Herbicide trial site (foreground) in buffel grass monoculture, Umuwa, APY Lands.



Effective herbicide trial results, Umuwa, APY Lands.

4 Technical Background

4.1 Description

Buffel grass is an erect, deep-rooted, tussock forming, C4, summer-growing perennial grass. Seed heads are dense, white to purple in colour, growing in a spike-like raceme up to 15 cm long and are covered in clusters of bristles giving them a fluffy appearance; the flowering heads appear from November to May or sporadically following rain (Smith 2002). The bristly burrs are borne on a zigzag central axis (figure 2).

Buffel grass is native to Africa, India and the Middle East (Whyte *et al.* 1959; Humphreys 1967).



Buffel grass (*Cenchrus ciliaris*) seed heads.

4.2 Taxonomy

The more common of the two species declared as buffel grass, *Cenchrus ciliaris* L., has highly variable morphological and physiological characteristics, reflecting its wide native range. This intraspecific variation has arisen both naturally and from the development of new strains to improve productivity of pastoral land. Cultivars have been developed commercially with increased growth rates, disease resistance and tolerance to a range of environmental conditions. Marshall *et al.* (2012) suggest that knowledge about the suitability of various strains in different environments may be critical for effective control of infestations.

Caution should be taken to ensure that records of *Cenchrus* species are credible, as a number of grasses in this genus can be difficult to distinguish from one another, and from grasses in the closely related genus *Pennisetum*.

Three other *Cenchrus* species that are considered invasive weeds of natural rangelands in some parts of Australia but are much less common in this state than *C. ciliaris*, are also considered in this plan:

- *C. pennisetiformis* Steud. is also included under buffel grass in the Declaration. It is also called Cloncurry grass or slender buffel grass.
- Birdwood grass (*C. setiger* Vahl)
- Mossman River grass (*C. echinatus* L.)

C. pennisetiformis, native to northern Africa, Arabia and India, is difficult to distinguish morphologically from *C. ciliaris*, and until recently they were considered to be the same species. It is also used for permanent pasture and has similar ecological requirements and invasive properties.

Birdwood grass *C. setiger*, native to Africa and India, is a perennial grass that is similar to smaller types of *C. ciliaris*. It has been planted as a fodder plant in pastoral areas in other states and is adapted to a wider range of soils and is more drought tolerant than *C. ciliaris*.

Mossman River grass *C. echinatus*, native to North and South America, is an annual grass forming loose tussocks and characterised by large spiny burrs. It has not been deliberately cultivated in Australia and is regarded as a pest of pastures and some crops.

4.3 Reproduction

Buffel grass plants are bisexual and commonly reproduce by seed (produced with or without fertilisation) or vegetatively through rhizome or stolon production (Franks 2002). After ripening and shedding from the plant, seeds remain viable for 12 months or longer. Field experiments conducted near Alice Springs (Winkworth 1971) found that a small portion of the seeds can remain viable for up to 4 years in the soil, however only 10% were viable after 2 years. Other studies (e.g. Silcock and Smith 1990) suggest that seed can survive 2–4 years in the soil.

Generally at least 25 mm of rainfall is required for seed germination (Cavaye 1988), with germination beginning immediately after rain and peaking in 3–6 days (Tinoco-Ojanguren 2016).

Wildfires may encourage germination as the ashes are reported to make good seedbeds (Paul and Lee 1978). Franks (2002) suggests that buffel grass seeds are triggered to germinate by even minor forms of soil disturbance, including breaking of the soil surface by stock movement.

Seedlings can reach reproductive size and set seed in as little as 3 to 6 weeks with sufficient moisture and re-shooting mature plants can flower within 10 days after a rainfall event (Dixon *et al* 2002; Puckey and Albrecht 2004).

4.4 Preferred habitat

Buffel grass currently predominates in areas where summer rainfall varies from 150-550 mm, winter rainfall is less than 400 mm, mean minimum winter temperatures rarely fall below 5°C, and soil texture is loamy (Cox *et al.* 1988). It favours creeks, alluvial plains, calcareous areas and rocky ranges (Albrecht and Pitts 1997), however, it has been successful in a broad range of soil types and landscapes. Buffel grass also readily establishes in road and track verges, parking bays, towns and other disturbed areas.

4.5 Dispersal and Persistence

Buffel grass spreads through dispersal of its fluffy burrs by water, wind, accidental transportation (e.g. in or on vehicles, animals, soils, etc.) or inadvertently transported (e.g. in hay) or, intentionally introduced by landholders seeking to establish an improved pasture (Puckey and Albrecht 2004). Seeds rarely survive ingestion and it is unlikely that herbivores are responsible for significant spread of buffel grass in this manner (Gardner *et al.* as cited in Griffin 1993).

Seeds are commonly introduced into new areas along roads and tracks. Spread along roads is assisted by vehicle draughts and movement of soil by graders and other machinery and vehicles. From the road or track verge buffel grass then spreads into the surrounding vegetation by wind or water, with drainage lines acting as conduits for more distant dispersal (Puckey and Albrecht 2004).

Buffel grass may initially be slow to establish, but under favourable seasonal conditions it may spread readily and aggressively invade arid riparian areas. Established buffel grass tussocks can remain dormant for long periods and plants can live for at least 20 years (Latz 1997). Leaves die off during dry or cold periods and new growth quickly emerges from the tussock with warm, moist conditions.

Buffel grass has a rapid growth rate, fast maturation, prolonged flowering/fruitlet periods, prolific seed production, high seed dispersal ability, relatively long seed dormancy, and is tolerant to drought, fire and grazing (Franks 2002; Franks *et al.* 2000). In the arid zone, it has spread extensively during infrequent episodes when summer rainfall was well above average for several years.

Buffel grass is competitive as an established plant and less competitive as a seedling. To limit its dominance it is therefore important to maintain competition from existing vegetation, however, this is unlikely to prevent spread altogether (McIvor 2003).

4.6 Impacts and uses

Buffel grass forms dense monocultures, changes fire regimes, threatens refugia and displaces native and endemic plants (McIvor 2003; Humphries *et al.* 1991; Griffen 1993; Low 1997). It has been identified as a 'transformer' species (Grice 2006); Richardson *et al.* (2000) have defined these as 'a sub-set of invasive plants which change the character, condition, form or nature of ecosystems over a substantial area relative to the extent of that ecosystem'. Bastin *et al.* (2008) identified it as a 'transformer weed' of the Australian rangelands. In NSW, the 'Invasion of native plant communities by exotic perennial grasses' is listed as a Key Threatening Process (KTP) under the *Threatened Species Conservation Act 1995*. Buffel grass is one of these grasses listed under this KTP.

Buffel grass aggressively and rapidly colonises preferred habitats where it forms dense monocultures, displacing native vegetation. In arid Australia, buffel grass often displays strongest growth along creek lines and embankments (Centre for Arid Zone Research 2001). Watercourses and other mesic areas are functionally critical in a landscape where water is limiting to growth. Mesic areas are also nutrient sinks and tend to support higher flora and fauna productivity, including endemic or rare species (Humphries *et al.* 1993).

Numerous studies have shown that the cover of buffel grass is negatively associated with species richness (e.g. Clarke *et al.* 2005). Where buffel grass density is high it is predicted that reductions in species richness will become more pronounced over time, because the seed banks of native forbs and grasses will gradually be depleted (Clarke *et al.* 2005).

Buffel grass threatens plant and animal communities that are not adapted to fire, by increasing the intensity and frequency of natural fire regimes (Adair and Groves 1998; Schlesinger *et al* 2013). Dry foliage can form a relatively continuous, flammable ground layer that can carry extensive and intense fires. Buffel grass produces approximately 2-3 times the combustible material of displaced native grasses, resulting in hotter, more intense fires (Humphries 1993) and is able to rapidly regenerate after fire and suppress regeneration of native species. An aspect of the ability of buffel grass to transform the fire regime at a landscape scale, particularly in dry environments, is its ability to infest creek-lines which would otherwise act as natural barriers to the spread of fire. In such environments, where creek-lines did not naturally support the growth of dense, fire-fuelling grasses, buffel grass can act as a "wick" for the transmission of a fire across the landscape.

Case study:

Impact of Buffel Grass on Aboriginal Culture

As buffel grass continues to invade and change ecosystems across large areas, Aboriginal people are experiencing the effects of this landscape transformation as bushfoods decline, human safety is threatened, and Aboriginal culture is impacted (Bowman 2017).

Two short films and one episode of ABC's *Landline* have investigated the effects of buffel grass on Aboriginal culture in remote Australia. ABC *Landline*'s episode "Mixed Blessing", the short film "Storm on the Horizon" by Ninti Media and PIRSA, and the short film "Desert Rangers War on Buffel Grass" by the Ten Deserts Initiative all interviewed Aboriginal elders, rangers and ecologists across the APY Lands (SA) and Spinifex Country (WA) in order to find out how the rapid invasion of buffel grass is affecting the culture of Anangu people.



Ili, one of the most important bushfoods.

Many Anangu in the films describe how buffel grass has dramatically changed the understorey vegetation: previously the plains country supported an abundance of bush foods, wildflowers and native grasses but now buffel grass has taken over and few of these species remain. Anangu remember being healthy eating many bush foods but now their health has deteriorated. Kampurarpa (*Solanum centrale*), wakati (*Portulaca oleracea*) and wangunu (*Eragrostis* spp.) are staple bush foods which are specifically mentioned in the films as having been lost from large areas due to buffel grass invasion. Buffel

grass also has the ability to grow right under trees and shrubs, which more easily carries fire and burns tree and shrub bush food and resource species such as ili (*Ficus brachypoda*) and ilykuwara (*Acacia kempeana*) and apara (*Eucalyptus camaldulensis*). Many bush medicine plants are also threatened directly by buffel grass and the hot buffel-grass fires.

Anangu women in the films explain how they are scared to hunt for maku (witchetty grubs) and tjala (honey ants) because buffel grass is so dense that they cannot see snakes when out hunting. Anangu men also say the thick buffel grass covers up tracks of key bush tucker species like ngintaka (perentie lizard) making hunting more difficult, and they have observed bush tucker species used for meat are in decline.

As buffel grass fuels hotter, more intense and more frequent fires, the whole fire regime of the ecosystem is changing. This impacts upon the ability of Anangu to use fire for many of their cultural practices. Human safety in remote Aboriginal communities is definitely at risk when surrounded by dry, large and continuous tussocks of buffel grass.

Overall the invasive buffel grass has been described by the Spinifex Rangers as destroying the Anangu way of life, because "you need the country, you need the animals to hunt and the plants to keep, and once that's all gone, basically you've got nothing left."



Thick buffel grass growing under the important bush food wattleseed *Acacia victoriae*

Pitjantjatjara names have been used for plants and animals. Films describing the impact on buffel grass on Aboriginal culture can be found online at:

"Storm on the Horizon" pir.sa.gov.au/buffel-grass

"Mixed Blessing" abc.net.au/news/2015-02-02/mixed-blessing/6063502

"Desert Rangers War on Buffel Grass" <https://youtu.be/6kyTaRSW87U>

Buffel grass threatens stands of long-unburnt vegetation, and the fauna that rely on these, for example mulga woodlands, hummock and spinifex grasslands. Research undertaken in central Queensland found counts of the native delicate mouse (*Pseudomys delicatulus*) declined as the cover of buffel grass increased (Ludwig *et al.* 2000).

Rare and endangered fauna species in northern SA threatened by buffel grass include: black-footed rock wallaby; great desert skink; spinifex bird; mallee fowl; and a suite of ground / low shrub / grassland foraging birds such as chestnut quail thrush, dusk grass wren, and striated grass wren (Paltridge *et al.* 2009). The Rare and Threatened Flora Management Plan for the APY Lands (Paltridge *et al.* 2009) identifies 12 plant species under threat from buffel grass. Appendix 4 provides a listing of indigenous flora and fauna species of conservation significance that are currently considered to be threatened by buffel grass in arid and semi-arid South Australia.

Buffel grass has been the subject of agricultural extension activity in northern Australia since the 1920s (Humphrys 1967); in the 1950s it became the prominent sown pasture grass for the more arid zones of northern Australia and was well researched for its potential to improve pastures across Queensland, Western Australia and the Northern Territory (Hall 2000). Most plantings have taken place since the late 1950s (Paull and Lee 1978).

Buffel grass is regarded as a resource by many northern Australian cattle producers because of its palatability, responsiveness to limited rainfall, ability to colonise and its tolerance to drought and heavy grazing (Fairfax and Fensham 2000). It responds to out of season rain when native species remain dormant (Hall 2000), however it can displace a large range of short-lived native grasses and forbs important in fattening cattle (Puckey and Albrecht 2004). This is of particular concern in far northern SA where these types of vegetation communities predominate (Greenfield 2007). It provides less protein and metabolisable energy than native grasses such as barley Mitchell grass (*Astrelba pectinata*), spear grasses (*Austrostipa* spp.), silky blue-grass (*Dichanthium sericeum*) and black-head grass (*Enneapogon nigricans*), insufficient to maintain adult dry stock in the absence of other feed (Natural Resources SA Arid Lands 2017).

Buffel grass invasion is facilitated by burning, producing positive feed-back between buffel grass and the fire. The consequence of this positive feedback loop is an increased rate of degradation of the landscape as buffel grass increases in density and out-competes non-fire-dependent native species and further dominates the ground layer (Butler and Fairfax 2003; Miller *et al.* 2010).

Buffel grass has a high demand for available soil nitrogen and phosphorus. As it assumes dominance, soil nitrogen is depleted and growth begins to decline in what has been described as a 'run-down' effect, with an associated decline in cattle live-weight gain (Puckey and Albrecht

2004). Buffel grass contains oxalates and can cause acute oxalate poisoning in ruminants, most often in young and hungry sheep (Thomas 2004). Under favourable conditions buffel grass can form monocultures or dense stands, displacing native plants including valuable forage species. Lack of diversity in pastures can limit the nutritive value available to stock during particular seasonal conditions (e.g. dry periods) or pasture "run-down".

Buffel grass has also been used for soil stabilisation and erosion control (Albrecht and Pitts 1997).

Major threats to country in South Australia include invasions of existing or new weeds, in particular buffel grass, which is considered one of the greatest risks to biodiversity and culture in the Alinytjara Wilurara Natural Resources Management Region (Alinytjara Wilurara Natural Resources Management Board, 2011). Biodiversity assets at risk within the region include culturally important or unique flora, fauna (e.g. the critically endangered warru or black-footed rock wallaby) and native habitats. Cultural practices at risk due to the impacts of buffel grass include collection of bush foods and medicine, hunting and tracking techniques due to a loss of species diversity and inter-tussock space and practices associated with cultural burning and 'special places' that are being overrun by buffel grass and impacted by wildfires.



Case study:

Addressing the threat of buffel grass to warru in the APY Lands

As buffel grass continues to invade and change The black-footed rock wallaby *Petrogale lateralis* (MacDonnell Ranges race), known as warru in Pitjantjatjara, has drastically declined in abundance and distribution since the arrival of Europeans in Australia. This species is now listed as critically endangered in South Australia with two remaining wild populations, one reintroduced population and one semi-captive population in the rocky hills of the Anangu Pitjantjatjara Yankunytjatjara (APY) Lands.

Buffel grass is threatening warru primarily by changing the fire regime. Buffel grass promotes hotter and more frequent fires due to its higher fuel load and ability to regenerate more quickly than native grasses. Currently, buffel grass has expanded throughout the northern part of the APY Lands, forming dense infestations particularly in the outwash areas adjacent to hills and increasingly up on the hills and right under overstorey vegetation. Increased fire intensity and frequency can destroy trees and smaller plants, many of which are important food for warru, such as fire-sensitive desert fig (*Ficus brachypoda*) and spearwood (*Pandorea pandorana*). More frequent fires could also reduce the vegetation cover which affords warru protection from predation by foxes and cats. Overall, buffel grass is changing the ecosystem where warru live and without management buffel grass could contribute to a further decline in warru populations.

Because the infestations around warru habitat range from dense to isolated patches, different management techniques have been employed by the Warru Recovery Team and Indigenous Rangers from APY Land Management. Given the remote area, hot arid climate, fluid workforce and high turnover of staff, there are challenges to reducing the threat of buffel grass around warru populations. For example, herbicides may not be as effective with either too little or too much rain and application on hot days; follow up is difficult with high turnover of staff; and carting water and PPE to remote sites is time-consuming and reduces the amount of area that can be covered. The four different warru populations have received different management strategies, which highlight some of these challenges:

In the far west of APY at Kalka community, buffel grass has already invaded the plains at the base of hills and is now climbing up hillsides and creeklines. Buffel grass control is focussed within creeklines of ecological and cultural importance. In Maku Valley rangers opted for a more delicate method of buffel grass control to avoid herbicide runoff impacting aquatic organisms such as rare frogs. Hand grubbing of buffel grass was completed in a 25



Looking after warru on the APY Lands with ranger Jacob MacKenzie

metre radius around the Maku Valley spring in early 2016, but after winter rains ruby dock, another resident weed in the APY Lands, covered the area. Following summer rains, buffel grass germinated again to worse than pre-control levels. However, with continual hand removal in 2017/2018, the Ranger team are maintaining a low density of buffel grass around the key ecological and cultural site in Maku Valley. In previous years, 360g/L glyphosate was sprayed in the same area but this was not fully effective.

At 'Pintji', the fenced enclosure containing captive-bred warru prior to their release, buffel grass is invading along tracksides and into the enclosure due to seed transport by wind, vehicles and human foot traffic. Tracksides and isolated patches were targeted in 2016 by spraying with a mixture of glyphosate/flupropanate to kill mature tussocks, prevent seeding and stop new recruits from emerging in following seasons. However, follow up monitoring detected new plants and several old plants which had re-sprouted. Overall the 2016 spraying was not considered successful, which could be due to poor water quality used in the

spraying mix. In winter 2017, dry granular flupropanate was shaken over specific buffel grass tussocks at a rate considered equal to 25 kg/ha. However, at this rate of hand application the granular flupropanate was not considered successful either, as after early summer rains finally activated the granular product, up to 20% of each buffel grass tussock maintained healthy growth. In winter 2018, a spray mix of glyphosate, flupropanate and the new addition of pine oil was used along roadsides and for isolated patches, with results yet to be confirmed.

Warru have recently been translocated to 'Wamitjara', a remote hill or inselberg away from the main area of buffel grass infestation. However, buffel grass has been found in small patches along tracksides, at camps and on the hillside. The remote location and isolated infestation makes this area suitable for dry granular flupropanate application. In winter 2017 the granular application was undertaken opportunistically, however, similar to at the Pintji, the granular flupropanate did not prove to be effective. Follow up control has occurred in June/July 2018 with a liquid spray mixture of glyphosate, flupropanate and pine oil applied to plants within approximately 60m either side of the loop track that encircles Wamitjara. This is the first time that pine oil has been trialled to control buffel grass in the APY Lands. Effectiveness of this treatment approach should be evident after summer rainfall. If effective, backpack spray units with this herbicide mix will be used to control buffel grass on the hill at Wamitjara and other project sites.

The main wild population of warru occurs at 'New Well' which is a large hill close to Ernabella. Buffel grass now occupies approximately one third of the plains surrounding the mountain, which poses an increased fire risk and is a source for buffel grass to invade up the hillside. Due to the size of this infestation, vehicle-based control is difficult. Application of the granular flupropanate at 22.5 kg/ha was trialled by helicopter in July 2017 to cover 90 hectares to provide residual control of buffel over large areas. This method provided partially effective as only a portion of each mature tussock was killed.

4.7 History of spread

Buffel grass is believed to have been accidentally introduced into the north-west coast of Western Australia in the 1870s in Afghan camel harnesses (Humphreys 1967). After the First World War, the WA Department of Agriculture was active in distributing *Cenchrus* varieties sent from Afghanistan. These were the source of the first buffel grass seeds being planted in Queensland at Cloncurry in 1926 (Humphreys 1967). Trials of buffel grass from Pretoria were recorded in the early 1920s in NSW and a buffel grass specimen was identified in Alice Springs in 1930 (Humphreys 1967). Since the late 1950s, buffel grass has been a major pasture grass sown in northern Australia (Loch 1999). Over 580 accessions of buffel grass have been brought into Australia from 35 countries by various agencies (Hall 2000) with new varieties continuing to be introduced (Friedel *et al.* 2006). Considerable genetic diversity was detected in field samples of *Cenchrus ciliaris*, and evidence of crossing between varieties shows the potential for recombinant forms to arise (Waycott 2006).

Buffel grass has been accidentally and intentionally introduced around northern South Australia. Small scale buffel grass trials have been carried out on many pastoral properties in South Australia since the 1950s (Greenfield 2007). Wind, water, animals and machinery dispersal vectors have spread it into other areas.

Declaration under the *Natural Resources Management Act 2004* prohibits further entry of buffel grass to South Australia, its sale, or transport on public roads either by itself or as a contaminant of produce. This is intended to minimise further movement by human activities.

4.8 Current distribution

Buffel grass is naturalised in Western Australia, the Northern Territory, Queensland, New South Wales and South Australia.

Current distribution data (Figure 1) consists of data collected by DPTI, regional NRM officers, the biological database of South Australia and numerous roadside surveys conducted since 2005. In South Australia, buffel grass is widely distributed across the northern regions with scattered populations varying in size and density (Figure 1). Extensive infestations occur in the state's far north-west, in the northern part of the AW NRM Region (APY Lands). Infestations are present in the Maralinga Tjarutja (MT) Lands and southern Alinytjara Wilurara (AW) NRM Region. Infestations also occur in and around the communities of Oak Valley, Maralinga and Yalata, along the east-west rail corridor from east of Barton to west of Ooldea and Cook, along the Eyre Highway and Lake Dey-Dey road, in the Tallaringa and Mamungari Conservation Parks and Nullabor Regional Reserve and National Park. These infestations are of particular concern because they threaten the cultural and environmental assets of the Great Victoria Desert.

In the SAAL NRM Region buffel grass is widely distributed as scattered populations with most located in the northwest (Marla – Oodnadatta District). North of Marla, along the Stuart Highway verge and adjoining land, buffel grass densities are high; south of Marla the density and extent declines, particularly away from the highway. Infestations of particular concern in the SAAL NRM Region include those in Witchera National Park (the gateway to the Simpson Desert), Innamincka Regional Reserve (threatening the Coongie Lakes complex—a nationally recognised Ramsar site of floodplains and dunefields) and small isolated populations along various roads and tracks acting as introduction pathways into uninfested sites of cultural and environmental significance.

In the Northern and Yorke NRM region there are small roadside populations along the Stirling North - Hawker road and an extensive infestation along the Port Augusta - Port Wakefield Road between Port Augusta and Port Pirie. There are relatively few infestations in the southern parts of the state. In early 2012 several small infestations were found within the SA Murray Darling Basin (SAMDB) NRM region with a number of small infestations found between 2015 and 2017 due to increased awareness and surveillance efforts. 52 infestations are now being managed in the SAMDB NRM region; prior to 2012, buffel grass had been recorded from only one location within the region (2004).

There is a growing number of as yet small, isolated infestations in the EP NRM region, typically associated with roadsides and townships.

In 2015 and 2016, five buffel grass infestations were found in the Adelaide and Mount Lofty Ranges (AMLR) NRM region. These infestations occurred in Port Adelaide, Bowden, along the Port Wakefield road and Northern Expressway. Two records of buffel grass were found in the South East NRM region in the road and railway corridor along the Dukes highway near Keith in 2015.

With the exception of the far north-west, known non-roadside occurrences of buffel grass are widely scattered and sparse. These infestations are mostly small; however its distribution along some watercourses is likely to be more extensive, for example in the North Flinders District of the SAAL NRM Region. Isolated infestations occur along the Oodnadatta Track, Coober Pedy - William Creek Road, Borefield Track, Marree – Hawker Road, Birdsville and Strzelecki Tracks, and in townships including Marla, Oodnadatta, Cooper Pedy, Copley, Glendambo, Roxby Downs and Port Augusta.

However, although many of the known infestations occur along roadsides, this is likely to reflect a significant bias resulting from presence and absence data being largely collected through roadside surveys. Significant infestations may well exist on pastoral properties and in drainage lines outside the scope of roadside surveys and therefore the true full extent of buffel grass distribution throughout South Australia is likely much more extensive than is currently known.

4.9 Potential distribution

Using BIOCLIM climatic modelling it has been predicted that 25% of Australia is potentially highly suitable, and 43% is suitable for buffel grass spread, with the arid to semi-arid areas of the continent being potentially the most favoured for this species (Lawson *et al.* 2004). The MaxEnt model indicated buffel grass intolerance to cold and wet stress, and regions where there are insufficient days above the minimum threshold temperature necessary for the species to complete a generation.

More recent climatic modelling for South Australia using MaxEnt³ (Hobbs *et al.* 2015) predicted that no part of the state's land area is entirely unsuitable for establishment of buffel grass (See Table 1 and Figure 3). The model also showed that the degree of suitability for establishment is variable across the state: 4% is “moderately suitable”, a further 9% is “suitable”, and a further 42% is “highly suitable”. A relatively large proportion of the state (45% or 45,000 ha, confined mainly to the SA Arid Lands and Alinytjara Wilurara regions) was predicted as “very highly suitable”.

Current breeding programs interstate may result in the use of buffel grass as pasture being extended to heavier soils and cooler regions. As a consequence, new forms of buffel grass may have the potential to invade a wider range of habitats.

Climate change modelling undertaken by Macquarie University in conjunction with the NSW Office of Environment and Heritage suggests that suitable climatic habitat for this weed will shift from northern and central Australia towards south-eastern Australia, including large areas in South Australia and New South Wales (Wilson *et al.* 2011).

³MaxEnt is a species distribution model that generates climate estimates based on meteorological data and topographical information. User input of the distribution of taxa is used to create climatic profiles, which can subsequently allow predictions of further distributions of these taxa (Busby 1991). BIOCLIM requires precipitation and temperature information, but does not take substrate into account.

Climatic suitability category	NRM Region Percentage of land area							
	SAAL	AW	SAMDB	NY	EP	KI	AMLR	SE
Not suitable	0	0	0	0	0	0	0	0
Moderately suitable	9	0.1	27.1	35.2	0.8	56.8	60.7	79.6
Suitable	47.6	38.2	37.2	35.2	6.7	43.2	21.6	20.4
Highly suitable	52	26.5	55.8	22.3	45	1	9.1	0
Very highly suitable	39	73.4	8.4	24.9	47.6	0	8.6	0

Table 1: Climatic suitability for establishment of buffel grass in South Australia: Percentage of land area within each NRM Region in each suitability category. The analysis using BIOCLIM (Marshall and Hobbs, 2010) was based on existing distribution records sourced from Biological Survey SA, Australian Virtual Herbarium, NRM regions, and local government groups, as well as roadside survey data (Shepherd and Marshall, 2010).

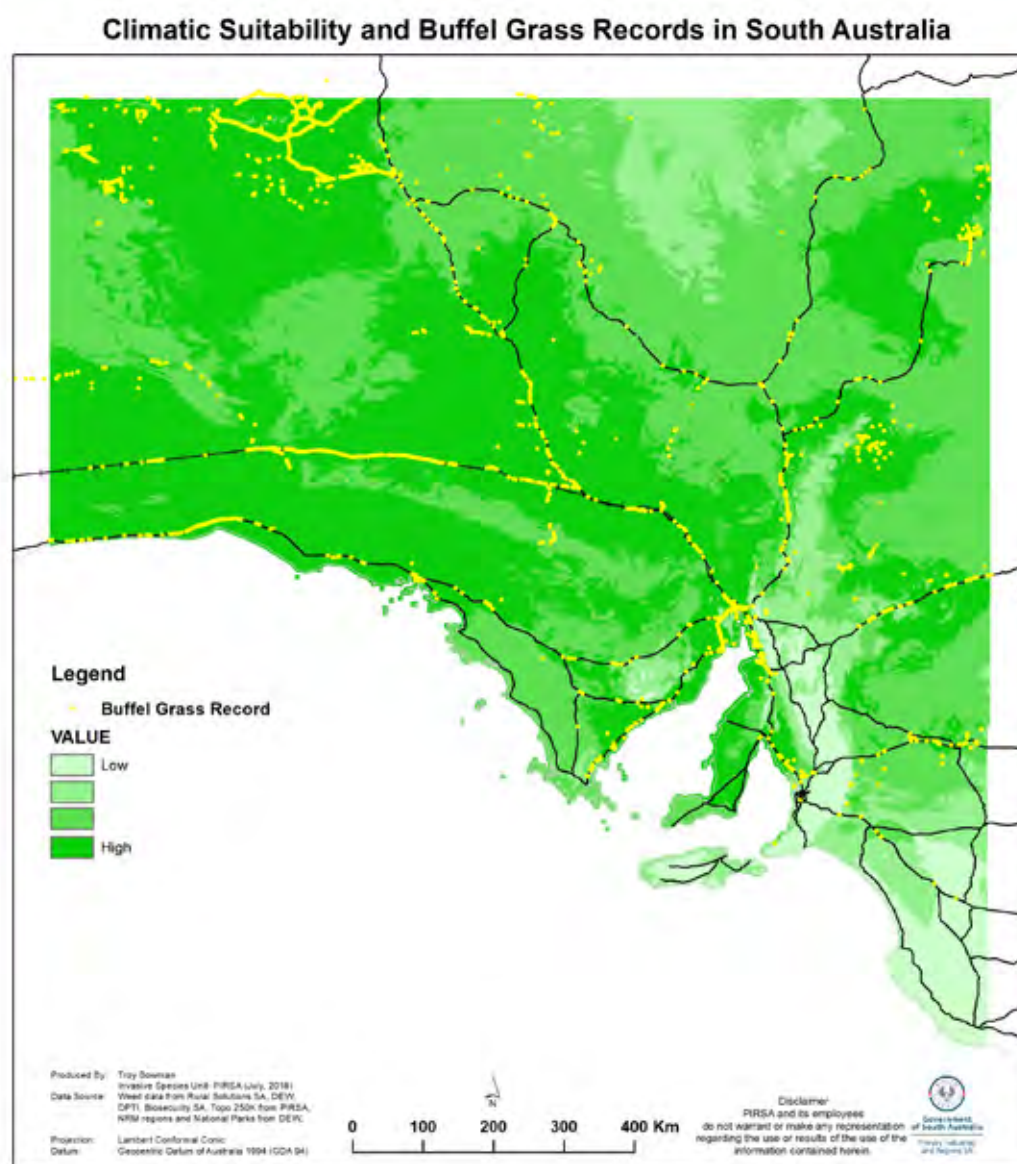


Figure 2. Climatic suitability and distribution records in South in South Australia. Climatic suitability is based on MaxEnt analysis. Current records are based on a range of sources including Australasian Virtual Herbarium, Rural Solutions SA, Department for Environment and Water, Department of Planning, Transport and Infrastructure and the Department of Primary Industries and Regions SA.

4.10 Risk Assessment

An updated state-level weed risk assessment was carried out in 2018 using the SA Weed Risk Management System (Virtue 2008) for the following land-uses:

Rangeland grazing:

Land-use is grazing on leases under the Pastoral Management Act, and also Aboriginal lands where these are grazed. It occurs in the arid and semi-arid parts of the state mainly in the AW and SAAL NRM Regions. Weed management is assumed to be sporadic and minimal in this land-use.

Native vegetation (whole state):

This land-use includes both public and private lands supporting native vegetation in all regions of the state. It includes all forms of land tenure including public and private protected areas and other land. It is assumed there is no routine weed management in this land-use.

The results of the assessment are given in Table 2 below.

Table 2: State-level risk assessment of buffel grass for two land-uses in South Australia using the SA Weed Risk Management System.

Land use	Weed risk (score)	Feasibility of containment (score)	State Level Management Response
Rangeland grazing	Very high (303)	Negligible (184)	Manage weed
Native vegetation	Very high (371)	Low (58)	Protect sites and manage weed

The assessed weed risk is very high for both land-uses due particularly to its invasiveness, especially its easy dispersal, high potential distribution and the impact on desired vegetation.

The lower assessment of its feasibility of containment for both land-uses is due to increased knowledge of biology of the plant, increases in buffel grass distribution, and our knowledge of this since 2013.

It is important to note that this is a state level risk assessment and regional risk assessments should be carried out to support development of regional management plans.

Feasibility of containment is lower for the rangeland grazing land use than for native vegetation across the whole state, principally due to the greater abundance and wider distribution of buffel grass in the arid and semi-arid regions. At a sub-regional level, feasibility of containment would be lowest in the APY Lands in the far north-west of the state

due their remoteness and the extent of land infested by the weed there.

In the rangeland grazing land-use, the aim of a “Manage weed” response is to reduce the overall economic, environmental and social impacts of the weed through targeted management.

In the native vegetation land-use, the aim of a “Protect sites” response is to prevent the spread of the weed to key sites and assets of high economic, environmental and social value.

Regional

In 2014, weed risk assessments for buffel grass using the SA Weed Risk Management System were undertaken for NRM Regions where the risk of introduction and establishment is considered to be the greatest in South Australia. The following regional-level management responses have been determined. It should be noted that knowledge of buffel grass distribution and ecology has improved considerably since 2014, and that consideration should be given to updating these assessments in line with the state-level risk assessment.

NRM Board	Management response as determined by weed risk assessments
Alinytjara Wilurara	Protect sites (APY Lands) Destroy infestations (MT Lands)
SA Arid Lands	Manage weed (Marla-Oodnadatta) Protect sites (all other Districts)
Eyre Peninsula	Destroy infestations
Northern and Yorke	Contain spread in native vegetation Monitor in non-arable grazing
SA Murray Darling Basin	Destroy infestations
Adelaide and Mt Lofty Ranges	Destroy infestations
South East	Destroy infestations
Kangaroo Island	Destroy infestations

Case study:

East west rail line

The Natural Resources region of Alinytjara Wilurara (NRAW) covers almost a third of the state of South Australia, extending from the Western Australian border east to around Nundroo, before heading along the dog fence, encompassing Yellabinna /Yumbarra regional reserve towards Tarcoola including the eastern section of the Great Victoria Desert (GVD), and then north, capturing Tallaringa Conservation Park and the Anangu Pitjantjatjara Yankunytjatjara Lands (APY). Within much of the APY, buffel grass has become firmly established, outcompeting native species due to its rapid growth, quick recovery after fire, and rapid dispersal of seeds. However, across the remainder of the NRAW region, buffel grass is only recorded in smaller tracts, mainly along transport corridors such as highways and rail lines. As such, a large scale initiative for NRAW is the Buffel Free GVD project, which aims to maintain the areas such as the Yellabinna/Yumbarra and Maralinga Tjarutja lands as a buffel grass free zone.

At present, road access within the GVD is relatively limited, with only a small number of business roads and one relatively low frequency 'tourist track' crossing the areas. To date, many of these roads show very little ingress of buffel grass, with small pockets being found and treated relatively successfully. However, the biggest risk for the movement of buffel grass is the East-West rail line, from Port Augusta West towards Perth, intersecting the GVD from around Lyons Siding to past Ooldea Siding before heading across the Nullarbor.

This particular rail line is a busy freight line, as well as offering some passenger services, as it is the direct link between Sydney and Melbourne to Perth. Its relationship to buffel grass is due to the trains coming into contact with buffel grass as they pass through areas such as Port Augusta or more recently Tarcoola, both of which have well established populations of buffel grass. Trains then carry the buffel grass seed within the 'cow catcher', with seeds being dispersed from the catcher when the train turns a corner, due to changing airflows and thus blowing seeds out onto the verge. This can be shown when accessing the rail line as the majority of buffel grass tends to be found on the corners of the track. Trains are as such one of the primary vectors for the transport of seeds along this line, however ARTC work vehicles (trucks, loaders and graders) all move along the access track from areas with buffel grass, as well as public, with the road also frequently used by people travelling from APY Lands to Oak Valley or Yalata. The combination of these vectors has resulted in the dispersal and slow progression of the species west into areas previously buffel grass free. As such the rail line corridor provides a weak link in keeping buffel grass out of the GVD, due to the relentless and constant risk of seeds being pushed along the length of the train line. Therefore,

this rail line has become a priority zone for the NRAW in the fight against buffel grass.

This rail line corridor has been monitored and treated for buffel grass since 2009, with annual trips of up to three days undertaken by two NRAW staff. However, since 2011 buffel grass works in the rail corridor have aimed to increase monitoring and escalate treatment of buffel grass along the rail line corridor in response to the noted increase in the spread and abundance of buffel grass. These have been facilitated by NRAW, using up to four staff, as well as employing approximately two to four community members. These large scale trips have occurred at a yearly rate, and take around six days for completion. In addition, smaller, two to three day trips are undertaken by NRAW staff, at a frequency of approximately three per year. NRAW also employed a private contractor, undertaking around four trips along the rail line in 2017 (which take around four days each trip). These surveys also involve at least one community member to undertake identification of buffel grass as well as the subsequent treatment of the plants.

All trips are undertaken by vehicle, such as a 4WD ute fitted with a boom spray unit, and for the larger trips up to two light utility vehicles also fitted with spray reels. In addition, workers also carry backpack units so that they can access small isolated outbreaks that hoses cannot reach from vehicles or outlier plants in the scrub. This 278 km of maintenance track and rail line corridor includes approximately a 30km buffer to the east of Lyon, extending to Malbooma Siding, to provide extra protection into tracks such as Googs Track. It must also be highlighted that gaining access to the rail line corridor takes a full day of travel, due to limited track access (Googs Track and Oak Valley Road) and the vast Yellabinna Yumbarra Conservation Park, limiting access to either Ooldea or Malbooma.

All outbreaks are mapped by simple GPS or as the case in 2013 and 2016, use of data logger, while buffel grass was treated. The data logger allows for a relatively accurate reading of number of plants in a rapid fashion as it is set up with only five buttons to assess populations. These buttons are set to record five different criteria; 'less than ten plants', 'less than 20 plants', 'less than 30 plants', 'less than 40 plants' and 'more than 50 plants' the only options. Each time any data are logged a GPS fix is also taken, which can then be mapped to allow visualization of the condition of the corridor. Each input is restricted to populations that were separate to each other, with a gap of at least a metre being the standard. However, with some of the larger populations (a few hundred plants) a different approach was required, with a best estimate made of the population (i.e. numerous records when walking and treating each 50 for example).

Many of the initial trips in 2009 mapped outbreaks and then treated the plants generally with just glyphosate. However, it was noted in May 2016 that many of the



Buffel grass infestations along the railway line

known populations of the weed had increased, and a different treatment method was required. As such, a combination of glyphosate and flupropanate have been used since May 2016 (flupropanate being a residual herbicide to prevent germination of new recruits).

Monitoring in October 2016 showed strong results from the treatment undertaken in May 2016, showing it to be far more successful than glyphosate alone. Many of the larger populations of buffel grass were succumbing to this treatment mix, with only single or very few plants being noted in these areas after follow up monitoring. We are yet to establish the viability of seed in or adjacent to these populations. In February to May 2017 treatment of the remnant populations continued, this time with the addition of pine oil to the treatment mix, in an attempt to also kill any seeds that may be persisting on plants or on the soil

surface. Again it is too early to determine the efficacy of the pine oil, however monitoring will continue through the summer.

Inspections undertaken in October 2017 indicated that very little of the known populations of buffel grass that were treated initially in May 2016 and subsequently in early 2016 and 2017 had re-established between Ooldea and Malbooma; again suggesting that the current combination treatment method employed is potentially having the desired effects. Unfortunately, recent inspections noted that at Watson (further to the west into the Nullarbor) a large outbreak was present in an area which was believed to have been last treated in late 2015/early 2016. However it appears that this germination and subsequent growth event was actually missed, due to some communication breakdowns and staff turnover. This has since been re-treated and is being monitored. It highlights the need for clear and concise communication methods, which are robust and can handle staff turnovers etc. to ensure that these types of events are treated properly. In addition, and despite the all the works between Ooldea and Malbooma, concerted efforts will need to be continued further along the line to ensure that any spread does not continue along the line further west of the current targeted area. This may need to be added to the program trips, with the addition of another day or two, extending the intensive monitoring from Malbooma to Watson or Cook. From October 2017 monitoring efforts have extended to at least Watson, and should assist in limiting any outbreaks that may sneak through undetected into the Nullarbor.

It should also be noted that at present ARTC provide access to the rail line to perform the inspections and control, as well as notifications of any significant outbreaks that they have observed.

4.11 Control options

There are considerable challenges to the control of buffel grass in northern South Australia: its physiological and ecological characteristics; its widespread geographic distribution; the extensive area infested; the land use present; and community awareness regarding impacts of this species (Greenfield 2007). In addition, spread by wind and water can potentially move buffel seed many kilometres in a single event.

Information on the distribution of buffel grass, including where control works have been completed, is critical to support planning. The degree of detail required varies with the scale and purpose of planning actions, for example planning in eradication areas with scattered plants requires knowledge down to single plant level.

Once established there is no single control method available for the successful management of buffel grass over extensive areas. Prevention is the most cost-effective means of weed control. It is important therefore to keep

currently uninfested areas free of buffel grass, particularly near high value assets.

As the current extent of buffel grass in northern South Australia precludes absolute control, effort needs to be guided by decision making based on biodiversity values and other assets potentially at risk, logistics, and available resources.

Information on best practice control techniques, chemicals and biological control can be found at the PIRSA website.

Chemical and mechanical methods, and in some situations fire, can be used in an integrated control program for buffel grass. All methods may be effective in particular situations depending on the infestation density and extent, terrain, resources, and the management objectives (e.g. eradication or containment). Control programs require several years of follow-up that may increase the cost several-fold; in some situations the long-term costs can make control of large dense infestations uneconomic.



Roadside outlier control near Port Pirie as part of Strategic Response collaboration among regions.

Without intensive follow-up control, buffel grass will persist, and usually dominate, post-fire communities. Fire may be used to reduce biomass before herbicide treatment of regrowth, but if used alone is unlikely to remove the seed bank when seed is buried even under shallow soil. Further research on buffel grass fires is necessary to define the fuel and fire characteristics required to effectively reduce aerial and soil seed banks (Tschirner 2016).

Buffel grass must be actively growing for effective uptake of herbicides. In arid or semi-arid regions of South Australia the period of active growth is unpredictable and may be short-lived, and timing is therefore very important for control. Foliar application of select herbicides to young plants or regrowth following rain provides the best opportunity for success. Simple physical removal of buffel grass may be considered for new, small infestations, particularly where the plants are bearing seed and the plants are not in an active growth phase. Fire or slashing and herbicides may be integrated to improve foliar uptake and to manage larger infestations.

The high cost of herbicides and associated labour is a hindrance to control. All control programs require several years of follow-up treatment and monitoring, which further increases the cost. Control and eradication of infestations

must be carried out on all tenures including government and Aboriginal lands.

Biological control is considered the most cost effective management method for dense areas of many weeds. However, as buffel grass is recognised as a valuable forage species in some parts of Australia, the potential use of biological control agents would require extensive and extended engagement with all interested parties to identify common ground, and is unlikely to gain acceptance in the term of this plan. There are no approved biocontrol agents in Australia for buffel grass, but it is affected by several diseases, and an insect pest. The most important diseases are buffel blight, caused by fungal pathogen *Pyricularia grisea*, and ergot (*Claviceps* spp.) affecting seed production (Perrott 2000). A condition known as buffel grass dieback in areas of central Queensland has been described but the causal agent(s) are unknown (Makiela *et al.* 2008). The buffel grass seed caterpillar (*Mampava rhodoneura*) is the only documented major insect pest of buffel grass. It has been recorded in warmer, higher rainfall areas of Queensland.

The range of options that may be considered for the control of buffel grass in South Australia are presented in Appendix 3.

Herbicide control

Buffel grass must be actively growing for effective uptake of herbicides. Foliar application of select herbicides to young plants or regrowth following rain provides the best opportunity for success.

Timing is critical to successful chemical control. Re-sprouting plants can flower within a week after rain and new germinations can set seed within three to six weeks with sufficient moisture (Dixon *et al* 2002). As a general rule, foliar herbicides should be applied after rainfall when the plant is actively growing and before seed set. Well-developed rootstock may mean that two or three sprays are required to destroy large plants (Dixon *et al* 2002) and

seeds can remain viable for up to four years (Winkworth 1971). Chemical control programs thus require flexibility and responsiveness around rainfall events and monitoring and follow up control is required for an extended period to ensure eradication.

There are 90 products registered in South Australia that can be used for the control of buffel grass. (PUBCRIS search, July 2019).The minor use permit PER9792 permits the use of four other herbicides. The following table summarises the advantages and disadvantages of each herbicide.

Herbicides registered or permitted for use on buffel grass.

Herbicide	Advantages	Disadvantages
<p><u>Active Ingredient</u> Diquat present as diquat dibromide / paraquat present as paraquat dichloride</p> <p><u>Example of Registered Product</u> Conquest Scorcher 250® Pacific Diquat/Paraquat 250® plus other registered products</p>	<ul style="list-style-type: none"> fast action, may be useful in burning seed heads off (to control seed set) if sprayed late. 	<ul style="list-style-type: none"> classed as moderately toxic (S7) to humans (LD50 by skin absorption is 260 mg/kg male rabbit). Not safe for general use. toxic to fish and wildlife also only burns the top off the plants registered for this use in SA, but buffel grass is not on the label.
<p><u>Active Ingredient</u> Haloxypop-p present as the haloxypop-p-methyl as the only active constituent.</p> <p><u>Example of Registered Product</u> Verdict 520 Herbicide ® Convict Herbicide® plus other registered products</p>	<ul style="list-style-type: none"> not residual (degrades within 24 hours) therefore will not prevent regrowth of competitive native plants. 	<ul style="list-style-type: none"> classed as slightly hazardous to humans (S6) available for use under APVMA permit PER 9792.
<p><u>Active Ingredient</u> 360, 450 or 540 g/L glyphosate present as the isopropylamine salt as their only active constituent.</p> <p><u>Example of Registered Product</u> Nufarm 360 Herbicide ® Roundup Biactive Herbicide ® plus other registered products</p>	<ul style="list-style-type: none"> relatively safe (S5) for general use by a broad range of people not residual therefore will not prevent regrowth of competitive native plants a general use herbicide that can be used on a range of weeds Roundup Biactive is registered for use in waterways can be mixed with flupropanate herbicides. 	<ul style="list-style-type: none"> 80% kill rate (Dixon <i>et al.</i> 2002) available for use under APVMA permit PER 9792.

⁴ A glyphosate – flupropanate-pine oil mix (e.g. Roundup Power-Max® Tussock® and BioWeed®), has provided the most effective long term control in most situations when applied correctly.(Pers. Comm., T. Bowman, PIRSA).

Herbicide	Advantages	Disadvantages
<p><u>Active Ingredient</u> 745g/L flupropanate present as the sodium salt as the only active constituent.</p> <p><u>Example of Registered Product</u> Taskforce Herbicide ® Tussock Herbicide ® plus other registered products</p>	<ul style="list-style-type: none"> residual herbicide is good for areas such as roadsides and fence lines good results achieved. prevents survival of a majority of new germinations reduces seedbank can be mixed with glyphosate herbicides.4 	<ul style="list-style-type: none"> classed as slightly hazardous to humans (S6) residual herbicides may prevent regrowth of competitive native grasses. available for use under APVMA permit PER 9792.
<p><u>Active Ingredient</u> 128 or 212g/L fluazifop-p present as the butyl ester as their only active constituent.</p> <p><u>Example of Registered Product</u> Fusilade Forte 128 ec Herbicide plus other registered products</p>	<ul style="list-style-type: none"> low persistence and mobility in soils (half-life of 1 week) therefore will not prevent regrowth of competitive native plants may only control seedlings (Pers. Comm., I. Honan, DEW). 	<ul style="list-style-type: none"> classed as slightly hazardous to humans (S6) ester formulations are relatively volatile with a greater chance of off target damage moderately toxic to fish available for use under APVMA permit PER 9792.
<p><u>Active ingredient</u> 86.9g/kg flupropanate present as the sodium salt as the only active constituent.</p> <p><u>Example of Registered Product</u> GP Flupropanate Granular ®</p>		<ul style="list-style-type: none"> registered for this use in SA, but buffel grass is not on the label.
<p><u>Active Ingredient</u> 680g/L alpha terpineol as pine oil</p> <p><u>Example of Registered Product</u> Bioweed™ Organic Herbicide Concentrate</p>	<ul style="list-style-type: none"> is suitable for use on organically certified properties can be mixed at 2% with glyphosate and flupropanate to destroy buffel grass seed. 	<ul style="list-style-type: none"> not proven to control mature buffel grass tussocks buffel grass is not on the label registered only for nonselective weed control in orchards, vineyards, commercial, industrial and public service areas, around agricultural buildings and other non-crop farm situations.

When using herbicides, it is important to follow safe use instructions on herbicide labels. Refer to product label for full conditions of use and application instructions. Some of the herbicides are soil active residuals and must be used with care to minimise damage to native vegetation.

In remote locations where follow up control is less likely to occur, the use of granular applied residual herbicides for isolated small infestations or single plants can be an alternative to mechanical grubbing (Greenfield 2007). Off-target impacts to native vegetation that could effectively compete with buffel grass need to be considered with this

method. More research into other potential herbicides for buffel grass control is required.

Friedel *et al.* (2009) provide an example of the costs involved in the chemical control of buffel grass for a project conducted at Alice Springs Desert Park, NT between 1997 and 2007, indicating the very high cost of control in arid regions. The cost of labour and materials for herbicide spraying varied from almost \$10,000/ha in 2000 in the initial stages of the project, to \$50/ha in 2006 for regular follow-up spraying of buffel grass after rain events once the buffel grass was largely under control. Over the 10-year period (1997-2007) the average cost was \$5500/ha.

5 References

- Adair, R. J. and Groves, R. H. (1998) Impact of Environmental Weeds on Biodiversity: A Review and Development of Methodology. Biodiversity Group, Environment Australia, Canberra.
- Albrecht, D. and Pitts, B. (1997) Buffel grass on parks and commission reserves. *Alice Springs Rural Review* 27.
- Alinytjara Wilurara NRM Board (2011) Natural Resources Management Plan for the Alinytjara Wilurara Natural Resources Management Region.
- Anon. (2008) Weed Management Guide: Buffel Grass (*Cenchrus ciliaris*). CRC for Australian Weed Management.
- Bastin, G. and the ACRIS Management Committee (2008) 'Rangelands 2008 – Taking the Pulse', published on behalf of the ACRIS Management Committee by the National Land and Water Resources Audit, Canberra.
- Bowman, T. (2014) *Buffel Grass Roadside Survey, April 2014*. Department of Primary Industries and Regions SA.
- Bowman, T. (2017) Buffel grass management in indigenous communities. *Proc. 19th Australian Rangeland Society Biennial Conference, Port Augusta*.
- Butler, D.W. and Fairfax, R.J. (2003) Buffel grass and fire in a gidgee and brigalow woodland; a case study from central Queensland. *Ecological Management and Restoration* 4:120–125.
- Cavaye, J.M. (1988) Buffel grass basics. *Queensland Agricultural Journal* 114: 69-72.
- Centre for Arid Zone Research (2001) Buffel Grass Distribution. Sustainable Ecosystems. CSIRO, Australia.
- Clark, P.J., Latz, P.K. and Albrecht, D.E. (2005) Long-term changes in semi-arid vegetation: Invasion of an exotic perennial grass has larger effects than rainfall variability. *Journal of Vegetation Science* 16: 237-248.
- Cox, J., Martin-R, M., Ibarra-F, F., Fourie, J., Rethman, N. and Wilcox, D. (1988). The influence of climate and soils on the distribution of four African grasses. *Journal of Range Management* 41: 127-139.
- Department of the Environment (2015) Threat abatement advice for ecosystem degradation, habitat loss and species decline in arid and semi-arid Australia due to the invasion of buffel grass (*Cenchrus ciliaris* and *C. pennisetiformis*). environment.gov.au/biodiversity/threatened/threat-abatement-advice/buffel-grass-introduction Accessed 29/7/2019.
- Dixon, I.R., Dixon, K.W., and Barrett, M. (2002) Eradication of buffel grass (*Cenchrus ciliaris*) on Airlie Island, Pilbara Coast, Western Australia. In: Veitch, C.R. and Clout, M.N. (eds). *Turning the tide: the eradication of invasive species*. IUCN SSC Invasive Species Specialist Group: Gland, Switzerland and Cambridge, UK. pp. 92-101.
- Fairfax, R.J. and Fensham, R.J. (2000) The effects of exotic pasture development on floristic diversity in central Queensland, Australia. *Biodiversity Conservation* 94: 11-21.
- Franks, A.J., Butler, D. and Fairfax, R. (2000) A weed by any other name. *Wildlife Australia* 37: 24.
- Franks, A.J. (2002) The ecological consequences of buffel grass *Cenchrus ciliaris* establishment within remnant vegetation of Queensland. *Pacific Conservation Biology* 8: 99–107.
- Friedel, M., Puckey, H., O'Malley, C., Waycott, M. and Smyth, A. (2006) The dispersal, impact and management of buffel grass (*Cenchrus ciliaris*) in desert Australia. *Proc. 14th Biennial Conference of the Australian Rangelands Society, Renmark* pp 160-163.
- Friedel, M., Marshall, N., van Klinken, R and Grice, T. (2009) *Quantifying Costs and Benefits of Buffel Grass*. Defeating the Weed Menace R&D report. (Land and Water Australia)
- Greenfield, B. (2007). SA Arid Lands Buffel Grass Management Plan, Draft. South Australian Arid Lands Natural Resource Management Board, Port Augusta.
- Grice, A.C., Clarkson, J.R. and Calvert, M. (2011) Geographic differentiation of management objectives for invasive species: a case study of *Hymenachne amplexicaulis* in Australia. *Environmental Science and Policy* 14: 986-997
- Griffin, G.F. (1993) The spread of buffel grass in inland Australia: land use conflicts. *Proc. 10th Australian Weeds Conference 1993* 2: 501-504.
- Hall, T. J. (2000) History and development of buffel grass pasture lands in Queensland. In: *Proceedings of buffel grass workshop, Theodore, Queensland, 21–23 February 2000* (ed. B. Cook). Dept. Primary Industries: Brisbane. pp. 2–12
- Harvey, A. (2015) *Buffel Grass Roadside Survey, March 2015*. Department of Primary Industries and Regions SA: Adelaide.
- Hobbs, T.J, Naby, N. and Schutz, A. (2015) *Minghiri – Developing a Rapid Assessment Technique for Native Vegetation Council Clearance and Offset Applications in the Arid Zone*. DEWNR Technical Note 2015. Department of Environment, Water and Natural Resources: Adelaide.
- Humphries, S.E., Groves, R.H., and Mitchell, D.S. (1991) Plant invasions of Australian ecosystems: a status review and management directions. CSIRO: Canberra.
- Humphries, S.E., Groves, R.H., and Mitchell, D.S. (1993) Plant Invasions: homogenizing Australian ecosystems. In: Conservation Biology in Australia and Oceania (eds. C. Moritz and J. Kikkawa) Surrey Beatty and Sons: Chipping Norton. pp 149-170.
- Humphreys, L. R. (1967) Buffel grass (*Cenchrus ciliaris*) in Australia. *Tropical Grasslands* 1: 123–34.
- Latz, P (1997) Long term monitoring at Simpson Gap National Park. Unpublished report.
- Lawson, B. E., Bryant, M. J. and Franks, A.J. (2004) Assessing the potential distribution of buffel grass (*Cenchrus ciliaris* L.) in Australia using a climate-soil model. *Plant Protection Quarterly* 19: 155-163.
- Low, T. (1997) Tropical pasture plants as weeds. *Tropical Grasslands* 31: 337–43.

- Ludwig, J.A., Eager, R.W. and Liedloff, A.C. (2000) Clearing and grazing impact on vegetation patch structures and fauna counts in eucalypt woodlands, Central Queensland. *Pacific Conservation Biology* 6: 254-72.
- Mclvor, J.G. (2003) Competition affects survival and growth of buffel grass seedlings – is buffel grass a colonizer or an invader? *Tropical Grasslands* 37: 176–181.
- Makiela, S. and Harrower, K. M. (2008) Overview of the current status of buffel grass dieback. *Australasian Plant Disease Notes* 3: 12–16.
- Marshall, V. and Hobbs, T. (2010) The suitability for establishment of buffel grass in South Australia using BIOCLIM climatic modelling. Unpublished data.
- Marshall, V., Lewis, M. and Ostendorf, B. (2012) Buffel grass (*Cenchrus ciliaris*) as an invader and threat to biodiversity in arid environments: A review. *Journal of Arid Environments* 78: 1-12.
- Marshall, V., Ostendorf, B. and Lewis, M. (2013) *Habitat suitability and susceptibility modelling for strategic control of invasive buffel grass, South Australia*. Report prepared for Biosecurity SA.
- Melzer, R.I. (2016) When is stock grazing an appropriate 'tool' for reducing *Cenchrus ciliaris* (buffel grass) on conservation reserves? *Proc. Royal Soc. Queensland* 120: 53-68.
- Miller, G, Friedel, M, Adam, P and Chewings, V. (2010) Ecological impacts of buffel grass (*Cenchrus ciliaris* L.) invasion in central Australia: does field evidence support a fire-invasion feedback? *The Rangeland Journal* 32: 353–365.
- Natural Resources Alinytjara Wilurara (2018) *Alinytjara Wilurara Buffel Grass Operational Strategy*. Department for Environment and Water: Adelaide.
- Natural Resources SA Arid Lands (2017) Nutritional value of common pastoral grasses to livestock. https://www.naturalresources.sa.gov.au/files/sharedassets/sa_arid_lands/plants_and_animals/20180117_nutritional_grasses_fs.pdf Accessed 18/2/19
- Paltridge, R., Latz, P., Pickburn, A., Ward, M., Ward, J. and Davey, M. (2011) Working with Anangu to conserve rare plants in the Anangu Pitjantjatjara Yankunytjatjara Lands of South Australia. *Australasian Plant Conservation* 19: 10-11.
- Paull, C.J. and Lee G.R. (1978) Buffel grass in Queensland. *Queensland Agricultural Journal* 104: 57-75.
- Perrott, R. (2000) Diseases of buffel grass. In: *Proceedings of buffel grass workshop, Theodore, Queensland, 21–23 February 2000* (ed. B. Cook). Dept. Primary Industries: Brisbane. pp 19-20.
- PIRSA (2015) *Buffel Grass Best Practice Workshop Report*. pir.sa.gov.au/buffel-grass
- PIRSA (2016) *SA Buffel Grass Project Report 2013-2016*. Funded by the Native Vegetation Council and the South Australian Arid Lands NRM Board. pir.sa.gov.au/buffel-grass
- Pitt, J. (2004) Current distribution and strategic management options for buffel grass (*Cenchrus ciliaris* L.) in South Australia. *Plant Protection Quarterly* 19(2): 73-74.
- Puckey, H., and Albrecht, D. (2004) Buffel grass (*Cenchrus ciliaris* L.) presenting the arid Northern Territory experience to our South Australian neighbours. *Plant Protection Quarterly* 19: 69-72.
- Schlesinger, C., White, S. and Muldoon, S. (2013) Spatial pattern and severity of fire in areas with and without buffel grass (*Cenchrus ciliaris*) and effects on native vegetation in central Australia. *Austral Ecology* 38: 831-840.
- Shepherd, B. (2011) *Draft State Buffel Grass Operational Plan May 2011*: proposed plan prepared by Rural Solutions SA for Biosecurity SA.
- Shepherd, B., and Marshall, V. (2010) *May 2010 Roadside Buffel Grass Survey*. Report to Biosecurity SA, Department of Primary Industries and Regions SA.
- Silcock, R. and Smith, F.(1990) Viable seed retention under field conditions by Western Queensland pasture species. *Tropical Grasslands* 24: 65–74.
- Smith, N.M. (2002) *Weeds of the wet/dry tropics of Australia – A field guide*. Environment Centre NT Inc.
- Thomas M (2004) Perennial grasses – potential grazing issues. *Farmnote 29/2004*. Department of Agriculture, Perth, Western Australia.
- Tinoco-Ojanguren, C., Reyes-Ortega, I., Sánchez-Coronado, M., Molina-Freaner, F. and Orozco-Segovia, A. (2016) Germination of an invasive *Cenchrus ciliaris* L. (buffel grass) population of the Sonoran Desert under various environmental conditions. *South African J. Bot.* 104: 112-117.
- Tschirner, A. (2016) The effects of temperature extremes and two herbicides on the germination of buffel grass (*Cenchrus ciliaris* L.) and implications for its management. Bachelor of Sustainable Environments (Honours) thesis, University of South Australia.
- Virtue, J. (2008) *SA Weed Risk Management Guide*. Department of Water Land & Biodiversity Conservation: Adelaide.
- Waycott, M. (2006) Genetic analysis of *Cenchrus ciliaris* in arid Australia with an emphasis on inferences for survivorship and dispersal in Watarrka National Park. Report to Desert Knowledge CRC.
- Wilson, P.D., Downey, P.O., Gallagher, R.V., O'Donnell, J., Leishman, M.R. and Hughes, L. (2011) Modelling climate suitability for exotic plants in Australia under future climate. Final Report on the potential impact of climate change on the distribution of national priority weeds in Australia. Macquarie University and New South Wales Office of Environment and Heritage: Sydney.
- Winkworth, R.E. (1971) Longevity of buffel grass seed sown in an arid Australian Range. *Journal of Range Management*, 24: 141-145.
- Whyte, R. O., Moir, T. R. G., and Cooper, J. P. (1959) *Grasses in Agriculture*. FAO Agricultural Study No. 42. FAO: Rome.

Appendix 1

Knowledge gaps and directions for future investigation and research on buffel grass in South Australia (refer Action 4.4)

Key areas	Activity
Farming	<ul style="list-style-type: none"> identify low-risk alternatives to buffel grass in rangelands and pasture, including native species.
Impacts	<ul style="list-style-type: none"> evaluate long-term outcomes on productivity and pasture sustainability identify adverse long term impacts on biodiversity (e.g. competition with native plants, effect on fauna, and effect of changed fire regimes), pastoral production (e.g. change in fire risk, loss of native forage species) and infrastructure (e.g. change in fire risk).
Management / control	<ul style="list-style-type: none"> investigate potential for fire as a component of integrated weed management for small and large infestations apply new knowledge of functional differences between varieties, germination requirements and seed longevity to improved management investigate cost-effective options for control of buffel grass on organic certified properties. continue to review, monitor and communicate the effectiveness of herbicides such as granular flupropanate and pine oil promoting and monitoring ecosystem recovery following buffel grass management.
Current distribution	<ul style="list-style-type: none"> continue to coordinate the development of a GIS layer of buffel grass distribution (including estimates of abundance /densities) and integrate data from different systems to enable uniform statewide monitoring and reporting improve understanding of the distribution and habitat requirements of <i>C. pennisetiformis</i> where available, utilise the satellite data, aerial surveys and ground validation to monitor and search for buffel grass infestations in large and inaccessible areas. Investigate / refine / apply survey methods able to detect low densities of buffel (hence early stages of invasion) acknowledging changes in technology.
Potential distribution	<ul style="list-style-type: none"> predictive spatial and/or habitat modelling at a range of spatial scales (state, regional, local), refined to identify environments prone to buffel grass infestation identify physical aspects such as climate and soil; biotic factors such as competition from other grasses, tree cover, effects of herbivores – to determine limitations on potential distribution, preferred habitats and mechanisms of invasion identify areas of high biodiversity value (e.g. areas of high diversity, threatened species, endemism, or ecological integrity) at greatest risk of invasion based on environmental preferences of buffel grass.
Ecology	<ul style="list-style-type: none"> identify habitat preferences, e.g. soil, invaded vegetation, disturbance regime, and consider possible differences between buffel grass varieties determine potential for establishment in different environments by natural or unassisted forms of dispersal fire ecology: effect of buffel grass infestations on the fire-proneness of different plant communities - e.g. changes to fuel loads, burn severity and potential for buffel grass-initiated positive fire-invasion feedback determine seed bank longevity - predict how long seeds will persist in different soils – consider potential varietal differences monitor ecosystem recovery after buffel grass control to identify strong native potential competitors, underlying drivers and thresholds that facilitate restoration impacts of native detritivores and potential biocontrol agents.
Taxonomy	<ul style="list-style-type: none"> genetic analysis of buffel grass varieties in SA to determine whether there is any association of genotypes with particular landscapes, determine dispersal pathways and enable rapid identification where non-reproductive material or seedlings is collected evidence of hybridisation and adaptation in South Australia.

Appendix 2

Isolated roadside and township infestations of buffel grass recommended for priority control based on a survey of outback roads undertaken 2010 - 2015 (Shepherd, 2011 Bowman, 2014 and Harvey, 2015).

Priority roadside occurrence (based on isolation)	Description of occurrences/ notes	Potential buffel grass free zone being protected
Roadside at Kokatha and Lake Everard Stations (Gawler Ranges)	<ul style="list-style-type: none"> small populations and one single occurrence mainly confined to the roadside disturbance zone with three locations where the plants extend into the natural zone. 	<ul style="list-style-type: none"> prevent roadside spread into the Gawler Ranges (primarily by graders) from the Glendambo to Tarcoola Road populations maintain the Gawler Ranges buffel grass free.
Roadside at Corunna Station (Gawler Ranges)	<ul style="list-style-type: none"> a small population confined to the disturbance zone small sparse populations of buffel grass are likely to be present on the Pt Augusta to Iron Knob road . 	<ul style="list-style-type: none"> prevent spread into the Gawler Ranges from Lincoln Highway infestations maintain the Gawler Ranges buffel grass free.
Roadside at Mt Eba and Mt Vivian Stations (north of Glendambo)	<ul style="list-style-type: none"> numerous small populations mainly confined to the roadside disturbance zone with a number of small infestations where the plants extend into the natural zone. 	<ul style="list-style-type: none"> prevent roadside spread from the Stuart Highway populations maintain all roads running east from the Stuart Highway buffel grass free.
Roadside on the William Creek to Coober Pedy Road, 63km from Coober Pedy.	<ul style="list-style-type: none"> a small clump of plants confined to the roadside disturbance zone. 	<ul style="list-style-type: none"> maintain all roads running east from the Stuart Highway buffel grass free.
All occurrences on the Oodnadatta Track from William Creek to Marree	<ul style="list-style-type: none"> six known small occurrences. 	<ul style="list-style-type: none"> prevent roadside spread along the Oodnadatta Track maintain the Oodnadatta track, between Marree and William Creek buffel grass free.
All occurrences on the Bore field Road	<ul style="list-style-type: none"> small infestations along the road and pipeline. 	<ul style="list-style-type: none"> contain spread in Zone 2
Roadside on the Strezelecki track, 17km east of Lyndhurst.	<ul style="list-style-type: none"> a small population confined to a large culvert closest other existing records are 20km east along the Strezelecki track in a drainage line. 	<ul style="list-style-type: none"> prevent roadside spread along the Strezelecki Track from Frome (and nearby) creek populations.
Arkaroola visitor centre.	<ul style="list-style-type: none"> several other existing records close by. 	<ul style="list-style-type: none"> prevent spread by vehicles from high visitation areas. promote awareness and control by the Arkaroola managers

Priority roadside occurrence (based on isolation)	Description of occurrences/ notes	Potential buffel grass free zone being protected
Roadside on the Quorn and Parachilna Road - excluding the area around the Brachina Creek and Brachina Gorge turn off.	<ul style="list-style-type: none"> • Four small populations confined to the disturbance zone. One population/clump 4.5 km north of Quorn the other 3 populations/clumps 2.5, 22 and 30km north of Hawker • larger populations of buffel grass were also mapped at the Brachina Gorge turn off, in the Brachina Creek and in Commodore Swamp These populations are listed under the heading <i>Locations where buffel grass was widespread in the natural zone.</i> 	<ul style="list-style-type: none"> • prevent spread into the Flinders Ranges.
Quorn to Wilmington Road	<ul style="list-style-type: none"> • two medium size infestations still contained within the road corridor. 	<ul style="list-style-type: none"> • control known infestations in Zone 3.
Glendambo, Tarcoola, Barton, Ooldea	<ul style="list-style-type: none"> • small clumps are present around Glendambo, Barton and Ooldea with significant infestations around the Tarcoola township and along the rail corridor from Kingoonya to West of Tarcoola 	<ul style="list-style-type: none"> • prevent further spread from high visitation areas into AW NRM, Yellabinna Regional Reserve, Gawler Ranges.
All occurrences along the Aboriginal business road from Oak Valley to the WA Border	<ul style="list-style-type: none"> • small clumps limited to the road corridor with two occurrences that extend into the naturalized zone. 	<ul style="list-style-type: none"> • prevent spread into the Great Victoria Desert.
Tallaringa Conservation Park	<ul style="list-style-type: none"> • one small roadside clump in the Eastern end of Tallaringa Conservation Park. 	<ul style="list-style-type: none"> • prevent spread into the Great Victoria Desert.
Lochiel rest area	<ul style="list-style-type: none"> • small medium density infestation on the roadside, extending into the naturalised zone adjacent to the Lochiel rest area. 	<ul style="list-style-type: none"> • control known infestations in Zone 3 and prevent spread.
Port Wakefield Road and Northern Expressway	<ul style="list-style-type: none"> • small isolated clumps along the Port Wakefield rd. and Northern Expressway 	<ul style="list-style-type: none"> • control known infestations in Zone 3.
Port Adelaide Container Terminal	<ul style="list-style-type: none"> • high priority infestation for control given the movement of containers around the state. 	<ul style="list-style-type: none"> • prevent the movement of contaminated good within the state.

Appendix 3

Summary of management options for buffel grass

Management Option	Description	Advantages	Disadvantages
Prevention - actively prevent deliberate introductions	Limit introduction and spread of buffel seed by preventing introduction of contaminated vehicles, produce, animals, soil, machinery, etc. Prohibit propagation under NRM Act	<ul style="list-style-type: none"> • cost effective • no need to use herbicides • likely to be successful for smaller strategic sites where maintenance is achievable. 	<ul style="list-style-type: none"> • difficult to justify and implement when such practices are not generally employed for other pest plants • requires vehicle washdown facilities – may be expensive to install and maintain • voluntary use of washdown facilities by community likely to be low • compliance activities are expensive.
Mechanical	Grubbing or digging out	<ul style="list-style-type: none"> • effective for small isolated patches • Mowing can stimulate regrowth that is more effectively killed by spraying • can be done any time of year (e.g. dry conditions when other methods unsuitable) • can be done by unskilled persons • no chemicals required. 	<ul style="list-style-type: none"> • labour intensive and costly • unsuited as a single method for extensive areas, but combined with another method may improve efficacy (e.g. mow and spray regrowth) • ongoing hand pulling and herbicide treatment of regrowth is required • soil disturbances can stimulate seed germination and enhance seedling establishment (though can also stimulate native spp.) • may need to destroy removed plants to avoid further spread
Fire	Burn and follow up treatment of regrowth with herbicide applications	<ul style="list-style-type: none"> • herbicide spray regrowth gives good results • burning stimulates regrowth • reduces seed bank • burning stimulates and provides uniform regrowth for follow up chemical control. 	<ul style="list-style-type: none"> • fire is not an effective management tool on its own • can stimulate buffel grass growth over native species • herbicide treatment of regrowth is essential • equipment and clean water needed for herbicide application • risk of fire escape.
Herbicide – foliar spray (refer Table 5)	Foliar spray when actively growing	<ul style="list-style-type: none"> • minimal soil disturbance. • can be very effective with follow up control. • can be cost effective on large and dense infestations • may be an effective follow up at sites cleared by mechanical removal. 	<ul style="list-style-type: none"> • buffel grass must be actively growing for effective uptake of foliar spray • brief opportunity for chemical application – timing is critical • Two or three sprays may be required to control large plants • residual herbicides may impact non-target and/or competitive species • efficacy is dependent on good quality water – may not be readily available in remote outback areas.
Herbicide-Residual (refer Table 5)	Application of residual herbicide prior to or during active growth.	<ul style="list-style-type: none"> • can be applied prior to active growth • significantly reduces the amount of follow-up control due to seedling suppression • some residual products (granular) don't require water for application. 	<ul style="list-style-type: none"> • requires sufficient rain to wash herbicide into the root zone • slow acting/possible seed production in the short term • heavy rainfall events can wash the herbicide out of the root zone • granular product application rates still being refined through targeted trials.

Management Option	Description	Advantages	Disadvantages
Herbicide – Residual and folia (refer Table 5)	Mixture of foliar and soil active residual herbicide (Glyphosate/ Flupropanate)	<ul style="list-style-type: none"> prevents seed production in the short term, control of mature tussocks and suppression of new germinations for approximately 18 months can be mixed with BioWeed to reduce seed bank. 	<ul style="list-style-type: none"> non-selective.
Herbicide – Pine oil (refer Tabel 5)	Contact herbicide said to destroy seed on contact (aerial and soil surface)	<ul style="list-style-type: none"> organically certified reduces the seed bank can be mixed with foliar and soil active residual herbicides above. 	<ul style="list-style-type: none"> not proven to kill mature tussocks (more trials needed) non-selective off label : not registered for use in native vegetation or rangeland.
Biological	There are no known biological controls of buffel grass	<ul style="list-style-type: none"> potential for ongoing reduction of the impact and spread of buffel grass highly target-specific and low cost once established potential to manage landscape-scale infestations. 	<ul style="list-style-type: none"> unlikely to gain support from pastoral industry at national level limited international track record on successful biocontrol of grass weeds high cost of long-term research until an agent is approved for release (typically 10 years).
Ecological	Maintain ground cover and competition from existing veg.	<ul style="list-style-type: none"> encouragement of good land management practices has triple-bottom line benefits. 	<ul style="list-style-type: none"> perceived conflict with grazing as a land use, particularly in arid areas. insufficient alone to prevent invasion
Pulse grazing	Graze to prevent formation of seed heads	<ul style="list-style-type: none"> potential in integrated control strategies (Melzer 2016) can reduce the soil seed bank, biomass and fire frequency/intensity reduce competition with native flora. 	<ul style="list-style-type: none"> difficult to implement selective grazing, in many situations disturbance by cattle can create favourable conditions for buffel grass establishment.

Appendix 4

Table 1. South Australian fauna of national &/or state conservation significance currently or potentially threatened by buffel grass, sorted in order of conservation status.

APY = Anangu Pitjantjatjara Yankunytjatjara Lands; AUS = Australia; CR = critically endangered; EN = endangered; NSW = New South Wales; NT = Northern Territory; RA = rare; SA = South Australia; ssp = subspecies; TSSR = Threatened Species Schedule Review panel; VU = vulnerable; WA = Western Australia; * = Recommended change in state conservation status by TSSR in 2015-17.

Scientific Name	Common Name	Conservation Status	Reason for status	Why buffel grass is a threat	Reference / Information
<i>Liopholis kintorei</i>	great desert skink / tjakura	VU (AUS) EN (SA) CR (TSSR*)	Seven isolated locations spread across WA, NT and SA; approximately 6000 individuals. In SA, estimated < 250 and declining, in very small (< 50) populations.	Ongoing spread of buffel grass, and the subsequent likelihood of more frequent wildfires, will change the habitat structure, particularly the open feeding grounds known to be important for tjakura.	National Recovery Plan http://www.environment.gov.au/biodiversity/threatened/publications/recovery/great-desert-skink/index.html ; TSSR (2015); E. Ryan-Colton, pers. comm. (2017)
<i>Petrogale lateralis</i> ssp. <i>lateralis</i> (McDonnell Ranges race)	black-footed rock wallaby / warru	VU (AUS) EN (SA)	Known mostly from sthn NT (Central Ranges), central eastern WA and APY. Estimated 250 individuals in SA.	Buffel grass promotes hot wildfires which can destroy fire sensitive vegetation, such as figs (<i>Ficus brachypoda</i>) and spearwood (<i>Pandorea doratoxylon</i>) that are important food sources for warru. Buffel grass already surrounds two warru populations and its uncontrolled spread would threaten other sites.	Warru Recovery Plan (Read and Ward 2011); TSSR (2015); E. Ryan-Colton, pers. comm. (2017)
<i>Leipoa ocellata</i>	malleefowl / nganamara	VU (AUS) VU (SA)	Known from NSW, Victoria, SA and WA. An observed > 30% decline in SA in the last 3 generations.	Continued invasion of buffel grass into arid mulga / minyura woodlands and shrub lands and mallee woodlands will increase the fire frequency, removing key food plants and habitat in which they build their mounds.	TSSR (2015); S. Gillam, National Malleefowl Recovery Team, pers. comm. (2017)
<i>Eremiornis carteri</i>	spinifex bird	EN (SA)	Estimated < 250 individuals in SA.	Quality spinifex important; habitat decline due to buffel grass spread.	TSSR (2015)
<i>Geophaps plumifera</i>	spinifex pigeon / plumed pigeon	RA (SA)	Estimated < 3000 mature individuals in SA.	Lives in spinifex, which is being replaced by buffel grass on hills and in rocky gorges and creek lines, causing a change in habitat structure and food availability.	TSSR (2015); E. Ryan-Colton, pers. comm. (2017)

Scientific Name	Common Name	Conservation Status	Reason for status	Why buffel grass is a threat	Reference / Information
<i>Pezoporus occidentalis</i>	night parrot	EN (SA)	Likely to occur in SA.	Occurs in spinifex; habitat quality in decline due to buffel grass spread.	Murphy <i>et al.</i> (2018)
<i>Chlamydera guttata</i>	western bowerbird	RA (SA)	< 3000 mature individuals in SA; restricted area of occupancy.	Habitat quality is in decline due to the spread of buffel grass.	TSSR (2015)
<i>Ctenotus grandis</i>	giant desert ctenotus	RA (SA)	Restricted distribution and area of occupancy in SA.	Occurs in spinifex; habitat quality in decline due to buffel grass spread.	TSSR (2015)
<i>Ctenotus piankai</i>	paleface ctenotus	RA (SA)	Restricted distribution in SA.	Spinifex obligate; habitat quality in decline due to buffel grass spread.	TSSR (2015)
<i>Varanus brevicauda</i>	short-tailed pygmy goanna	RA (SA)	Restricted distribution in SA.	Occurs in spinifex; habitat quality in decline due to buffel grass spread.	TSSR (2015)
<i>Carlia triacantha</i>	desert rainbow skink	EN (TSSR*)	Restricted and declining distribution in SA, < 5 locations, declining habitat quality.	Prefers large spinifex clumps; threatened by buffel grass spread.	TSSR (2015)
<i>Crenadactylus ocellatus</i>	clawless gecko	EN (TSSR*)	Restricted and declining distribution in SA, < 5 locations, declining habitat quality.	Prefers spinifex; habitat quality in decline due to buffel grass spread.	TSSR (2015)
<i>Amytornis purnelli</i>	dusky grasswren	VU (TSSR*)	< 10 locations in SA; continuing decline in habitat quality.	Breeds in spinifex, which is being replaced by buffel grass on hills and on the sand plains.	TSSR (2015)
<i>Ctenotus ariadnae</i>	pin-striped ctenotus	RA (TSSR*)	Restricted distribution in SA.	Occurs in spinifex; habitat quality in decline due to buffel grass spread.	TSSR (2015)
<i>Ctenotus dux</i>	narrow-lined ctenotus	RA (TSSR*)	Restricted distribution in SA.	Occurs in spinifex; habitat quality in decline due to buffel grass spread.	TSSR (2015)
<i>Delma nasuta</i>	Centralian snake-lizard	RA (TSSR*)	Restricted area of occupancy in SA.	Spinifex obligate; habitat quality in decline due to buffel grass spread.	TSSR (2015)
<i>Diporiphora paraconvergans</i>	western grey-striped dragon	RA (TSSR*)	Restricted distribution in SA.	Occurs in spinifex; habitat quality in decline due to buffel grass spread.	TSSR (2015)

Table 2. South Australian flora of national &/or state conservation significance currently or potentially threatened by buffel grass. Sorted by conservation status.

APY = Anangu Pitjantjatjara Yankunytjatjara Lands; AUS = Australia; AW = Natural Resources Alinytjara Wilurara Region; CR = critically endangered; DEW = Department of Environment and Water; EN = endangered; EP = Natural Resources Eyre Peninsula Region; EPBC = Environmental Protection and Biodiversity Conservation Act; N&Y = Natural Resources Northern and Yorke Region; NT = Northern Territory; Qld = Queensland; RA = rare; SA = South Australia; SAAL = Natural Resources South Australian Arid Lands Region; ssp = subspecies; TSSR = Threatened Species Schedule Review panel; var = variety; VU = vulnerable; WA = Western Australia; * = Recommended change in state conservation status by TSSR in 2015-17.

Scientific Name	Common Name	Conservation Status	Reason for status	Why buffel grass is a threat	Reference / Information
<i>Acanthocladium dockeri</i>	spiny daisy	CR (AUS) EN (SA) CR (TSSR*)	Only 6 remnant populations, all clonal.	Not currently a threat; however all remnant populations are found on roadsides in N&Y Region. If buffel grass invaded any of these sites it would outcompete spiny daisy and become a serious threat.	D. Bickerton, Spiny Daisy Recovery Team, pers. comm. (2017)
<i>Haloragis eyreana</i>	prickly raspwort	EN (AUS) EN (SA)	< 600 km ² extent of occurrence and declining. < 120 km ² area of occupancy and declining. ≤ 5 locations, decline in habitat quality.	Not currently a threat; however all remnant populations are found on roadsides in EP Region.	D. Bickerton, DEW, pers. comm. (2017)
<i>Prostanthera nudula</i>	naked mintbush	VU (AUS) VU (SA)	Sw NT & APY. In SA, a small number of populations the APY Lands. Area of occupancy < 100 km ² .	Sensitive to fire, threatened by the increased intensity and frequency of fires fuelled by buffel grass on hills.	EPBC Conservation Advice: http://www.environment.gov.au/biodiversity/threatened/species/pubs/7091-conservation-advice.pdf
<i>Acacia latzii</i>	Latz's wattle	VU (AUS) RA (SA) VU (TSSR*)	Restricted to two disjunct areas 200 km apart: sthn NT & nthn SA (2 locations near NT border in SAAL). Localised in SA, < 1000 plants.	A slow growing species, sensitive to fire. Requires low fire frequencies, and therefore threatened by increased intensity and frequency from buffel grass fires.	<i>National recovery plan</i> : http://www.environment.gov.au/resource/national-recovery-plan-threatened-acacias-and-ricinocarpos-gloria-medii-central-australia ; TSSR (2015)
<i>Teucrium grandiusculum</i> ssp. <i>grandiusculum</i>		VU (SA)	Endemic to central ranges, highly localised.	Found on rocky slopes that are not currently invaded by buffel grass, but potentially could be in the near future.	TSSR (2016); E. Ryan-Colton, pers. comm. (2017)
<i>Stylidium inaequipetalum</i>		VU (SA) RA (TSSR*)	Restricted distribution and area of occupancy in SA.	Found on flood-outs and creek lines in rocky hills, which will potentially be invaded by buffel grass in the future	TSSR (2016); E. Ryan-Colton, pers. comm. (2017)

Scientific Name	Common Name	Conservation Status	Reason for status	Why buffel grass is a threat	Reference / Information
<i>Acacia symonii</i>	Symon's wattle	RA (SA) VU (TSSR*)	Difficult to find, small relictual populations, < 1000 plants, limited extent of occurrence.	Botanical experts consider buffel grass and fire a threat. Buffel grass is invading the creek lines and alluvial flats at the base of hills where this species occurs. This invasion could fuel more frequent and intense wildfires that escape into the hill country, threatening <i>A. symonii</i> .	TSSR (2015). E. Ryan-Colton, <i>pers. comm.</i> (2018)
<i>Acacia tenuior</i>	Central Ranges wattle	RA (SA) VU (TSSR*)	Restricted to high peaks in AW Region. < 1000 plants and 3 locations in SA.	Buffel grass promotes inappropriate fire regimes. The ongoing invasion of buffel grass will outcompete this species and increase fire frequency and intensity, posing a threat to small and isolated endemic plant populations.	Paltridge <i>et al</i> (2009); TSSR (2015)
<i>Basedowia tenerrima</i>		RA (SA) VU (TSSR*)	Records from Biological surveys in 1998 indicate very restricted distribution. ≤ 5 known locations in SA.	Buffel grass and fire considered to be a threat.	TSSR (2015)
<i>Acacia ammobia</i>	Mount Connor wattle	RA (SA)	Relatively abundant in sw NT, but mostly restricted to the Mt Connor / Uluru area of the Central Ranges Region. Only 1 known location in SA, in APY.	Highly sensitive to fire - killed by the mildest of fires and populations would require a fire frequency of more than 25 years. Buffel grass promotes very hot fires and invasion of buffel grass poses a threat long-term.	Paltridge <i>et al</i> (2009); TSSR (2015)
<i>Dampiera roycei</i>		RA (SA)	Restricted distribution in SA.	Found in spinifex country in nw of APY Lands, where buffel grass is expanding through sand plain habitat, and could outcompete this species or promote inappropriate fire regimes.	TSSR (2016); E. Ryan-Colton, <i>pers. comm.</i> (2017)
<i>Goodenia brunnea</i>	Central Ranges goodenia	RA (SA)	Endemic to Central Ranges, mostly APY, but also sw NT. Restricted distribution and area of occupancy in SA.	A primary successional plant following fire. If buffel grass becomes the dominant successional species, <i>Goodenia brunnea</i> will be out-competed.	Paltridge <i>et al</i> (2009); TSSR (2016)

Scientific Name	Common Name	Conservation Status	Reason for status	Why buffel grass is a threat	Reference / Information
<i>Hibbertia glaberrima</i>	Central Australian guinea-flower	RA (SA)	APY Lands. Restricted distribution and area of occupancy in SA.	Occurs in a similar habitat to <i>Prostanthera nudula</i> in crevices on granitic outcrops and ranges. Buffel grass is expanding up these hills, and could promote inappropriate fire regimes for fire sensitive species or outcompete this species for space.	TSSR (2016); E. Ryan-Colton, <i>pers. comm.</i> (2017)
<i>Melaleuca fulgens</i> ssp. <i>corrugata</i>	wrinkled honey myrtle	RA (SA)	Endemic to the Central Ranges; found in sw NT, central east WA and SA (APY Lands). All APY populations surveyed contain very few individuals and are under threat from inappropriate fire regimes. Area of occupancy in SA < 5 km ² with < 2500 mature individuals.	The ongoing invasion of buffel grass will outcompete this species and increase fire frequency and intensity, posing a threat to small and isolated populations. Currently the species is at high altitude amongst bare rock or fire shadow habitats, but large wildfires promoted by buffel grass at lower elevations may expand into this species habitat range.	Paltridge <i>et al</i> (2009); E. Ryan-Colton, <i>pers. comm.</i> (2017)
<i>Samolus eremaeus</i>	desert samolus	RA (SA)	Limited creek line habitat. Restricted distribution in SA.	Occurs in creek lines, which are subject to severe invasion by buffel grass on the APY Lands. Buffel grass could outcompete this species directly or promote inappropriate fire regimes	TSSR (2016); E. Ryan-Colton, <i>pers. comm.</i> (2017)
<i>Acacia aneura</i> var. <i>macrocarpa</i>	weeping mulga	VU (TSSR*)	Scattered, ≤ 5 known locations in SA.	Buffel grass and fire are threats. Long-lived but killed by frequent fires.	TSSR (2015)
<i>Nicotiana rosulata</i> ssp. <i>ingulba</i>		VU (TSSR*)	NT, SA & WA. Only 2 known records in SA. Restricted.	Buffel is a threat on the wash-out plains (its preferred habitat).	TSSR (2016)
<i>Acacia validinervia</i>	veined wattle	RA (TSSR*)	NT, SA (APY) & WA. Restricted distribution and area of occupancy in SA	Buffel grass is now growing in close proximity to this species, and could fuel more intense fires that threaten isolated populations.	TSSR (2015); D. Bickerton, DEW, <i>pers. comm.</i> (2018)
<i>Apowollastonia stirlingii</i> ssp. <i>stirlingii</i>	sunflower daisy-bush	RA (TSSR*)	NT & SA (APY). Restricted distribution and area of occupancy in SA.	Buffel grass and fire considered to be a threat.	TSSR (2015)

Scientific Name	Common Name	Conservation Status	Reason for status	Why buffel grass is a threat	Reference / Information
<i>Calostemma abdicatum</i>	Everard garland lily / apita	RA (TSSR*)	Currently only one general locality in Australia, near Mimili in APY Lands; restricted distribution and area of occupancy.	This species occurs along creek lines and in runoff/seepage areas in rocky hills where conditions are moist. Buffel grass is invading this habitat and may outcompete this species for space.	Paltridge <i>et al</i> (2009); E. Ryan-Colton, <i>pers. comm.</i> (2017)
<i>Comesperma viscidulum</i>	varnished milkwort	RA (TSSR*)	Near endemic to SA, where it is only known from the APY Lands and Yellabinna Reserve. Scattered, not commonly abundant. Restricted distribution and area of occupancy in SA.	Found in sandplain and spinifex habitat, which could become invaded by buffel grass in the future. A large infestation of buffel grass on APY (at Watarru) is uncontrolled and may spread to the locations of this species.	TSSR (2016); E. Ryan-Colton, <i>pers. comm.</i> (2017)
<i>Dicrastylis exsuccosa</i>	sand-sage	RA (TSSR*)	Near endemic, SA (APY) & WA. Disjunct populations. Restricted distribution in SA	Buffel grass and fire considered to be a threat.	TSSR (2016)
<i>Grevillea eriostachya</i>	orange grevillea	RA (TSSR*)	Sw NT, WA & SA (APY). Not found in large populations. Restricted distribution and area of occupancy in SA. Under-collected.	Buffel grass and fire considered to be a threat.	TSSR (2016)
<i>Halgania glabra</i>		RA (TSSR*)	Only one known site in SA (APY Lands), mostly in sw NT & WA.	Responds after fire; buffel grass could promote overly frequent fire regimes.	TSSR (2016); E. Ryan-Colton, <i>pers. comm.</i> (2017)
<i>Monotaxis luteiflora</i>		RA (TSSR*)	WA and nw SA (Everard Ranges, APY Lands). Only 2 SA records. Restricted distribution and area of occupancy in SA.	Responds after fire; buffel grass could promote overly frequent fire regimes.	TSSR (2016)
<i>Orianthera centralis</i>		RA (TSSR*)	Known from sw NT, WA & SA (APY), where it is restricted to the sandy plain of Mt Lindsey. Disjunct population. Could be under-collected.	A large infestation of buffel grass at Watarru is currently uncontrolled and may spread to the locations of this species.	TSSR (2016); E. Ryan-Colton, <i>pers. comm.</i> (2017)
<i>Psyrdrax ammophila</i>		RA (TSSR*)	Central Australia, naturally uncommon, sparsely distributed. Sandy loam plains, may be under-collected. Limited number of locations in SA.	Buffel grass is spreading to sand plain habitat, and could create inappropriate fire regimes for this species	TSSR (2016); E. Ryan-Colton, <i>pers. comm.</i> (2017)

Scientific Name	Common Name	Conservation Status	Reason for status	Why buffel grass is a threat	Reference / Information
<i>Stemodia viscosa</i>	clammy stemodia	RA (TSSR*)	WA, NT, Qld & NW SA (mostly APY Lands). Rocky sheltered gorge habitat within the ranges. Low numbers. Restricted distribution in SA.	Not currently threatened by buffel grass, although buffel could potentially invade the sheltered gorges it inhabits.	TSSR (2016); D. Bickerton & E. Ryan-Colton <i>pers. comm.</i> (2018)
<i>Teucrium reidii</i>	showy germander	RA (TSSR*)	Small population sizes and limited distribution. SA endemic: APY Lands & Nth Flinders Ranges (Arkaroola). Total known population size estimated < 5000.	Buffel grass is encroaching significantly on the two largest known populations. The species is fire sensitive. Inappropriate fire regimes and competition from buffel grass will significantly affect this species' status.	National Recovery Plan for <i>Olearia macdonnellensis</i> , <i>Minuria tridens</i> (Minnie daisy) and <i>Actinotus schwarzii</i> (desert flannel-flower)
<i>Tietkensia corrickiae</i>		RA (TSSR*)	WA, sw NT & NW SA (APY Lands). Hilly or sandy habitat. Restricted distribution and area of occupancy in SA.	Occurs in the far NW corner of APY Lands. In this area buffel grass is encroaching the flats adjacent to where this species has been recorded. Small annual species probably susceptible to changes in soil structure, hydrology and habitat structure brought about by buffel grass invasion.	E. Ryan-Colton, <i>pers comm.</i> (2018); South Australian Seed Conservation Centre Herbarium Sheet.

References

Murphy, S.A., Paltridge, R., Silcock, J., Murphy, R., Kutt, A.S. and Read, J. (2018) Understanding and managing the threats to Night Parrots in southwestern Queensland. *Emu - Austral Ornithology* 118: 135-145.

Paltridge, R., Latz, P., Pickburn, A., and Eldridge, S. (2009). Management Plan for rare and Threatened Flora in the *Anangu Pitjantjatjara Yankunytjatjara Lands of South Australia*. Department for Environment and Heritage: Adelaide.

Read, J.L. and Ward, M.J. (2011) Warru Recovery Plan – Recovery of *Petrogale lateralis* MacDonnell Ranges Race in South Australia. Warru Recovery Team, South Australia. Department for Environment, Water and Natural Resources: Adelaide.

TSSR Threatened Species Schedule Review (2015) Unpublished DEW assessments.

TSSR Threatened Species Schedule Review (2016) Unpublished DEW assessments.

Photo credits

Cover: Dense buffel grass infested hills and plains near Umuwa, APY Lands. Photo: Troy Bowman, PIRSA
Cenchrus ciliaris, buffel grass. Photo: Troy Bowman, PIRSA
Aerial herbicide trial, Mambray Creek.
Photo: Grant Roberts, DEW
Rocky hill with pristine *Triodia* grassland.
Photo: Troy Bowman, PIRSA
Rocky hill heavily invaded by buffel grass.
Photo: John Read
Shrubs killed by buffel grass fire, surrounded by a sea of buffel regrowth, APY Lands. Photo: Troy Bowman, PIRSA
Buffel grass invasion in native shrubland.
Photo: Troy Bowman, PIRSA
Buffel grass invading spinifex grassland.
Photo: Troy Bowman, PIRSA
Controlled burn of buffel grass, Umuwa, APY Lands.
Photo: J. Stelmann, DEW
Buffel grass strategic response team, Coober Pedy.
Photo: Troy Bowman, PIRSA
Herbicide trial site (foreground) in buffel grass monoculture, Umuwa, APY Lands. Photo: Troy Bowman
Effective herbicide trial results, Umuwa, APY Lands.
Photo: Troy Bowman, PIRSA
Buffel grass (*Cenchrus ciliaris*) seed heads.
Photo: Troy Bowman, PIRSA
Roadside outlier control near Port Pirie as part of Strategic Response collaboration among regions.
Photo: T. Bowman
Buffel grass fire, Oak Valley, MT Lands.
Photo: Teresa Gurney, DEW
Last page: Rangers from across Western and South Australia after the first Southern Desert Ranger Forum at Ilkurlka. Photo: Arid Lands Environment Centre
Bon Bon case study:
Buffel grass on Stuart Hwy before treatment.
Photo: Mike Chuk
Same site post treatment.
Photo: Mike Chuk
Regeneration after buffel grass control.
Photo: Mike Chuk
Hand removal of buffel grass by volunteers.
Photo: Julia Harris
Bush food case study: *lili*, one of the most important bushfoods.
Photo: Ellen Ryan-Colton
Thick buffel grass growing under the important bush food wattleseed *Acacia victoriae*.
Photo: Ellen Ryan-Colton
East West rail line case study:
Buffel grass infestations along the railway line.
Photo: Troy Bowman, PIRSA

Great Victoria Desert case study:
Rangers from the APY Lands spraying buffel grass.
Photo: Arid Lands Environment Centre

Warru case study:
Looking after warru on the APY Lands with ranger Jacob MacKenzie.
Photo: Ellen Ryan-Colton

Disclaimer

While reasonable efforts have been made to ensure the contents of this publication are factually correct, the Government of South Australia makes no representations and accepts no responsibility for the accuracy, completeness or fitness for any particular purpose of the contents, and shall not be liable for any loss or damage that may be occasioned directly or indirectly through the use of or reliance on the contents of this publication.

2019 © Government of South Australia



Rangers from across Western and South Australia after the first Southern Desert Ranger Forum at Ilkurka.
Photo: Arid Lands Environment Centre





Standard Work Procedure

Document Number

SWP-EMR-013

Document Title

Bushfire Response Procedure

Revision Status

Date	Revision Details	Proposed By	Approved By	Review Date
10/08/2014	1 st Edition	Amber Doyle and Ben Waechter	Mathew Smith	01/08/2016

Purpose/Scope

This procedure describes the steps taken in the event of a bushfire at the Beverly Mine Leases in the North East Pastoral Fire ban district.

Special Instructions

Contact CFS and report the bush fire in the area and follow any instructions which they provide. Report information to the CFS as required.

Environmental Issues

All measures will be taken to avoid an environmental incident.

PPE Required

Light weight turnout gear, leather steel cap boots or structural fire boots, leather gloves, flash hoods and fire-fighting helmets goggles, BA (Breathing Apparatus) plus plenty of drinking water at all times.

Supporting Documentation

CFS Fire ground practices manual, July 2006.

Warnings/Notifications

In warm to hot weather attention must be paid daily to Fire bans and ratings information for the North East Pastoral district which will be provided in the daily toolbox talk and the notice board in reception.

Procedures

Task Sequence	Procedure	Hazards	Precautions/PPE
1. Information of fire approaching is received	Control room operator advises ERT (Emergency Response Team) via the pager system and UHF radio call.		
2. ERT assemble at the ERT shed and prepare themselves and equipment.	<ol style="list-style-type: none"> ERT members don their protective equipment. Prepare equipment such as Fire Truck including BA (Breathing apparatus). ERT members change their UHF radios over to BEV03 (Channel 53) and notify the control room of this change. The production manager (or their appointed person) becomes the Incident Controller (to be located in the Wimala room at the Beverley Plant Offices) and also need to be on BEV03 (Channel 53). The incident controller will have someone to scribe for them and assist with phone calls. The control room operator stays on BEV01 (Channel 51). 	<ul style="list-style-type: none"> Fatigue due to night call outs. Darkness / low light. Reversing vehicles. Manual handling. 	<ul style="list-style-type: none"> Ensure members are rotated and rested regularly during the callout. Ensure that lighting and portable lighting are available for use. Licensed vehicle operators only and the use of spotters when reversing any vehicle. Correct lifting techniques.
3. Assess the situation of the fire.	<ol style="list-style-type: none"> A light vehicle will be taken out to the scene of the fire to assess the severity and resources needed. ERT members to set up forward command and prepare equipment for fire-fighting depending on the fire location, size and wind direction. All available water trucks are to be filled and mustered at a central point. 	<ul style="list-style-type: none"> Weather (wind direction). Burns. Smoke inhalation. Poor visibility. Heat stress. Moving Vehicles. Slips, trips and falls. Manual handling. Breakdown of communications. Collision with animals. Vehicle damage. 	<ul style="list-style-type: none"> Keep a safe distance from the fire while assessing. Use binoculars to visualise fire rather than driving too close. Use of aircraft for aerial visual if available. Hand held radios to be in use on channel 53. Correct lifting techniques
4. Report the fire to the CFS	After the assessing the fire, the incident controller (or ERT Captain) will report all the details to the CFS such as	Breakdown of communications	<ul style="list-style-type: none"> Use of satellite phone. Use of repeater 6 radio station to

fire size, location, fuel load, wind direction, speed and any other information that they require. Any information that is given by the CFS is to be relayed to the ERT.

surrounding stations to relay the message to the CFS on our behalf.

<p>5. Small, containable bush fire.</p>	<p>After the initial assessment, if the fire deemed to be small enough for the ERT to contain or fight without putting life at risk then the ERT will deploy the CFS truck to fight the fire with the back-up of the fire-fighting trailers and the water truck. The load shifting vehicles such as grader, bobcat, backhoe and front end loader will be used to create fire breaks initially around the camp and plant and used to make fire breaks to contain the oncoming fire.</p>	<p>Weather (wind direction). Burns. Smoke inhalation. Heat stress. Moving Vehicles. Slips, trips and falls. Manual handling. Breakdown of communications. Vehicle damage.</p>	<p>Don light weigh CFS fire-fighting PPE as required including gloves, boots, flash hoods, and helmets. Ensure a PPE check is undertaken on each member involved before entering the area. Safety goggles. BA (Breathing Apparatus) if required. Continued rest breaks and hydration. Watch footing while fighting the fire. Use spotters when moving vehicles. Use correct lifting techniques. Use hand held radios on channel 53. Only licenced drivers to operate vehicles. Satellite phones for back up communications.</p>
<p>6. Large uncontrollable bushfire</p>	<ol style="list-style-type: none"> 1. Fire / Emergency alarm is activated by the control room operator at the request of the production manager. 2. All personnel are to assemble at the Emergency Assembly Point. Fire Wardens ensure that their respective areas are cleared of all personnel. The Production Manager who is now the incident controller (or delegate if he/she is in the Wimala room managing the bush fire) will account for all staff that are on the Emergency Evacuation list. 3. Once all staff have been accounted for, they will be 	<p>Strong gusty winds. Intense radiant heat. Heat stress. Flames. Heavy smoke (making it hard to breathe). Smoke inhalation. Embers causing spot fires. Power, telephones and water being cut off. Moving Vehicles.</p>	<p>Don light weigh CFS fire-fighting PPE as required including gloves, boots, flash hoods, and helmets. Safety goggles. Don BA (Breathing Apparatus) if required. Ensure a PPE check is undertaken on each member involved before entering the area. Continued rest breaks and</p>

required to evacuate to the Beverley Camp using the bus and light vehicles.

4. All field workers will be evacuated from the field and assemble at the Beverley Camp (this message will be relayed by the control room operator after Emergency radio procedures have been used to communicate this information).

5. The CFS fire truck, fire-fighting trailers and all available water trucks will be taken up to the camp.

6. All load shifting equipment will be taken to the camp to create additional fire breaks for life and infrastructure protection.

7. Using camp water supply, wet down the camp and surrounding areas including roofs of buildings, roads.

8. Isolate the gas supply to the camp from the ELGAS Bullet.

The ELGAS Bullet must be guarded by the fire truck or fire-fighting trailers. The Vessel must be kept cool in the event that the fire front passes through the area.

9. All personnel not involved in actively preparing for the fire will be required to stay assembled in the mess hall

Slips, trips and falls.
 Manual handling.
 Breakdown of communications.
 Vehicle damage.
 Asset damage.
 Panicked people.

hydration.
 Watch footing while fighting the fire.
 Use spotters when moving vehicles.
 Use correct lifting techniques.
 Use hand held radios on channel 53.
 Only licenced drivers to operate vehicles.
 Satellite phones for back up communications.
 Prepare mine lease for evacuation.
 Ensure ERT members are rotated and rested regularly during the call out.
 Ensure ERT members are trained to handle situations in which they may see disturbing images.
 Counselling made available to ERT members and all other staff.

7. Clean up.

1. Put out any spot fires.
2. Clean up and re-stock equipment






Weather (wind direction).
 Burns.
 Smoke inhalation.
 Heat stress.
 Moving Vehicles.
 Slips, trips and falls.
 Manual handling.
 Breakdown of communications.
 Vehicle damage

Don light weigh CFS fire-fighting PPE as required including gloves, boots, flash hoods, and helmets.
 Safety goggles.
 Don BA (Breathing Apparatus) if required.
 Ensure a PPE check is undertaken on each member involved before entering the area.
 Continued rest breaks and hydration.
 Watch footing while fighting the fire.

Use spotters when moving vehicles.
 Use correct lifting techniques.
 Use hand held radios on channel 53.
 Only licenced drivers to operate vehicles.
 Satellite phones for back up communications.
 Ensure ERT members are rotated and rested regularly during the call out.
 Ensure ERT members are trained to handle situations in which they may see disturbing images.
 Counselling made available to ERT members and all other staff.

<p>8. Debrief.</p>	<p>ERT members will meet to debrief after the fire to discuss the event and</p>	<p>Stress. Heat stress.</p>	<p>Ensure ERT members are trained to handle situations in which they may see disturbing images. Counselling made available to ERT members and all other staff. Ensure plenty of refreshments are available to ERT members.</p>
--------------------	---	---------------------------------	--

Warning and PPE Symbols

			 SAFETY VEST MUST BE WORN				 HEAD PROTECTION MUST BE WORN IN THIS AREA
	 SUN HAT MUST BE WORN ON SITE						

Comments/Revision



MANAGEMENT PLAN

HEATHGATE RESOURCES

Document Number

MP – 19

Document Title

RADIATION MANAGEMENT PLAN Exploration

Version Status

Date	Revision Details	Proposed By	Approved By
18 Apr 2009	Version 1.0	S. Kutty	P. Woods
28 Nov 2012	Revision 1	S. Kutty	S. Carter
2 Aug 2017	Revision 2	S. Kutty	K. Levingstone

Revision History

Revision	Date	Changes/Comments	Authorisation
1.1	28/11/12	Updated Section 10	
1.2	30/11/12	Changed the document from Quasar to Heathgate. Saved as MP-19A. Original Quasar plan kept as MP-19	
2	2/8/17	Complete review of the document. Changed the Document Number to MP-19	

Document Number	Date Modified	Authorised By	Page Number
MP-19	2 August 2017	S. Kutty	Page 2 of 15

Contents

1	SCOPE.....	4
2	INTRODUCTION	4
3	SOURCES OF RADIATION EXPOSURE AND ITS CONTROL	5
3.1	Exposure from drilling and airlifting	5
3.2	Exposure from on site storage of samples	6
3.3	Exposure from handling and analysis of samples	7
3.4	Monitoring.....	7
3.5	Radiation clearance of items.....	7
3.6	Dose estimation and reporting	8
3.6.1	Dose estimation at Four Mile exploration area.....	8
3.6.2	Dose estimation at other exploration areas.....	9
4	INCIDENT REPORTING.....	9
5	WASTE MANAGEMENT	9
5.1	Liquid waste disposal.....	9
5.2	Solid waste disposal	9
5.2.1	Pit closure report	10
5.2.2	Analytical samples & contaminated objects	10
5.2.3	General waste and non contaminated objects	10
6	DECONTAMINATION OF TOOLS AND EQUIPMENT.....	11
7	SPILL MANAGEMENT	11
8	TRANSPORT OF SAMPLES.....	11
8.1	Transport of radioactive samples	11
8.2	Incidents during transport of RAM.....	12
9	STORAGE OF RADIOACTIVE SAMPLES.....	12
10	PERSONNEL AND RESOURCES.....	13
11	INDUCTION AND TRAINING	14
12	RECORD KEEPING	14
13	REFERENCES	15

Document Number	Date Modified	Authorised By	Page Number
MP-19	2 August 2017	S. Kutty	Page 3 of 15

1 SCOPE

This Radiation Management Plan has been prepared by Heathgate Resources to comply with the requirement of the Department of Premier and Cabinet (DPC) to have a management plan to deal with the radiation hazards to people and environment associated with mineral exploration in areas of known uranium or thorium deposits.

Under the conditions of an Exploration Licence (EL) pursuant to the Mining Act 1971, Heathgate Resources is required to submit a PEPR for authorisation to DPC before the commencement of an exploration programme involving the use of drilling or earthmoving equipment.

The purpose of this management plan is to provide a systematic approach to effectively manage the radiation hazards associated with exploration of uranium and to ensure compliance with current standards and regulatory requirements.

2 INTRODUCTION

This management plan covers the radiation protection and radioactive waste management issues arising from the exploration drilling, sample handling, sample analysis, transport, storage and site rehabilitation in areas of known uranium mineralisation.

The plan describes what radiation safety measures are to be applied to activities in an exploration area and what measures must be applied to activities conducted outside an EL.

Development of this plan is based on the radiation safety requirements stipulated in the following Commonwealth documents:

- Code of Practice on Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing, ARPANSA August 2005
- Code of Practice for the Safe Transport of Radioactive Material, ARPANSA December 2014
- Code of Practice for the Near Surface Disposal of Radioactive Waste in Australia, NHMRC 1992.

Compliance with this management plan will satisfy the requirements of the above codes and also the relevant requirements of the Radiation Protection and Control Act 1982 and the Ionising Radiation Regulations 2015, South Australia. It will also ensure that appropriate procedures and work methods are in place:

- For the minimisation of radiation exposures associated with an exploration programme
- For the management of radioactive samples, and wastes associated with exploration
- For the transport of radioactive samples and its off site storage.

The radioactivity of the drill cuttings, rock hand specimens and core samples handled during exploration activities are expected to be low. Consequently the radiation exposure to workers expected from this activity is very low and by using appropriate control measures the doses received by the personnel involved in drilling, sample handling and

Document Number	Date Modified	Authorised By	Page Number
MP-19	2 August 2017	S. Kutty	Page 4 of 15

transport activities can be kept well below the applicable dose limits and also As Low As Reasonable Achievable (ALARA).

3 SOURCES OF RADIATION EXPOSURE AND ITS CONTROL

The three pathways through which radiation exposure is expected in exploration activities are:

- Inhalation of Long Lived Alpha (LLA) Activity in dust
- Inhalation of Radon Decay Products (RnD)
- External exposure to gamma radiation.

Exposure to LLA dust can occur during drilling, handling and analysis of dry core samples and during core sample cutting. Inhalation of radon decay products is possible from the exposure of personnel to the RnD released during drilling operation and from the core samples that are in long term storage in areas of poor ventilation.

Exposure to gamma radiation is possible from handling of large quantities of drill cuttings and core samples, proximity to storage areas where large quantities of samples are kept and from the transport of large quantities of samples.

3.1 Exposure from drilling and airlifting

The exploration drilling is carried out using rotary mud rigs under dry ground conditions. Drill mud generated during this operation is contained in mud pits that are adjacent to each drill hole. Drill cuttings from the mineralised zone are diluted with cuttings from non mineralised zones and then disposed off in these pits. The pits, when dried out, are refilled with excavated material then re-covered with previously removed top soil.

Water used in the drilling and airlifting activities is also directed to the mud pits for disposal.

The wet nature of the drill cuttings and mud, during drilling operations keeps the LLA dust concentration in air to negligible levels. As a result the radiation dose contribution from this source is expected to be very low.

Cutting dry core samples can be a source of airborne alpha dust. Exposure from this can be minimised by using wet cutting methods.

Small quantities of radon decay products may be released during drilling operations. Dilution by wind reduces this to negligible levels near the drill rigs where operators are positioned.

Drill cuttings, core samples and rock hand samples are a source of low levels of gamma radiation. In most cases the drill cuttings and samples contain very low concentrations of radioactive materials and the resultant gamma dose is expected to be negligible. Occasionally there can be samples with elevated gamma radiation dose rates.

Exposure from this pathway can be controlled by adopting suitable work practices such as:

- Using appropriate tools to handle high grade drill cuttings/samples
- Minimise the time spend near sample storage areas and handling high grade samples

Document Number	Date Modified	Authorised By	Page Number
MP-19	2 August 2017	S. Kutty	Page 5 of 15

- Use of gloves and work cloths to avoid skin contamination and exposure through ingestion of radioactive material
- Maintaining good personal hygiene. Wash hands after handling core and cleaning of work areas to keep free of contamination
- Disposal of drill cuttings and mud in the pits and then covering it with sufficient thickness of top soil.

Storage areas of large quantities of core samples must be sufficiently away from continuously occupied areas like offices and access to the storage area by non essential personnel must be limited.

Small quantities of RnD may be released during airlifting operations if exploration holes are converted to water wells to allow sampling of groundwater. Dilution by wind available is usually sufficient to minimise radiation exposure from this source to negligible levels.

Elevated RnD concentrations may be encountered while airlifting during no wind conditions or during early morning temperature inversions. Temporarily suspending night airlifting activity during conditions of no wind or during periods of early morning temperature inversions will help to minimise exposure from this source.

The exposure from alpha dust and external gamma radiation is expected to be negligible during airlifting operations.

3.2 Exposure from onsite storage of samples

Samples stored in a place can be a source of radiation exposure to workers and public. The main pathways of exposure are:

- Gamma radiation from large quantities of samples
- Alpha dust generated from dry uncovered samples
- RnD released from samples kept in storage areas with poor ventilation.

Gamma exposure can be controlled by using the time distance and shielding principle. The control measures include:

- Not to store samples in high occupancy areas like an office, workshop or the like
- Use designated areas (shed or containers) for storage
- Label the storage area using appropriate radioactive signage
- Label the sample trays that contain high grade core with elevated gamma radiation field
- Limit the access to the storage area to authorised personnel only using administrative controls
- As far as practicable minimise the time spent near core samples with elevated gamma dose rates and near the store
- Provide whirly fans at the top of the storage area to aid air changes which will help to prevent build up of RnD.

To minimise exposure from dust and RnD the samples should be sealed in plastic sample bags.

Document Number	Date Modified	Authorised By	Page Number
MP-19	2 August 2017	S. Kutty	Page 6 of 15

3.3 Exposure from handling and analysis of samples

While handling core samples exposure can occur from airborne dust inhalation and through ingestion of radioactive material. To minimise exposure from these pathways:

- Use gloves and work cloths while handling core samples. This will prevent skin contamination as well as ingestion of radioactive material
- Wash hands and face after handling core samples as well as before eating, drinking or smoking
- Keep the samples sealed in sample bags or covered as for as practicable
- If there is a possibility of dust inhalation from dry loose core use a P2 half face dust mask or respirator.

Cutting of core can generate airborne dust as well as can lead to surface contamination. To prevent this:

- Use wet or water injection cutting methods
- Use P2 dust respirators while cutting core
- Perform the activity in the designated core cutting area (a concrete floor provided with a sump to collect the liquid waste and mud from the cutting activity)
- Treat and dispose the waste as radioactive
- Regularly wash and clean the work benches, tools and floor to prevent build up of contamination.

Chemical analysis of the core samples if required must be done in licensed external laboratories. Even though the radioactivity in the samples is usually low certain sample preparation/chemical analysis methods can concentrate the radionuclides in the sample and can result in elevated radiation levels as well as pose higher exposure risks.

3.4 Monitoring

The radiation dose contributions from exposure to LLA dust and RnD during exploration activities are expected to be very low. Because of this reason area/personal monitoring of dust and RnD are not considered to be essential.

Thermoluminescent Dosimeters (TLD) are used for the monitoring of external exposure to employees from gamma radiation. These dosimeter badges are issued depending on availability to either all the long term employees and contractors or to a group of employees in certain categories (e.g. geologists, drillers, support staff etc).

3.5 Radiation clearance of items

All the tools, equipment and other items used at the exploration sites are thoroughly washed and cleaned before moving it off site. All the items are checked and cleared of any radiation contamination using an appropriate surface contamination monitor.

Monitoring of core samples and drill cuttings to determine the presence of radioactive material is done by geologists or by trained support staff using a scintillometer.

The radiation safety section of Beverley Uranium Mine will provide necessary support for the measurement of radiation fields from particularly active samples and for the radiation clearance of items that leaves the Exploration area.

Document Number	Date Modified	Authorised By	Page Number
MP-19	2 August 2017	S. Kutty	Page 7 of 15

In case, exploration activities are carried out at locations that are away from Beverley Mine area and when it is not practical for Beverley radiation staff to provide support, the following arrangement will be made:

- All the items leaving the exploration site must be cleaned thoroughly to remove contamination
- Samples will be carried in appropriate packages so that there will not be any dispersal of the materials during its transport or storage. The external surfaces of the packages will be cleaned to remove any contamination. A visual inspection will be considered sufficient enough to make sure that the surfaces are clean.

3.6 Dose estimation and reporting

All the long term exploration employees will be issued with a TLD badge for the monitoring of exposure from external gamma radiation or alternatively each category (geologist, support staff, drillers etc) will be issued with one badge.

If badges are not issued to all the employees but only to groups based on the categories then the dose recorded in a badge will be assigned to each member of that category.

Total dose received by an employee is calculated as the sum of dose contributions received from the following three exposure pathways:

- Inhalation of Long Lived Alpha (LLA) Dust
- Inhalation of Radon Decay Products (RnD)
- External Exposure to gamma radiation

3.6.1 Dose estimation

Dose calculations of exploration employees working at the Exploration areas will be done as part of Beverley quarterly dose calculations. For the estimation of doses from LLA dust and RnD, area sampling results of monitoring done at the Beverley drilling areas will be used (this may lead to a slight over estimation). The expected concentrations of LLA dust and RnD at the exploration areas are comparable to that of Beverley area.

External gamma exposure is measured using radiation badges. These badges are issued for a period of three months and at the end of the term are analysed externally to assess the gamma doses received by the wearer.

The total dose to an employee working at the exploration areas will be calculated as the sum of the contributions from the above three pathways.

The contributions from LLA dust and RnD are expected to be very low during exploration activities and majority of the total dose received, if measureable, is expected to be from external gamma radiation.

The dose received by each person working in the exploration area is recorded in the Radiation Data Management System maintained at Beverley Site. All the above employees will come under the category, Geology and Drilling.

The doses received by these employees are reported to the Radiation Protection Division of South Australian EPA on a quarterly basis. The details of the monitoring methods used and dose statistic are contained in the Quarterly Occupational Radiation

Document Number	Date Modified	Authorised By	Page Number
MP-19	2 August 2017	S. Kutty	Page 8 of 15

Monitoring Report discussed during the In Situ Recovery (ISR) meetings convened by the RPD-EPA.

3.6.2 Dose estimation at exploration areas

Since it is not practical to carry out LLA dust and RnD monitoring at exploration sites that are far away from Beverley Mine the dose estimation of personnel working at these locations will be done solely based on the TLD badge result.

The gamma dose results of the personnel working at these locations will be presented to EPA-RPD at the time of quarterly ISR meetings.

4 INCIDENT REPORTING

All the incidents involving radiation sources and exposure will be recorded and investigated. Any incident that is reportable under the Radiation Protection and Control Act and Regulations will be communicated to the RPD-EPA.

Corrective actions will be implemented based on the findings of the investigations to prevent the recurrence of the incident.

All the incident reporting, investigation and implementing corrective actions will be carried out as per the existing procedures available at Beverley Mine.

5 WASTE MANAGEMENT

The radioactive wastes usually generated during exploration activities include:

- Drill mud, core cutting slurry, drilling and airlifting water
- Core samples, used PPE and contaminated equipment
- Analytical samples returned from external laboratories

5.1 Liquid waste disposal

All the liquid waste generated during the exploration activities will be disposed in the drill mud pit adjacent to each drill hole. The construction of the mud pit is done in such a way that sufficient bunding is provided around the drill hole to prevent the spill of liquid outside the bund.

The pit is allowed to dry before being filled in. Once dried, it is covered with compacted clean soil of at least 1m cover.

5.2 Solid waste disposal

All the drill cuttings collected during the drilling operation are disposed of in the mud pit adjacent to the drill hole before it being filled in. Any radioactive core samples collected during the operation are disposed in the drill holes (before other cuttings) as far as practicable. If this is not possible samples from the drill holes will be buried in adjacent drill pits and then covered with compacted clean soil to provide at least 1 m cover.

Samples that cannot be immediately disposed and that are kept for analysis in the storage areas are disposed either:

- In the approved low level radioactive waste disposal facility at Beverley Mine, or
- In a purpose built disposal pit in the exploration area.

Document Number	Date Modified	Authorised By	Page Number
MP-19	2 August 2017	S. Kutty	Page 9 of 15

The purpose built bulk disposal pit can only be used for the disposal of samples (after removing them from the sample bags and mixing with clean soil to reduce concentration of the samples) and will not be used for disposing any other waste generated during the exploration activities.

This pit will be located in an area that is stable, with no incompatible future use and on a ground that is not subjected to erosion or flood.

The construction of the pit is to be done in such a way that after disposing the diluted samples there is a cover of at least 2 m of clean and compacted soil.

If a bulk disposal pit is required in the exploration area, its location, dimensions and construction details will be included in the PEPR while submitting it to DPC for approval. The pit will be located within the exploration licence.

If the need for a bulk disposal pit is not included in the PEPR and if the requirement arises later, Heathgate Resources will provide an addendum to the authorised program for approval.

The application for approval will demonstrate why a specific location has been proposed taking into account of all potential stakeholder and environmental issues including topography, social, biological and radiological aspects.

5.2.1 Pit closure report

In case a bulk pit is constructed and used, Heathgate Resources will complete a pit closure report and forward it to DPC within one month of closure of the pit. This report will contain:

- The dimensions of the pit and its GPS coordinates
- Type and quantity of contents
- Photos showing various stages of the construction of the pit
- Photos to confirm the pre closure waste location within the pit indicating depth
- Gamma dose rate (or scintillometer) readings before construction of the pit and after its closure.

5.2.2 Analytical samples & contaminated objects

Samples and concentrates send back from external laboratories will be disposed in the low level radioactive disposal facility available at Beverley Mine.

Any tools equipment, PPE or other objects suspected to be contaminated will be disposed in the above low level radioactive facility.

5.2.3 General waste and non contaminated objects

Any waste (tools, equipment, PPE) that are non contaminated will be collected and then taken either to the general waste disposal facility at Beverley Mine (in the case that the exploration areas are close to the mine) or to a licensed landfill (in the case that the exploration sites are far away from Beverley Mine site).

Document Number	Date Modified	Authorised By	Page Number
MP-19	2 August 2017	S. Kutty	Page 10 of 15

6 DECONTAMINATION OF TOOLS AND EQUIPMENT

Tools and equipment used in the exploration areas may get contaminated as a result of them coming into contact with radioactive material. Even though the chances of contamination are very low during exploration activities its potential cannot be neglected.

All the equipment that has come into contact with drill mud, drilling water, samples etc. will be thoroughly cleaned with water before leaving site. All the wash down water will be directed to the drill pits for disposal.

While carrying out exploration activities near Beverley Mine, larger items like drill rigs, trucks etc. will use the vehicle wash down facility available at Beverley before leaving offsite.

7 SPILL MANAGEMENT

Spills of drilling water, drill mud and any other fluid needs to be avoided or controlled as far as practicable. Earthen bunds will be constructed around drill holes to prevent the escape of water during drilling and to direct it to the mud pit.

If gamma or alpha surveys of a spill site indicate contamination the affected soil will be removed and disposed either in a drill pit or in the bulk waste disposal pit.

8 TRANSPORT OF SAMPLES

Core samples from above the mineral zone will be treated as non-radioactive and the samples from ore zone and below will be treated as radioactive (considering the fact that during drilling the samples from below the ore zone get mixed up with that from the ore zone).

Non radioactive core samples will be transported in suitable packages (cardboard boxes, gunny bags etc.) that safely contain the material, withstand the normal conditions of transport, storage and handling and also prevent escape of material during transport and handling.

8.1 Transport of radioactive samples

Majority of core samples are very low in activity and hence comes under the "Excepted Package" category. The following criteria will be used in deciding whether a sample package is classified as excepted or not:

- The gamma dose rate at any point on the external surface of the package does not exceed 5 $\mu\text{Sv/h}$.

If the external surface gamma radiation dose rate is more than 5 $\mu\text{Sv/h}$ then the samples will be classified as Low Specific Activity (LSA-1) material and will be transported as Category 1, 2 or 3 package depending on the transport index and external surface dose rate.

Samples will be packed, labelled and transported according to the conditions from the Code of Practice for the Safe Transport of Radioactive Materials.

The packages selected for the transport of samples must satisfy the requirements stipulated in the Transport Code. Suggested packaging for transporting excepted package material is:

- Sturdy card board box

Document Number	Date Modified	Authorised By	Page Number
MP-19	2 August 2017	S. Kutty	Page 11 of 15

- Plastic bucket
- Steel drum.

LSA material will be transported in steel drums. All packages selected must be strong enough to contain the material under routine conditions of transport and the external surface contamination levels must remain within the limits specified in the Transport Code.

Radiation Advisors of Beverley Mine will provide assistance in selecting appropriate packaging, labelling and documentation of the samples.

8.2 Incidents during transport of RAM

Drivers of vehicles carrying radioactive packages will be given sufficient information on the following:

- Contents of the package and its properties
- Actions to be taken in case of an emergency
- Emergency contact details at Beverley Mine and EPA-RPD.

In case of an emergency the driver will be directed to contact Beverley Mine for advice. The Radiation Safety Advisors available at site will provide information on how to deal with the situation as per the existing procedures.

The emergency response team of Beverley Mine will carry out the task of cleaning the affected area in case of a spill/leak in consultation with EPA-RPD.

9 STORAGE OF RADIOACTIVE SAMPLES

Radioactive core samples from the exploration areas close to Beverley will be stored at the storage facility at Beverley Mine. Samples originating in other exploration sites will be temporarily stored there in appropriate storage rooms and if long term storage is required then will be moved to Beverley Mine Site storage area.

The suggested storage facilities that can be used in the exploration areas are either:

- Shipping containers (refrigerated or non refrigerated) or
- Portable cabins.

The core samples will be wrapped in plastic sheets to prevent dispersal and then placed in plastic sample trays. The trays are then stacked inside the storage rooms.

Sample trays containing high grade core and the ones with elevated gamma/scintillometer readings will be kept away from the occupied areas of the store room and also the trays with low grade core will be used as a shield to reduce the exposure from high grade ones.

The trays containing core with elevated gamma or scintillometer readings will be appropriately marked to warn people of the elevated radiation exposure risk. A "Radioactive Material" sign (diamond shaped with yellow trefoil symbol) of 50 mm x 50 mm is ideal for this purpose.

Radioactive material signs (300 mm x 300 mm) will be fixed on to the sides and front of the storage container/cabin to warn people of the presence of radioactive material.

Document Number	Date Modified	Authorised By	Page Number
MP-19	2 August 2017	S. Kuty	Page 12 of 15

The storage rooms will be always kept closed and access will be limited to essential personnel only.

A gamma survey meter or scintillometer will be used to measure the radiation levels inside and outside the containers. These measurements will be carried out at least once in a quarter. In the storage facility located at Beverley Mine the radiation safety personnel will carry out this measurement and in case of storage facilities located away a trained personnel of Heathgate Resources will conduct this measurement. Records of these measurements will be kept by the personnel who conduct these measurements.

If large quantities of core samples are kept in a storage facility with no ventilation there is a very low possibility of radon decay products accumulating inside the rooms. This can be managed by:

- Providing a vent for air changes (a whirly fan or a window)
- Allowing sufficient time after opening the doors for wind to aid natural dilution.

The RnD monitoring done so far at Beverley Mine indicates that the chances of its accumulation inside the storage areas are almost negligible (but cannot be completely ruled out).

10 PERSONNEL AND RESOURCES

The responsible personnel for the implementation of this plan in Heathgate exploration areas are:

Geology, Manager – Ben Packer

Tenement Manager – Joyleen Barnes

The above personnel will have the responsibility of providing information, support and resources to the Radiation staff at Beverley Mine to carry out the tasks appropriately to comply with the commitments made in this radiation management plan.

The radiation safety personnel at Beverley Mine will provide their assistance to the above personnel in implementing this management plan by:

- Providing advice on radiation safety issues
- Use and maintenance of radiation monitoring equipment required for the surveys at exploration areas
- Conducting area and personal monitoring as and when necessary
- Training of employees
- Dose calculations, maintaining dose records, reporting dose statistics to EPA-RPD.

The personnel currently available at Beverley Mine to provide the above services are:

- Senior Radiation Advisor – Sankaran Kutty (RSO)
- Radiation Advisor – Martin Jane

The Radiation Safety Section of Beverley Mine has the resources to monitor radiation levels, equipment to carry out personal and area sampling, and calibration of most of the above equipment. Some of the equipment available at site is listed below along with their calibration frequencies in parenthesis:

Document Number	Date Modified	Authorised By	Page Number
MP-19	2 August 2017	S. Kutty	Page 13 of 15

- Bicon / Thermo micro survey meter for gamma radiation measurement (Yearly)
- Ludlum alpha surface contamination meters for surface contamination measurement (Quarterly)
- SKC air sampling pumps for LLA dust activity in air measurement (fortnightly)
- Ludlum 2200 alpha counter and 43-10 detector for counting of filters from LLA dust sampling (Monthly)
- Environmental Radon Daughter Monitors (ERDM) for the measurement of radon decay products (Quarterly)

Calibrations of all the above equipment are carried out at Beverley Site except that of the gamma survey meters which are carried out at external calibration facilities.

11 INDUCTION AND TRAINING

All the personnel working at the exploration areas are inducted at Beverley Mine before they commence their work. The induction includes a computer based presentation and a multiple choice objective type test.

All new personnel and those who are returning after a gap of twelve months or more are required to do the induction.

A section of the induction presentation is on radiation safety. This part includes information on basics and types of radiation, sources of radiation, its effects and principles of minimising radiation exposure, work practices, PPE, importance of personal hygiene, radiation clearances, waste management and use of personal monitoring devices.

More detailed radiation safety training is conducted at Beverley Mine multiple times a year to cover all the employees.

12 RECORD KEEPING

All the records related to radiation management will be kept at the HSSE Department at Beverley Mine. The Radiation Advisors will have the primary responsibility of collecting the data, its management and keeping.

All the records will be kept till thirty years after the closure of the mine. The records that are kept includes, but not limited to:

- Radiation monitoring and survey data
- Equipment calibration data
- Employee dose records
- Radiation clearances
- Radiation incident investigations and actions
- Radioactive material transport.

These records will be destroyed only with the written approval of EPA-RPD.

The Geology Manager will have the assigned responsibility of forwarding the records related to radiation monitoring and management at exploration sites that are away from Beverley Site to the radiation section. Most of these data are related to:

Document Number	Date Modified	Authorised By	Page Number
MP-19	2 August 2017	S. Kutty	Page 14 of 15

- Radiation clearances issued
- Sample transport
- Monitoring of sample storage areas.

The data records received from Geology Manager will be kept with the Radiation Safety Section at Beverley Mine. Records will be kept till thirty years after the closure of the mine.

13 REFERENCES

1. ARPANSA (2005). Code of Practice and Safety Guide, Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing, Radiation Protection Series No 9.
2. SA Government (2015). Radiation Protection and Control (Ionising Radiation) Regulations 2015, South Australia.
3. ARPANSA (2014). Code of Practice, Safe Transport of Radioactive Material, Radiation Protection Series No 2.
4. SA Government (1982). Radiation Protection and Control Act

Document Number	Date Modified	Authorised By	Page Number
MP-19	2 August 2017	S. Kutty	Page 15 of 15