AUSTRALIAN MINERA RESOURCES Pty Ltd

MINING MANAGEMENT PLAN (EXPLORATION OPERATIONS)

FOR

CANTEEN CREEK PROJECT, EL 27821

Authorisation Number :TBA

	Author	Reviewed by	Approved by
Date	23 June 2018	25June 2018	25 June 2018
Name	AMR PTY LTD	G S Eupene	AMR PTY LTD
	Michael Beer		

I, Michael Beer, Director of Australian Minera Resources Pty Ltd, Licensee of EL27821, declare that to the best of my knowledge the information contained in this mining management plan is true and correct and commit to undertake the works detailed in this plan in accordance with all the relevant Local, Northern Territory and Commonwealth Government legislation.

Signature: .....

DATE: 25 June 2018

Copies to: Australian Minera Resources Pty Ltd, DPIR (Mining Operations Division)

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DISCLAIMER

This Mining Management Plan has been prepared to comprehensively account for exploration work intended to be undertaken. Every effort has been taken to ensure the reliability and completeness of information used to prepare and collate this Plan. However, the proponent accepts no responsibility in situations where information provided by a third party that is relied on in good faith proves to be inaccurate or incomplete. Further, the physical and social environments of the proposed exploration are dynamic. Unforeseen changes in the context of this exploration may require adjustments to the Plan. Any such changes will be communicated to relevant stakeholders in accordance with regulatory requirements.

This Plan has been prepared for a particular purpose and audience. Information included in the Plan is not intended to be, and should not be, relied on or used by others. The proponent accepts no liability for any action resulting from information included in this Plan being used by any person of for any purpose other those intended.

AMENDMENTS

Section	Amendment
New Document	

1.0 OPERATOR DETAILS

Table 1: Operator details

Operator Name:	**Australian Minera Resources Pty Ltd**
Key Contact Person/s:	**Mr. Michael Beer - Director**
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1.1 ORGANISATIONAL STRUCTURE / CHART

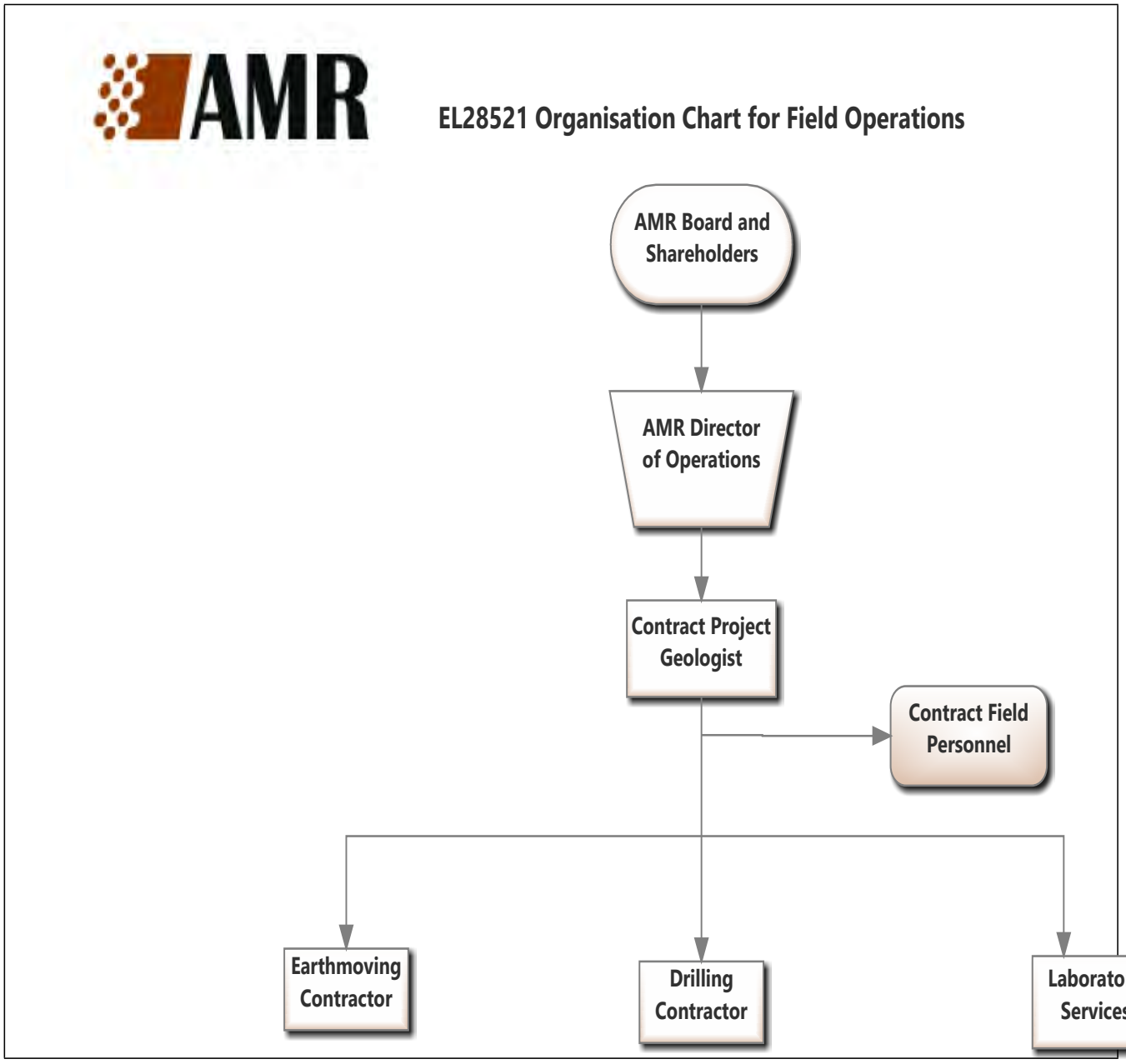

Figure 1: AMR Organisational chart for field operations

1.2 WORKFORCE

It is anticipated that Australian Minera Resources Pty Ltd (AMR) will have an on-site project workforce that will consist of a Consulting Project Geologist and a contract field assistant. Other project personnel will comprise a contracted diamond drilling crew and an earthmoving operator; the latter will most likely be an employee of Kurundi Station, subject to successful negotiations for use of their earthmoving equipment. The geologist and drill crew might establish a camp according to approved guidelines close to their work site, with the cooperation of the pastoralist.

2.0 IDENTIFIED STAKEHOLDERS AND CONSULTATION

The Project has identified the following stakeholders:

- Pastoralists – Kurundi Station
- Aboriginal Traditional Owners
- Nearby Aboriginal Communities: Canteen Creek, Wutunugurra
- AAPA
- DPIR ME
- NT WorkSafe
- NT Bushfires Council

The Operator has an established process of consultation with landowners and managers (pastoralists), which has involved:

- Initial notification of the landowner and land manager by letter as part of the licence application procedure. Establishing with the landowner parties their preferred means of communication.
- Contacting the landowner prior to entering the land following grant of title.
- Arranging initial meetings with affected landowners to explain the company's exploration objectives and the likely activities that these will involve.
- Seeking advice from landowner re. their expectations relating to exploration activities. Take note and obey any specific requests from the landowner in relation to access restrictions and any other special conditions required.
- Seeking advice from landowners regarding flora and fauna, especially relating to native species. Advice on endemic weed types and feral animals.
- Seeking advice from landowners regarding knowledge of conservation or heritage sites
- Updating landowners regularly of our movements and proposed exploration activities.
- Utilising landowners assets on a commercial basis if available so that landowners have direct knowledge of the company's movements and any land disturbance carried out and enjoy some direct financial benefit from our exploration on their land.
- Working with landowner and manager to maintain compliance with notification requirements of Mining Management Act and Regulations, while minimising inconvenience for them.

On-site personnel have experience in maintaining good relationships with all parties that have a direct interest in the land.

The Operator has contacted Kurundi Station in relation to the proposed works. A communication was forwarded to the Station Manager which included a letter and email that included:

A. an extract from the department's MMP Guidelines and
B. a map showing the proposed drillhole locations and access to them.

Based on initial consultation, a positive response is expected from the Manager of Kurundi (**Appendix 1**).

3.0 PROJECT DETAILS

Table 2: Summary of project details

Project Name:	**EL27821, Canteen Creek**
Location:	The EL is in the Tennant Creek region, being 170 km southeast of the town, in the Costello District. The western part of the EL is on Kurundi Station. The eastern section is on NT government controlled 'vacant crown land', NT Portion 4246, which includes the Canteen Creek Aboriginal Community. The licence is on the Frew River 1:250,000 Geological Series Sheet SF53-3.
Site Access:	The EL is accessed from the Stuart Highway from a turnoff 87km to the south of Tennant Creek, then on gravel road 48km to Kurundi Homestead, then 68km to Epenarra, then turning south-south-west for 14.5km to the Canteen Creek turnoff, then 32.3km to the western boundary of EL27821. Tracks on Kurundi and Epenarra stations lead off the main road to provide some access to all parts of the tenement but these will require maintenance before they can be used to get vehicular access to worksites proposed in this Management Plan. From the south, 4WD access is available via the Davenport Range National Park.
Mining Interests	EL 27821
Title holder/s:	Title Holder: Australian Minera Resources Pty Ltd Operator: Australian Minera Resources Pty Ltd

MAPS OF SITE LOCATION

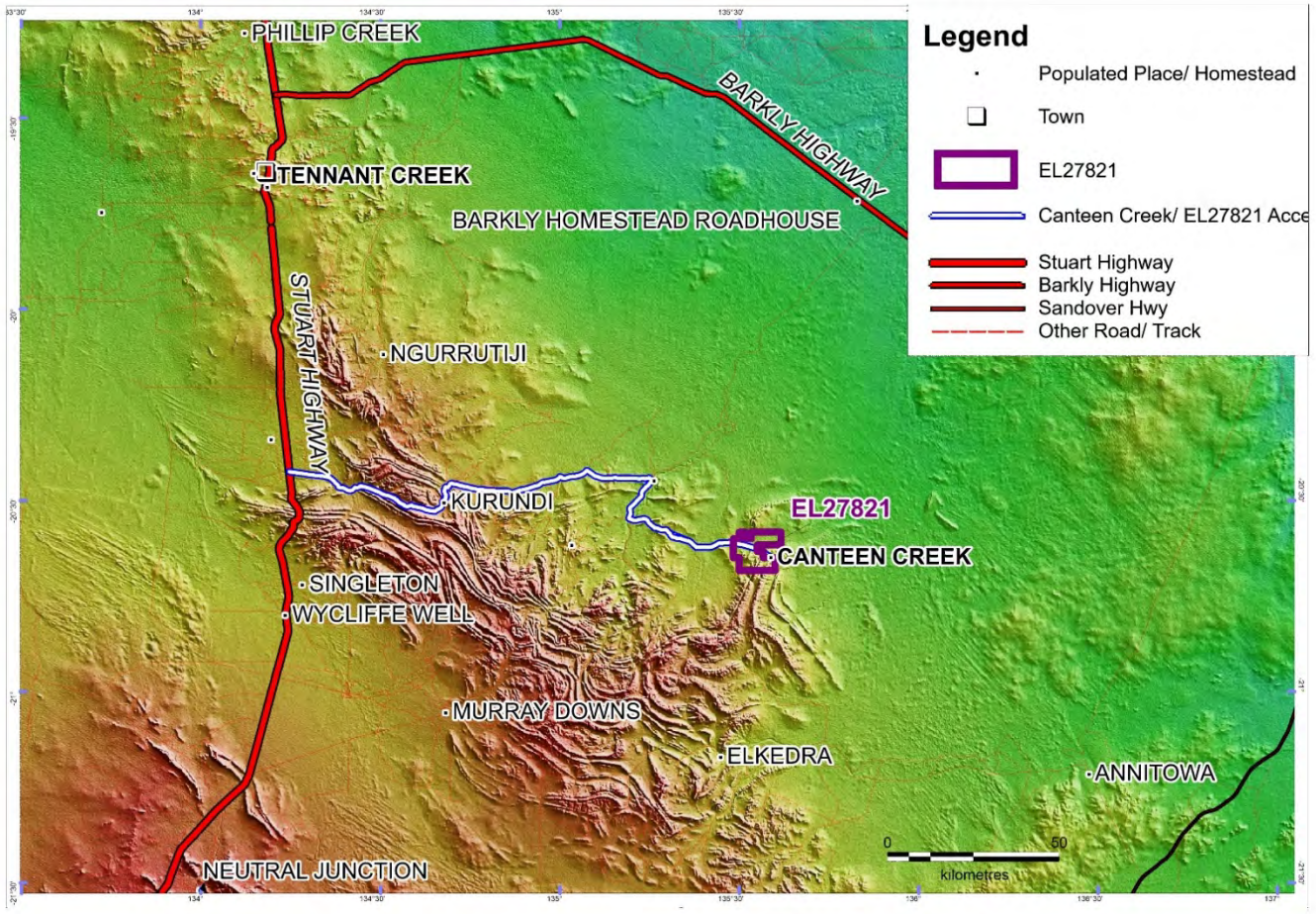

Figure 2: Regional Location of Canteen Creek

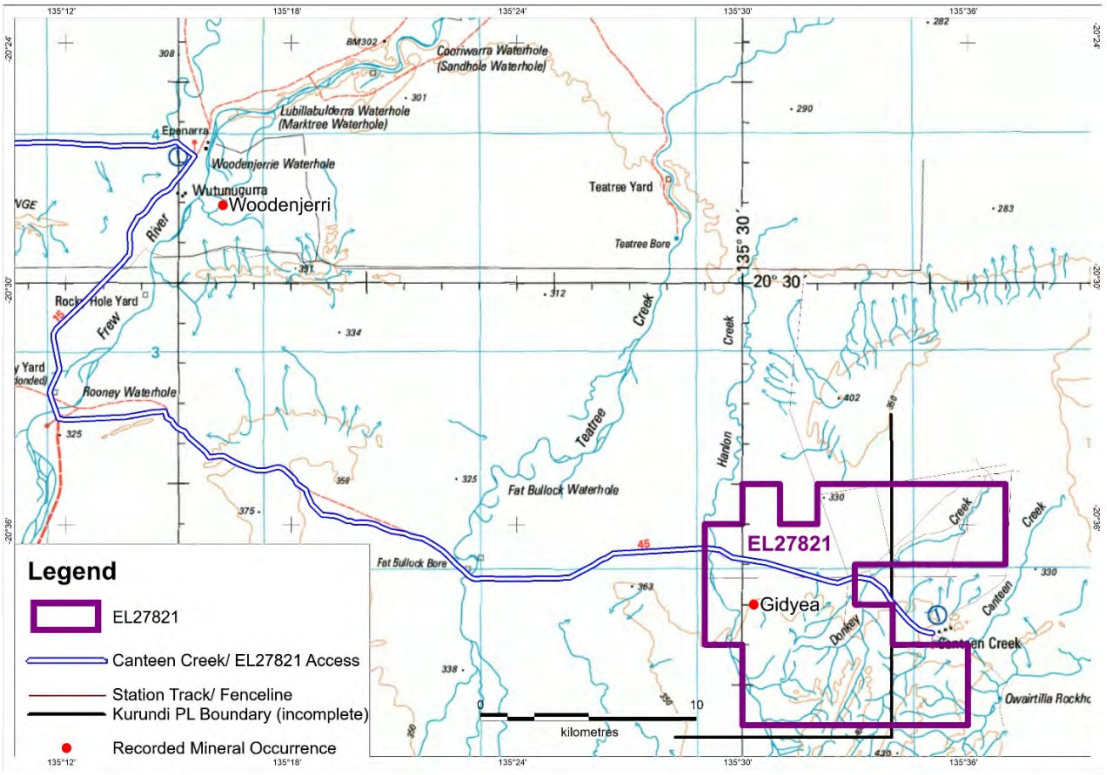

Figure 3: Location of EL 27821 on 1:250,000 Topo Map

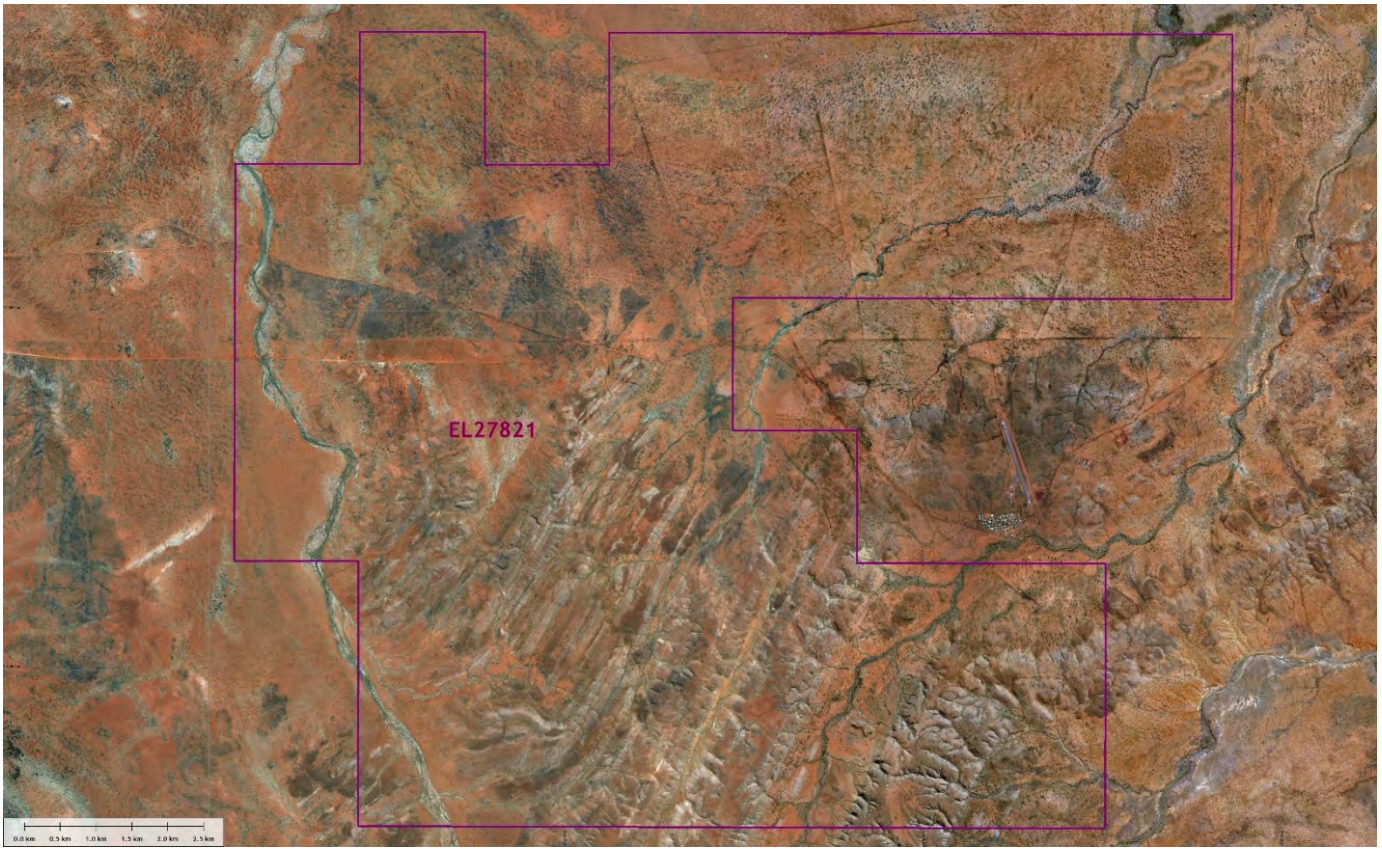

Figure 4 EL27821 on Worldview Image.

3.1 Previous activities and status

3.1.1 Historical Mining/Exploration

The NTGS 1:250,000 Explanatory Notes mention that only small-scale mining activities took place in the region (Walley A M 1987: see Appendix 3). These operations were restricted to the Hatches Creek area, located in the southwest corner of the Frew River sheet and at Kurinelli, approximately 40 km to the northwest of the EL. The Hatches Creek deposits contain tungsten, associated with bismuth, copper and some gold; these deposits are quartz vein hosted. At Kurinelli, gold occurs in quartz veins cross cutting a gabbro body. Much of the mining activity took place between 1913 and 1960. Renewed exploration conducted by GWR Group Ltd at Hatches Creek is producing impressive results.

There has been a history of exploration activities carried out within the boundaries of the current licence dating back to the 1980s, directed mainly at the Gidyea copper-gold-cobalt prospect and at Warramunga Group rocks on a more regional basis. The latter host the typically small but high-grade gold deposits of the Tennant Creek type further to the northwest of the licence. The only disturbance activity on record is an NTGS sponsored diamond core hole, which was drilled *ca*. 1979 on the "Gidyea Gabbro". Drill core for the hole has been located at the NTGS core facility at Alice Springs but there is no written record that can be found that gives any information about the hole or acknowledging its existence.

Non-disturbance exploration activities include geophysical surveys, geological mapping and sampling.

Companies who have carried out exploration work include Australian Energy and Gold NL, Posgold, Orion Resources, Imperial Granite and Minerals, Tennant Creek Gold and Thor Mining. Gold has been the

major commodity sought. The current licence holder acquired the tenement from Imperial Granite and Minerals who were granted the licence in 2010. AMR has previously conducted regional stream sediment sampling, as well as geological reconnaissance and rock chip sampling in 2013, and an airborne magnetic and radiometric geophysical survey in 2014.

3.2 Proposed activities

Seven drill sites are proposed. The initial plan is to drill four holes; dependent upon results the additional three sites will be considered for drilling. This provides some flexibility in the priority of drill holes dependent on emerging results. Particulars currently proposed for the drill holes are listed in Tables 3 and 4 below. These may change as knowledge is acquired.

Table 3 Particulars of proposed diamond core holes, EL27821, 2018

Hole_Id	MGA_Z53_Em	MGA_Z53_Nm	Level_m	Plan_Depth_m	Dip_deg	Azimuth_deg
CCD18_001	553,635	7,717,500	377	250	-60	45
CCD18_002	555,300	7,719,250	345	250	-60	45
CCD18_003	554,145	7,719,790	339	250	-60	270
CCD18_004	556,590	7,721,600	326	250	-60	350
CCD18_005	558,450	7,721,400	325	250	-60	330
CCD18_006	553,050	7,722,535	327	250	-60	45
CCD18_007	553,175	7,720,590	339	250	-60	315

Five of the sites have been positioned on or near existing tracks / fence lines to minimise new disturbance. On existing tracks, some tidying of the track, and widening if the hole is located on the existing track is expected. Two sump pits will normally be dug at each site to ensure adequate storage capacity for drill cuttings. Planned disturbance details have been summarised in Table 3 below, in Figures 5 and 6, and on the Security Calculation document (**Appendix 5**).

Table 4: 2018 Planned Activities

Mining Interests	**EL27821**
What time of the year will exploration occur?	Aug to Oct
How long is exploration expected to occur?	40 days
Type of drilling	Diamond core drilling; RAB/ Mud for Water supply drill holes
Target commodity*	Base Metals, Gold, Tin, Tungsten
Is drilling likely to encounter radioactive material?	No
Number of proposed drill holes	Up to 7 DDH, and up to 3 Water Supply drill holes, most likely on DDH pads.
Planned maximum depth of holes (m)	250
Number of drill pads.	7
Is drilling likely to encounter groundwater?	Unsure
Number of sumps	2 per pad; 14
Length of line / track clearing (up to 20 Kilometres x Width: 3.5 m) =7Ha.	Max. 20km
Number of costeans	None
Total bulk sample from small pits	None
Will topsoil be removed for rehabilitation purposes?	Surface layer containing vegetation will be stockpiled from drill pads
Previous disturbance yet to be rehabilitated on title (ha) if known	None
Camp (Length: 2 5 m x Width: 25 m); refuse pit 6m x4m x2.2m max depth; location to be confirmed with pastoralist	0.063
Maximum total area to be disturbed –(ha)	(say) 7.5

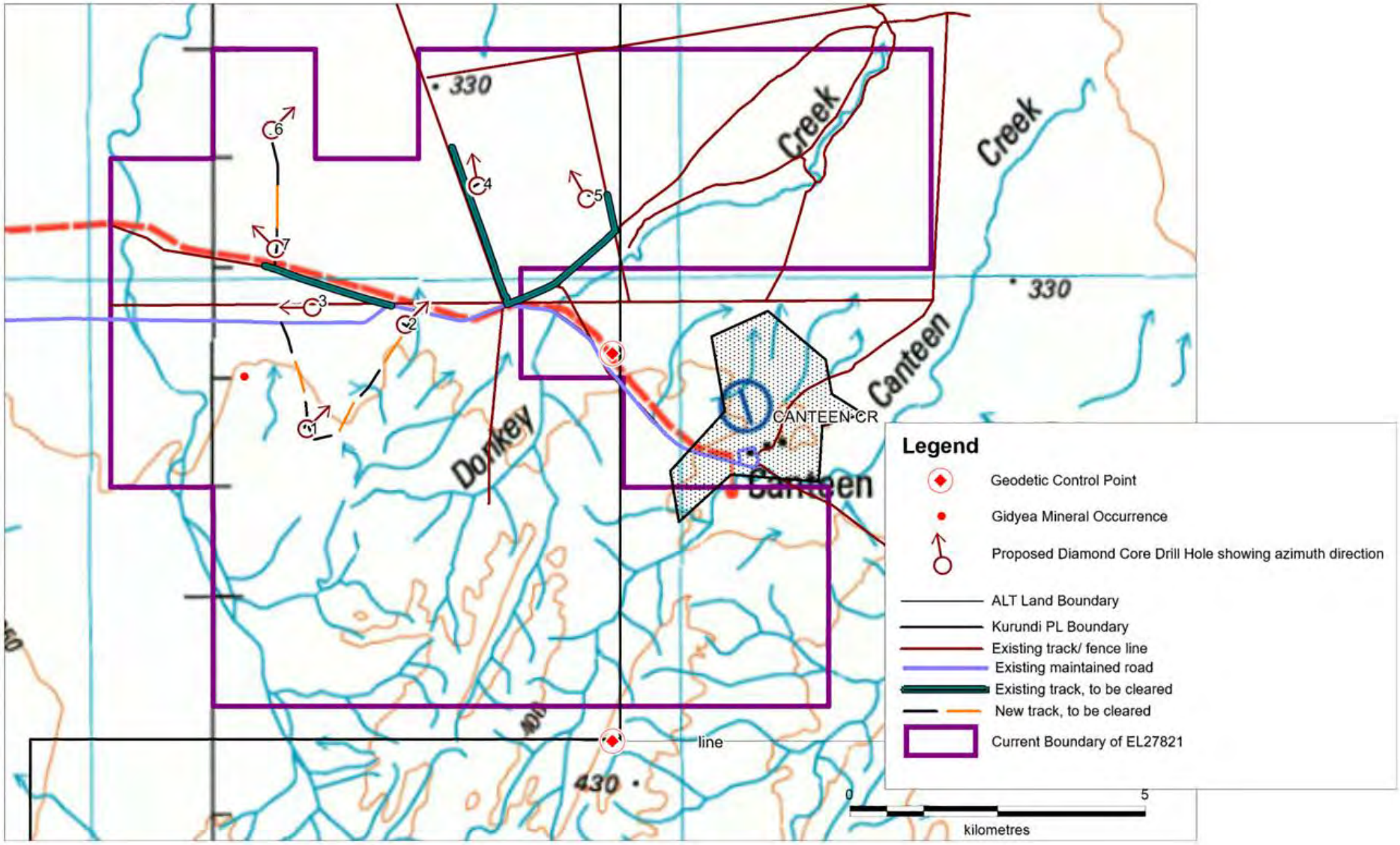

Figure 5: Layout of proposed work NB: Campsite not included – this will be finalised in consultation with the landholder (Basemap shows old access route).

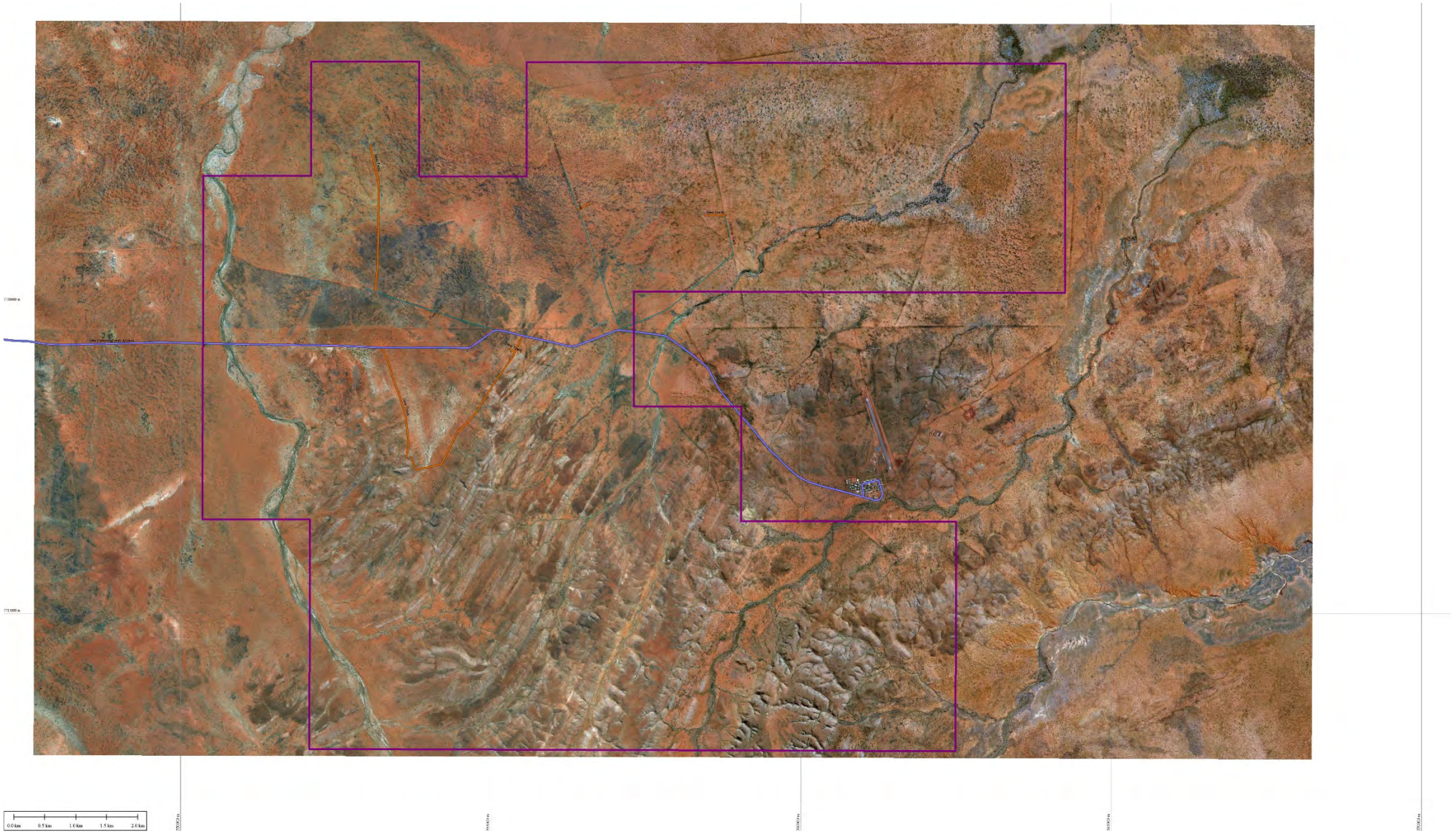

Figure 6: EL27821 - Proposed Track Construction on Worldview Image (Enlarge to view detail)

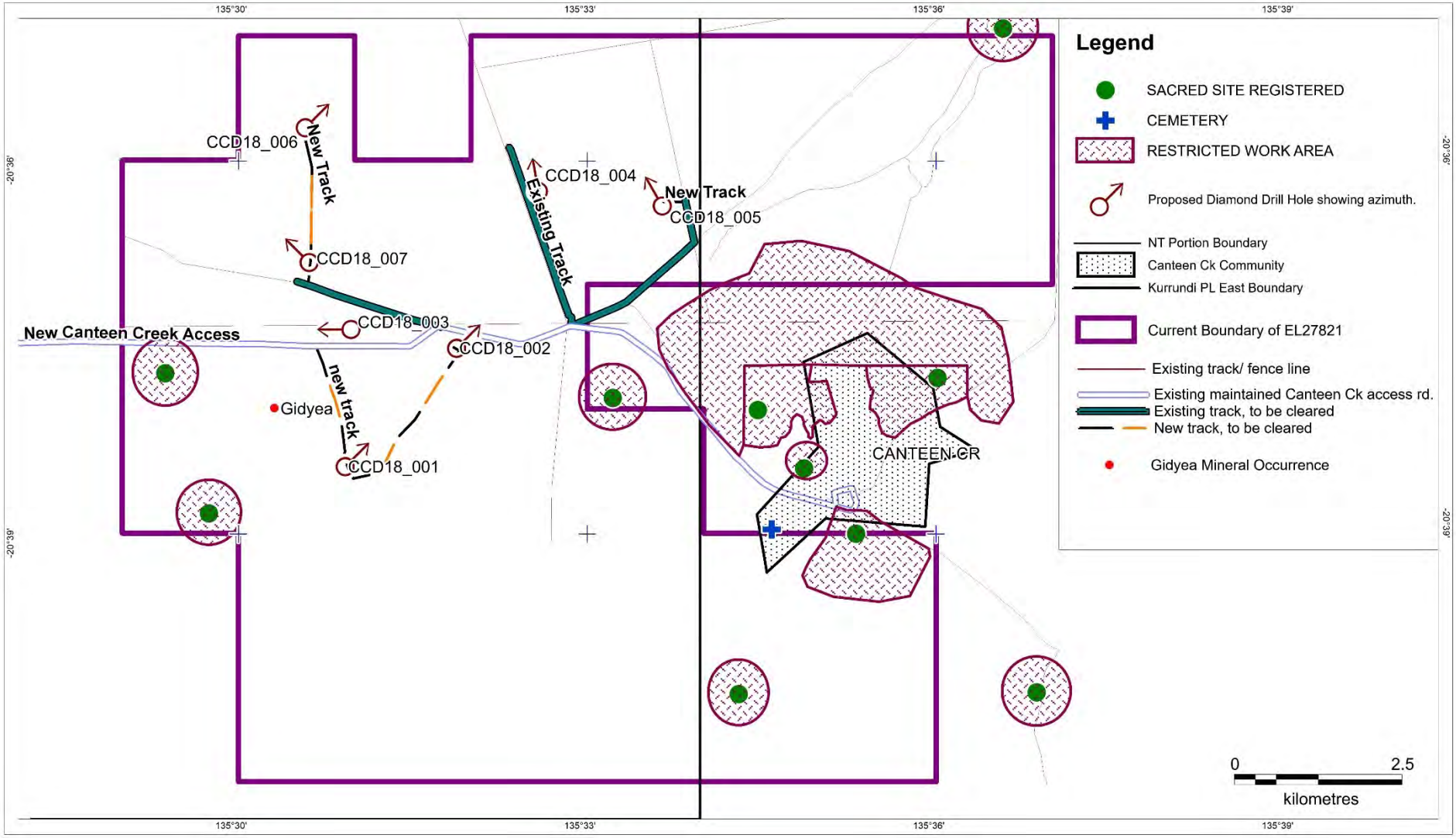

Figure 7: EL27821, showing proposed works and results of Sacred Sites Survey, 2013.

4.0 CURRENT PROJECT SITE CONDITIONS

Table 5: Current site conditions

Site Conditions	Description
Geology and Landform	The EL covers the boundary between three major geological provinces. It straddles the contact between the Warramunga Province and the younger Davenport Province rocks. To the north, fringing the EL, is the Georgina Basin. The geology as recorded in the most recent 1:250,000 FREW RIVER Explanatory Notes (Walley 1987; Appendix 3) has been superseded. An important unconformity, which traverses the south-eastern section of the EL has been recognized. This unconformable contact separates the older Warramunga Province rocks (the Ooradidgee Group) from the overlying Hatches Creek Group (Davenport Province). There are potential economic implications connected with this re-interpretation. Rocks of both provinces consist of sedimentary and volcanic units. Intrusive rocks mapped within the licence include granite and gabbro (the 'Gidyea Gabbro'). Remnants of Cambrian stratigraphy outcrop in the west and north. Approximately 40% of the licence is devoid of outcrop, being covered by various unconsolidated materials as well as minor calcrete and ferricrete. This area will be targeted to ascertain the concealed geology and test the economic potential. AMR's 2014 airborne geophysical survey suggests that further refinement of the setting presented above is needed. AMR's current interpretation is that the Warramunga Province rocks are confined to a corridor that passes through the northern and western sectors of the presently- retained EL, and these will be the main exploration target f the 2018 drilling campaign. Landforms vary from "high bevelled ridges and uplands" of the Davenport Range in the south of the tenement to undulating peneplains and semi-desert sandplains with low, broad dunes to the north and east. The Davenport Range reaches up to 600 m ASL; the plains country averages around 300 to 350 m ASL but gradually decreases progressing eastwards. See **attached** NTGS Explanatory 1:250,000 Notes **(Appendix 3)** for detailed Geology. See **attached** NRETAS map of Soil types **(Appendix 4)**.

Site Conditions	Description
Hydrology	All watercourses flow north and east, having their headwaters in the Davenport Ranges. The main drainages are the Frew River and its main tributary Hatches Creek located to the west of the tenement. Within the licence there are several creeks flowing north out of the hilly country; all of these terminate in diffuse 'flood-outs' on the plains to the north. **Appendix 6** provides the Groundwater profile provided through NR Maps on 1 June 2018.
Flora	The surrounding environs are dominated by open woodland containing drought-resisting trees and shrubs, particularly Acacia species and spinifex grasses. The proposed exploration site is better described as sparse shrubland. A diverse range of ferns and flowering plants has been collected from the general area, although no threatened species are identified (refer to the NT NRM Report included as **Appendix 4**). Certain weeds are listed on www.nt.gov.au/weeds site as being endemic in the region (classified as the Barkly Region). The most commonly identified weeds include Starburr, Gallon's Curse, Awnless Barnyard Grass, Spiked Malvastrum, Parkinsonia, Coffee Senna and Townsville Lucerne (refer to **Appendix 2.3 and Appendix 4.2**). Of these, a review of the Barkly Region Weed Management Plan (Appendix 4.2) suggests the major endemic weed species may be *Parkinsonia aculeate*, a NT Class B weed, and a Weed of National Significance. A search of the EPBC Act Register indicates that there are no vulnerable, threatened or endangered species in the region.

Site Conditions	Description
Fauna	The Davenport Range National Park is located to the southwest of the licence area. The NT Parks website and associated links provide information on native species that inhabit the park. Biodiversity in the Park benefits from waterholes that also support fish species peculiar to the region as well as a variety of reptiles, birds and marsupials. Identified marsupial species found within the Park include: Dunnart, Marsupial Mouse (Antechinus), Spectacled Hare Wallaby, Northern Nail Kangaroo, Mountain Kangaroo and Black-footed Rock Wallaby. Some of this data may be relevant to the licence area, although there is very sparse permanent water within it and subsequently significantly reduced biodiversity. While the NT NRM report on the broad region identifies the Greater Bilby, the Common Brushtail Possum (southern) and the Black-footed Rock Wallaby to be vulnerable or endangered, a search of the EPBC Act Register indicated that there are no particular vulnerable, threatened or endangered species associated with the region. Surveys have identified a range of pest animals, particularly wild dogs, wild cattle and donkeys (refer to **Appendix 4**). The Commonwealth Governments Register of Critical Habitats indicate that there are no threatened eco communities in the region. **Appendix 7** provides an overview of threatened fauna species in the general region.
Land Use	The western part of the tenement is within the Kurundi Pastoral Lease where cattle grazing is the sole land use activity. Other pastoral leases exist in the region. The remaining part of the licence lies within vacant crown land. The Canteen Creek Aboriginal community is in the south-eastern quadrant of the licence, on the vacant crown land. The Davenport Range National Park is located to the southwest of the licence; it is on leased freehold aboriginal land. Tourists visit this park during the winter months.
Historical, Aboriginal, Heritage Sites	A Sacred Site Survey has been completed by AAPA in 2013 to cover the entire Exploration Licence. The areas where AMR will carry out disturbance activities have avoided these areas, many of which are not included in the current EL area. The results of the survey are indicated on Figure 7. Native Title claim: NTD 6017/01 (Kurundi) and Aboriginal Land Claim (ALRA) 'Wakaya Alyawarra' relate to the EL area.

5.0 ENVIRONMENTAL MANAGEMENT SYSTEM

AMR has contract/ consulting technical personnel at its disposal who have been involved in the production of environmental documentation for various mineral exploration projects in the Northern Territory. The same personnel have also been involved in the implementation and maintenance of the environmental standards as set out in these documents as well as monitoring of the environmental aspects involved in mineral exploration activities.

The Operator's Environmental Management System includes DPIR ME Advisory Notes (eg advisories on Weeds, Drillhole Remediation, track making etc) in its folder of documents. Personnel on the project will be aware of all environmental aspects covered by the company's plan.

Documents that are regularly referenced include:

- Environmental Guidelines
- General Induction Documents
- Weed Management
- Road and Track Construction/Repair
- Drilling Contractor Check List and Site Inspection

The above documents are contained in **Appendix 2**.

5.1 Environmental policy and responsibilities

The policy of the Operator is to conduct its exploration activities in a sustainable way so that there is minimal impact to both the physical and social environment. The Operator's policy document 'Protecting the Environment' is contained in **Appendix 2**.

The Operator will ensure the implementation of the environmental policy through the site Project Geologist. That person will report directly to the Operator.

Personnel engaged by the Operator have experience in all styles of drilling and will ensure that best practice is carried out regarding clearing of access and the final rehabilitation of drill holes.

Personnel are aware of the procedures to follow should there be any chance finds of archaeological sites, aboriginal artefacts, or cultural items etc. Any such finds will be reported to the Operator, who will then inform AAPA.

The proposed programme of Diamond Core drilling is planned for flat, open country in the northern and western sectors of the tenement. In 2013 the Operator made an application to AAPA to carry out a site survey the entire original EL area. The survey identified several sites and areas covered by Restricted Work Areas. For the planned Diamond Core program, drill rig access and siting of drill holes will take into account the location of these identified Restricted Work Areas and Sacred Sites, as indicated in Figure 7.

5.2 Statutory and non-statutory requirements

5.2.1 Statutory requirements

- Aboriginal Land Rights (Northern Territory) Act
- Bushfires Act
- Dangerous Goods Act
- Environment Protection and Biodiversity Conservation Act
- Environmental Offences and Penalties Act

- Heritage Conservation Act
- Mining Management Act
- Mining Management Regulations
- Mining Management Plan Authorisation Requirements
- Minerals Titles Act
- NT Aboriginal Sacred Sites Act
- Parks and Wildlife Service NT – various legislation
- Native Title Act
- Pipelines Act
- Soil Conservation and Land Utilisation Act
- Territory Parks and Wildlife Conservation Act
- Work Health and Safety Act and Regulations (National Uniform Legislation)
- Waste Management and Pollution Control Act
- Water Act
- Weeds Management Act

5.2.2 Reporting requirements

- DPIR ME - Annual Technical Reports and Mining Management Plan
- NT Worksafe - monthly employment/ injury and safety statistics
- CLC – Work Programmes and Submissions if applicable

5.2.3 Non-statutory requirements

There will be constant continuing communication with Kurundi Management relating to land access, land care, exploration activities and movements. Additionally, local communities and traditional landowners will be advised of our activities and their location, as well as our intention to avoid sites identified in the 2013 AAPA survey. The Operator and its representatives will consult the following when required: DPIR ME Advisory Notes, NT Erosion and Sediment Control Guidelines – Linear Developments, NT Land Clearing Guidelines 2010, NT Sites of Conservation Significance.

5.3 Induction and training

Technical and other personnel who will be carrying out the activities on this exploration licence have undergone the environmental induction process as a requirement while working on other exploration projects in the Northern Territory. The Induction document is contained in **Appendix 2**.

Contractors coming on site e.g. drilling company personnel will be required to show that they have a policy and documents relating to environmental management and that their personnel have been trained in implementation of procedures related to the environment. The Operators representative will induct the drill personnel and inspect the contractor's equipment. The drilling contractor will induct the Operator's personnel on drill site access and behaviour.

In relation to environmental performance, all personnel are encouraged to raise concerns at any time. The drilling contractor in conjunction with the geologist will hold Toolbox Meetings on-site on a minimum weekly

basis.

The most relevant environmental issues that all personnel will be alerted to include:

- Fire
- Weeds
- Disposal of wastes
- Hydrocarbon management
- Driving and its possible effects on the local environment
- Adherence to the wishes and instructions of the pastoralists
- Strict adherence to instructions from AAPA in relation to sacred and heritage sites and other aboriginal matters.

In the carrying out of basic exploration activities, most environmental issues relate to ground disturbance. The Operator has documented procedures to cover activities such as camp set-up and camp management, road and track making and rehab, drill site construction and rehab and drill rig inspection etc.

5.4 Identification of environmental aspects and impacts

AMR utilises the Risk Matrix illustrated below to assist in evaluating risk for its various activities.

Table 6: Risk management framework

Likelihood Rating \ Consequence Rating	UNKNOWN	1 NEGLIGIBLE	2 MINOR	3 MODERATE	4 MAJOR	5 SEVERE
UNKNOWN	UNKNOWN					
A ALMOST CERTAIN		M	H	H	E	E
B LIKELY		M	M	H	H	E
C POSSIBLE		L	M	M	H	H
D UNLIKELY		L	L	M	M	H
E RARE		L	L	L	M	M

By applying this framework to conditions identified in the proposed exploration site, risks have been identified and assessed as documented in Table 6.

Table 7: Environmental aspects and management measures

Aspect	**Possible/Probable Impact**	**Risk Rating**	**Management measures (prevention)**	**Management measures (remediation)**
Campsite *	Minimal disturbance to local environment	Low	Minimal clearing and disturbance.	Rehab where necessary. Sanitise and Infill toilet excavations; fill any garbage pits.
Vehicle Operation	Fauna and Flora disturbance; weed and pest spread Dust Noise; Hydrocarbon Spill; Soil erosion	Low	Monitoring of vehicle use; driver training; washdowns; personnel and contractor awareness of issues. Regular vehicle maintenance. Slow driving in camp and drilling operation areas.	Removal of hydrocarbon contaminated soil. Disposal of weeds Site remediation.

Aspect	Possible/Probable Impact	Risk Rating	Management measures (prevention)	Management measures (remediation)
New tracks as access for drill rig.	Vegetation clearing Soil erosion Soil compaction Possible disturbance to drainage lines	Low	Existing Station roads/ tracks utilised where-ever possible. New access construction – scrapes only.	Rehab where necessary – erosion prevention. Allow to naturally re- vegetate
Drill site prepared, and sump(s) excavated	Vegetation clearing Soil compaction Soil erosion	Low	Cleared areas kept to minimal size	Sumps infilled. Drill holes capped, sites raked over. Topsoil re- spread. Rubbish removed to designated disposal sites.
Drilling Operation	Slight noise. DD rigs are comparatively quiet. Waste and rubbish. Soil contamination.	Low	Minimise noise. Waste and fuels management	Drillholes backfilled with drilling material and plugged. Removal of all waste from sites. Bunding of fuel storage area.
Waste Management	Pollution of local environment – flora, fauna, surface/ground water, air.	Low	Proper management and disposal of non-recyclable/industrial wastes – removal from site. Drilling contractor to remove all waste from site for subsequent proper disposal.	Inspect all drill sites and monitor disposal procedures to designated disposal sites.
Fire	Neighbouring landowners impacts. Flora and fauna loss. Potential injury to personnel. Loss/damage to equipment and infrastructure.	Low to Moderate	Induction document covers AMR's policy on fires in Project Area.	Fires not to be lit except in an emergency. Back burning if necessary to protect personnel, equipment, or infrastructure– Contact / warn / cooperate with landowners. Contact authorities.
Cultural or Heritage Sites	Discovery of Cultural or Heritage Sites/ Damage of Cultural or Heritage sites	Low	Invasive work is limited to areas cleared by the CLC and/or AAPA. All personnel instructed to keep out of AAPA designated areas	Reporting of any finding to senior personnel who will notify the Operator.
Hydrocarbons	Pollution of environment	Low	It is anticipated the drilling contractor operate a purpose-built fuel tank. All fuel drums to be stored in a cleared bunded facility.	Clean up spills, bag contaminated material. Take to appropriate waste management site.

Aspect	Possible/Probable Impact	Risk Rating	Management measures (prevention)	Management measures (remediation)
**Invasive Species including weeds	Damage to environment	Low	Vehicles trips to originate in weed-free locations. In consultation with the pastoralist, ensure that vehicles have wash-down at an appropriate site (eg homestead) before entering the exploration-precinct.	Identify infestation and remove where feasible.

* Drilling Contractor and supervisors will establish Campsite close to area of operations; exact location to be agreed with pastoral land management.

** Certain weed species are endemic. The species are recorded in **Appendix 4** of this document.

5.5 Environmental audits, inspections and monitoring

The company's on-site representative will be responsible for inspection of all areas of disturbance and, after consultation with the Operator, will direct what remediation / rehabilitation works are required to be carried out.

The main disturbance activity that will be carried out on the licence during the current year will be Diamond Core Drilling. There will be no other form of drilling, apart from water supply drillholes to support the drilling activities, incorporated into specific core drill sites. It is envisaged that there will be minimal disturbance to the land surface as pre-existing tracks and fence lines will be utilised for access to most drill holes. It is anticipated that the field operations including tracks, drill sites, and camp will involve clearing of a total of less than 7.5 Ha.

Contractor vehicles will be inspected and checked to ensure that there is no site contamination by vehicles/equipment leaking fuels or fluids. The on-site Project Geologist has the authority to approach the contractor's representative to ensure all breaches are corrected immediately.

Contractors will be required to present their environmental Policy and Procedures manual to the Operator's Representatives prior to formal engagement.

Methods of auditing will be to record observations and take located and dated photos. If necessary, a report will be prepared. The company will take photographs with a GPS equipped camera before and during disturbance activities and will follow up with photos of remediation / rehabilitation results. The will include all access clearing and the drilling operation.

All vehicles coming on to the project area will be required to be clean of weeds, mud etc. At this stage it is hoped that the drilling company to be contracted will be based in Tennant Creek. The drilling vehicles, equipment will be clean and compliant when they leave their base. The Operator's vehicles will leave their base (Darwin) clean and compliant. All mobile equipment will also be washed down prior to entry to the work site at either Kurundi Homestead wash- down area, or another site agreed with the pastoralist.

5.5.1 Environmental Performance Objectives and Targets

5.5.1.1 Water Management

Water encountered in drill holes is not normally analysed. In the case of diamond core drilling, water is required for the drilling process. Water would be accessed from an external source such as a bore or a

waterhole. Where to access water for drilling was discussed with the Pastoralist (telephone conversation 2nd June 2018). Initially water will be drawn from Fat Bullock Bore, but it is the Operator's intention to seek drilling water supplies from purpose drilled holes closer to drill sites.

5.5.1.2 Invasive Species Management

All contractor vehicles coming on to the licence will require proof of washdowns carried out since their previous job. The contractor also needs to state where the vehicles have been prior to entering the project area and, if known, what weed species occurred there. The detailed wash- down procedures is described in Table 6 above.

Feral animals are not expected to be an issue that the Operator will need to directly deal with. The proximity of the licence area to Canteen Creek and the localised population density influences the presence and distribution of feral species.

5.5.1.3 Flora and Fauna Management

All exploration activities in the present MMP will be carried out on pastoral land. The Operator intends to utilise existing access such as fence lines and station tracks to conduct its activities. This greatly reduces the risk of interfering with natural habitats should they exist in the region.

A record will be made, and a location posted of any significant habitat so that personnel are aware of the specific area to be avoided. The relevant Commonwealth website indicates that there are no specific flora/fauna habitats of significance in the region.

5.5.1.4 Waste Management

- No refuse will be left on any drill site.
- For diamond drilling, plastic sheeting will be placed under the drill rig and any operating motors to contain potential leaks/spills of hydrocarbons or other fluids.
- Management of fuels is set out in the *Remote Area Camp Setup and Management* document.
- No bulk fuels will be stored on the licence. Only sufficient fuel for the drilling and support equipment will be kept on-site.
- No hazardous substances/chemicals will be stored on the EL during the period of the MMP.

5.5.1.5 Noise and Air Quality Management

There are no lasting environmental effects from engine noise or dust production.

Diamond core drill rigs are quiet. No dust is produced by the drilling process.

Personnel will abide by a strict speed limits off-road, which will reduce dust produced by motor vehicles. The effects of dust on fauna and flora are minimal, dust is visibly seen to settle within 2-5 minutes of a vehicle passing through and within close bounds of the tracks.

All attempts will be made to keep dust and noise to a minimum.

5.5.1.6 Culture and Heritage Management

AAPA were contracted to complete a Sacred Site Clearance of the area and a certificate was provided to AMR in n2013. The results of the Clearance survey are summarised in Figure 7. This indicates that all areas notified in the Certificate have been avoided in the planning of activities.

The Operator and its employees and its contractors will be made aware of the location of culturally sensitive and sites and areas. Contractors such as earthmoving contractors, will be accompanied by the Operator's

representative when performing their work duties to ensure that no such sites are entered.

5.5.1.7 Rehabilitation and Environmental Performance

The Operator, AMR has a policy document (Appendix 2), which has been designed to cover all the environmental and social aspects of its operations. The document is titled 'Protecting the Environment' and states that the company will 'conduct exploration activities in ways that create minimal disturbance to the environment and people'. In accordance with this policy, strict compliance with rehabilitation procedures and statutory regulations will be followed.

For Air Core or Reverse Circulation drilling programs, all holes are plugged immediately after the hole is completed. Sites are then cleaned up and raked over, either at the completion of the hole or at the end of the program. Excess sample will be used as back-fill for the holes. Hole collar coordinates are recorded

For Diamond Core drilling programs, after completion of the hole the plastic outer collar pipe is plugged. Once it is determined that the hole will no longer be required for deepening etc, the casing will be cut below ground level, re-plugged, and the collar covered in line with departmental Guidelines. The site is cleared of all rubbish. Excavations (sumps) are back-filled ASAP when earthmoving equipment is available, but within 6 months of completion. The site is raked over and topsoil redistributed along with any cleared vegetation.

Constructed access will be minimised with station tracks and fence lines used where possible. Scrapes, utilising a Front-End Loader (bucket up) is the preferred method for constructing access if required. This method creates minimal surface disturbance of flora and has been used very successfully in the region in past AMR programmes in the district. All Operator constructed access tracks will be assessed for rehab after completion of the drilling program and thereafter at ideally 6 monthly intervals until obviously stable. These inspections will be combined with other excursions to maximise cost effectiveness.

The level of activities planned will not affect water, flora, or fauna. Operator's personnel and contractors will be accommodated in a nearby campsite to be selected following discussion with the pastoralist. The camp will be installed according to approved procedures.

The principal disturbance activities that are most likely be carried out in the future will be drilling programmes (Air Core, RC or Diamond Core) with probable associated access track clearing.

Soil management hasn't been necessary as the 'bucket-up scrape' method used to clear access does not disturb topsoil and natural vegetation quickly re-establishes. This would be confirmed with 6-monthly inspections until obviously stable.

Issues of environmental have been identified in Table 6, along with mitigation and remediation measures. Consistent with the Operator's policy, all issues of environmental performance:

- will be undertaken in collaboration with stakeholders connected with EL 28521 and surrounding area
- will involve regulators where required
- will monitor both include continual monitoring of company and contractor work practices
- will be included the maintenance, continual review and upgraded where necessary of documentation.

Targets set for the rehabilitation of drill sites are:

- plugging / capping the drill hole after drilling, removal of any sample bags from site (if applicable),
- general site clean-up and removal of flagging tape, survey pegs etc
- checking that there are no residual impacts such as stains etc from fuels or drilling products

- in the case of Air Core and RC drilling methods, excess sample will be returned to the hole
  the condition of access and drill hole locations will be rechecked at the completion of the program and six-monthly intervals following rehabilitation, every 6 months completion until the rehabilitation areas are stable
- all holes will be GPS recorded for future monitoring
- cleared tracks will be monitored for regrowth (as with the exploration site, monitoring can be carried out at approximately six-monthly intervals until stable to provide data for the calculation of percentage regrowth of grass and shrubbery).

5.5.2 Performance reporting

The Operator will ensure that personnel are regularly monitored for their environmental awareness - vehicle handling, hydrocarbon management, fire management, flora and fauna considerations and waste disposal. Thus, the performance outcomes are expected to meet AMRs requirements for managing the minimal impact of environmental issues.

The Operator will ensure that the above objectives will be successful. As explained in the previous section, all aspects of environmental performance will be appropriately documented for the scrutiny of stakeholders and regulators.

5.6 Emergency procedures and incident reporting

Environmental incidents / emergencies likely to occur in the mineral exploration workplace / environment would be mainly associated with hydrocarbon spillage, and wild fire.

The on-site Project Geologist is the senior person and is responsible for instigating emergency procedures and conducting incident reporting after consultation with the Operator. The Project Geologist will be on site for the duration of any exploration activity.

It is expected that the drilling contractor will have a purpose-built fuel tank on the support vehicle and adequate fire control equipment (fire extinguishers etc.). Refuelling of the rig from the support vehicle will be monitored. Amounts of fuel involved are small. It is a requirement that the drilling contractor will provide fuel spill kits.

In the case of a scenario where a fuel spillage occurs, the Emergency Procedure is as follows:

- Contain any spills
- Notify persons affected and eliminate source of emergency if possible
- Report incidents to the Operator who will alert the statutory authorities
- Rectify problem
- Prepare Incident Report

Reporting procedure for fires will involve alerting the pastoralist and local communities and if necessary to implement actions to protect life and property.

Incident reporting requirements are legislated under the Mining Management Act – Division 4 whereby the Operator must report a serious accident or critical incident, which may be followed by an investigation. Failure to comply with these terms may results in penalties as outlined under the Mining Management Act.

The Operator's obligations to report incidents or accidents under the Mining Management Act are summarised

as follows:

- The Operator must report the serious accident or critical incident as soon as practicable after the Operator becomes aware of the occurrence of a serious accident or critical incident on the site.
- The Operator must notify the Chief Executive Officer (DPIR ME) of the occurrence. If the Operator gives oral notification, then the Operator must also give the Chief Executive Officer written confirmation of the occurrence as soon as practicable after the notification.
- The Operator must investigate a serious accident. If a serious accident occurs on a mining site, the operator for the site must carry out an investigation to determine, if possible, the cause of the serious accident, and give the Chief Executive Officer a written report about the serious accident that includes information on remedial actions taken or to be taken and recommendations for the prevention of the occurrence of further similar accidents.

The written report referred to must be given within 14 days after the occurrence of the serious accident or within the period that is agreed between the operator and Chief Executive Officer.

A person must not interfere with a place where a serious accident occurred unless permitted to do so by a Mining Officer. A person is not to be taken as interfering with a place where a serious accident occurred if the person takes an action at the place to prevent further environmental harm.

6.0 EXPLORATION REHABILITATION

6.1 Exploration rehabilitation register

The following table provides the rehabilitation register.

Table 8: Rehabilitation register

Disturbance	**Rehabilitation Activities**	**Schedule (Timing)**	**Closure Objectives / Targets**	**Monitoring Techniques**
Drill holes – Diamond Core	Collar pipes cut to 400mm below ground level then capped. All holes plugged and backfilled.	At completion of hole. Take photos	No further rehab of collar anticipated	Hole coordinates GPS recorded. Hole collars will be inspected at about 6 months to ensure stability. Photos of site area to be taken before disturbance and after rehabilitation for comparison.
Drill Sites	Backfill sump(s). Clean up site. Rake over. All sites on level pre-disturbed ground.	Site clean-up and rake-over at completion of hole. Backfill sumps when earthmoving equipment on-site or within six months.	No further rehab is anticipated	Four of the 2018 drill sites are on or near established tracks; the other three will require new access tracks and pads. Sites will be inspected and monitored in conjunction with collars.
Tracks / Gridlines	Access to sites and position of sites on pre-existing station tracks and clearings will not be rehabilitated, and new tracks will be rehabilitated if required by pastoralist.	At the same time as sites are rehabilitated	Any rehabilitated tracks would be expected to regrow rapidly and naturally since 'blade-up' clearing does not remove topsoil.	Monitored during inspection of drill collar rehabilitation.
Camp	Clear up site; infill any excavations; remove all rubbish	At completion of drilling program.	No further rehab anticipated	Will monitor at 6 months.

6.2 Costing of closure activities

Accompanying this MMP is the Security Calculation) sheet for the current years proposed program. Closure costs are included (**Appendix 5**). The summary of the Security Calculation is included below (refer to Appendix 5 for assumptions and itemised calculations).

Table 9: Security calculation summary EL27821

M & E Security Calculation Tool Exploration Operations "AMR"			
Security Calculation Summary			
Details			
Contact Name	Michael Beer	**Authorisation #**	TBA
Project	EL27821	**Date**	6-Jun-18
MMP			
Calculation Trigger			
New Authorisation	**MMP Renewal/amendment**	**Audit Finding**	**Client Request**
☒	☐	☐	☐
Domains			**Calculated Cost**
Site Infrastructure			**$0.00**
Exploration			**$3,744.00**
Post Closure Management			**$2,755.00**
Sub-Total - All Domains			**$6,499.00**
CONTINGENCY @15%			**$974.85**
TOTAL COST			**$7,473.85**
10% Discount			**$747**
Amended amount			**$6,726**
1% levy			**$67**

Appendix 1: Correspondence with Kurundi Station Manager

The following provides correspondence between the proponent and the Manager of Kurundi Station relevant to the proposed exploration.

App1.1 Correspondence to Kurundi Manager

AUSTRALIAN MINERA RESOURCES PTY LTD

2 June 2018

Attention Mr. Ben Saint,

The Manager, Kurundi Station,

PO Box 508,

Tennant Creek, NT, 0861

Dear Mr. Saint,

Mining Management Plan 2018 for EL27821, Australian Minera Resources Pty Ltd.

Recent changes to Mining Management Plan (MMP) approval procedures require that the holders of exploration licences who wish to conduct "substantial disturbance" must obtain the written consent of land owners and managers, and possibly other stakeholders to our programmes. For your information, I attach an extract from the MMP guidelines.

These formalities are now required in lieu of the informal cooperative relationship that has existed between us for several years now. Hopefully these requirements will not interfere with those relationships nor result in too much inconvenience.

In 2013, Australian Minera Resources Pty Ltd (AMR) conducted geochemical surveys and an airborne geophysical programme on AMR's EL27821, which straddles the Canteen Creek access road on the eastern boundary of Kurundi and includes a little of the NT Crown Land on which Canteen Creek Community is located. The next phase of the exploration programme that AMR wish to pursue is the drilling of a few deeper core holes which will be initially on Kurundi.
This is based on the evidence we have that there may be favourable rocks beneath cover within the EL for mineralisation of the types found elsewhere in the district, as well as copper- gold deposits like those found at Tennant Creek. The attached map shows the approximate locations of the holes we propose to drill. Please note that only three or four of the seven indicated sites will be drilled in this phase, and which of these will be drilled has yet to be decided by AMR. At each site, a nominal 250m deep core drill hole will be completed, and then rehabilitated.

Drilling of diamond core holes is normally conducted by a contractor on 2x 12-hour shifts with a crew of a driller and an offsider for each shift. Each hole will take about 6 days to drill. A geologist from Eupene Exploration Enterprises (EEE) will supervise the drilling and determine the location, orientation, and progress of the hole, then decide when the hole will be terminated. Subsequently the core will be logged and processed and removed from site. A camping site would be established somewhere on Kurundi, possibly near Fat Bullock Bore to take advantage of existing supply if you are OK with that. At least initially, some water would be drawn from that bore to get drilling underway, but we would attempt to locate water closer to the drill sites once we are established.

Lubrication of the bit and removal of cuttings from the hole in diamond core drilling is achieved by circulation of water, along with natural or biodegradable additives to assist lubrication, prevent water loss into down hole openings, and return of cuttings. This drilling water is kept in a closed circuit between the hole and the sump, with make-up water from a clean water tank supplied from a bore by a water truck, normally supplied by the contractor. The cuttings will be buried, and the holes

Australian Minera Resources Pty Ltd
Phone: **03 9600 3599**
E-mail: mbeer@beerandco.com.au

plugged once the programme is completed. Given the local geology, there is no chance that the programme will have an impact on aquifer integrity.

Access to each site would be by existing tracks or fencelines where possible, and we would give these a tidy up before commencing the programme. Otherwise, new tracks would be cleared of vegetation with minimal ground disturbance. Drill pads of around 50m x 50m would need to be cleared and a drill sump to collect cuttings will need to be excavated at each site. The sump, as well as the drill site clearing, and campsite will be rehabilitated after the programme. We would consult you on whether you wish the tracks we clear to be rehabilitated. Some pastoralists ask us to leave these to assist with fire management and if you would like us to do this we will need a letter to that effect at the end of the programme.

I assure you that this programme has nothing to do with "Fraccing" and there is no potential for those resources in EL27821. This is just normal mineral exploration of the sort you are already quite familiar with.

We would be keen to utilise any earthmoving equipment that the station has available on a competitive basis, as well as to discuss campsites or accommodation as well as water truck with you, though our final requirements will depend on the particular drilling contractor and his equipment.

Please be assured of our ongoing desire to maintain a mutually cooperative and straightforward relationship for the conduct of exploration on Kurundi.

As you will understand I require some written confirmation that you are OK with this proposed programme. If I can assist with this, please contact me or Geoff Eupene.

With best regards,
Yours sincerely,

Michael Beer,
Director.

Australian Minera Resources Pty Ltd
Phone: 03 9600 3599
E-mail: mbeer@beerandco.com.au

AUSTRALIAN MINERA RESOURCES PTY LTD

EXTRACT FROM "Mining Management Plan and Public Report Structure Guide for Exploration Operations"

DEPARTMENT OF **MINES AND ENERGY** 29 August 2016 Version 1.0:-

2.0 Identified Stakeholders and Consultation

This section must include the following:

- A list of all interested parties and stakeholders that have been consulted. This may include, but is not limited to:

- Lease owner

- Land owner

- Land/pastoral Manager

- Land claimants (Native Title)

- Land Council representing the Traditional Owners for the country

- Neighbours and communities

- Tenement manager

- Government Departments

- Shareholders.

- Name and title of persons consulted, and issues discussed. Include any specific concerns raised during consultation, actions taken to address them and the status of these matters.
- An outline of the ongoing arrangements and consultation process undertaken with the underlying landowners and managers, and other interested stakeholders, to ensure they are informed and that their concerns are considered.
- Evidence that two-way stakeholder communication has been carried out with the managers of pastoral property at title application stage and after grant, informing them of intended activities. This two-way stakeholder communication must be undertaken each year or when activities change.
- Where exploration is proposed on parks and reserves and land managed by the Parks and Wildlife Commission, evidence of two-way communication with Parks and Wildlife Commission must be provided (may be included as an appendix).
- Details of the plan and arrangements for maintaining the communications process throughout the life of the MMP.
- Evidence of the agreement reached with the land managers regarding access to the pastoral property and specific requirements of the land owners and managers (may be included as an appendix).

Notification to and responses from landholders and managers will be considered before MMP approval is issued.

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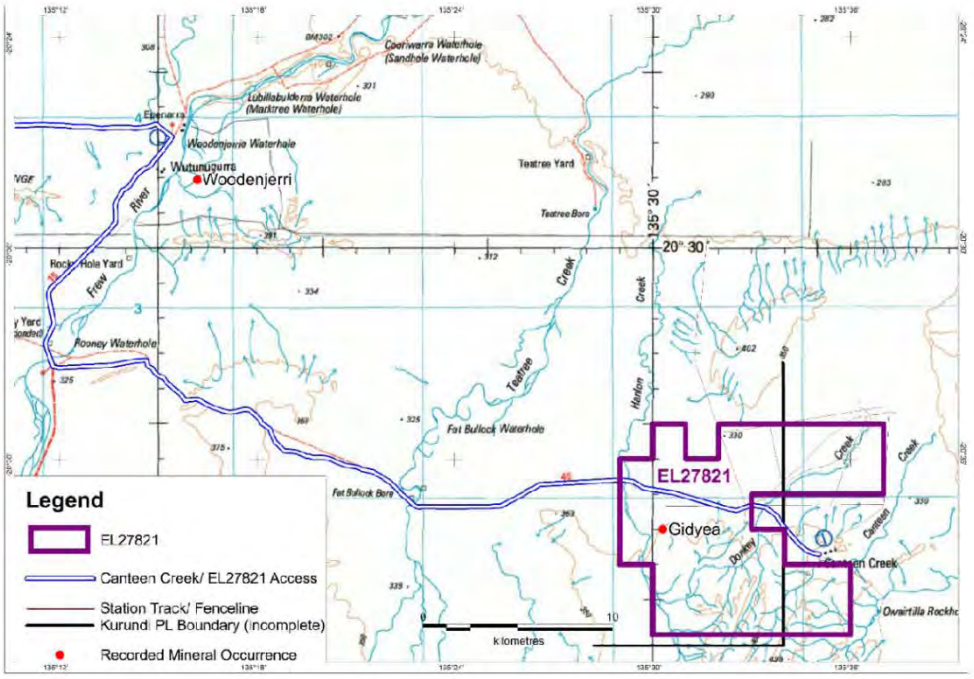
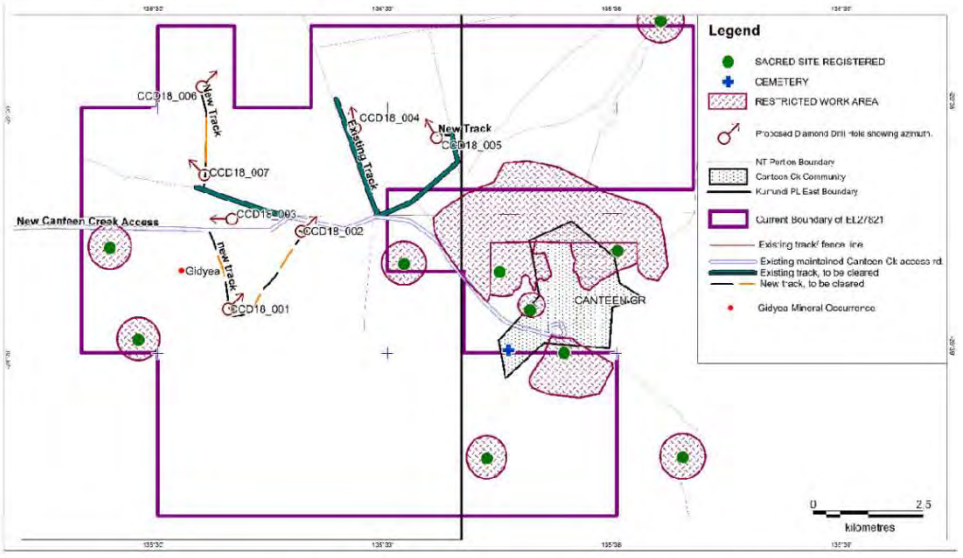
E-mail: mbeer@beerandco.com.au

AUSTRALIAN MINERA RESOURCES PTY LTD



Location of Exploration Licence 27821.



Map showing activities proposed in 2018. (not all holes will be drilled but sites may be cleared).

Australian Minera Resources Pty Ltd
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App1.2 Correspondence from Kurundi Manager

KURUNDI QQT STATION

PW & BM SAINT
PO BOX 508
TENNANT CREEK
NT 0861
Email kurundi@bigpond.com

KURUNDI STATION
PH 08 89641964
FAX 08 89641516
ABN 12 759 740 071

Attn Michael Beer
Director
Australian Minera Resources Pty Ltd

Dear Mr Beer,

Re: Mining Management Plan 2018 for EL27821, Australian Minera Resources Pty Ltd

Thank you for your letter detailing your planned drilling activities on your exploration lease located near Canteen Creek and Fat Bullock on Kurundi Station.

As mentioned in your letter any agreements are to be more formalised than in previous years. For your information we are now obliged to have a biosecurity plan for our pastoral activity in place plus we are applying for organic status for our property. This means we have to be more diligent in overseeing the activities on our pastoral lease.

Our consent to the outlined drilling programme is given with the following conditions:

- Under our biosecurity obligations all vehicles that will be driven on to pastoral land need to be cleaned of any possible weed contamination prior to entry.
- Induction – All personnel on site at the drilling are to be made known to the management of Kurundi and contact numbers given , the main reason being in the event of an emergency ie bushfire, response procedures can be established.
- Environmental management, all waste from drilling and the camp is to be contained and removed from the station.
- Cattle Management – measures be taken to exclude cattle from the camp and activity areas
- Road Access - prior to any upgrading of existing tracks or establishment of new tracks full consultation with Ben Saint on use of our equipment and location is required.
- Water – Again consultation with Ben as to use of water truck at commercial rates if required, estimates of water to be used and costs associated with the supply of water.
- Camp Site – to be negotiated with Ben as to the most suitable. Camp site to be fully rehabilitated at the completion of the programme.
- Drilling Outcomes – Kurundi management is to be advised if any water is found in the drilling process.

If you have any queries on the above points please let us know as we would also like to maintain a mutually cooperative and straight forward relationship during your time at Kurundi for the drilling programme.

Yours sincerely

For PW & BM Saint

Appendix 2: AMR Environmental Policies & Management Standards

Please find below a copy of AMR's Environmental Policies and Management Standards documents. Where relevant, these follow NT Government Guidelines.

1. AMR Environmental Guidelines
2. AMR FIELD SITE ENVIRONMENT and SAFETY INDUCTION DOCUMENT
3. NT Weed Management
4. Construction and Rehabilitation of Exploration Drill Sites
5. Clearing and Rehabilitation of Exploration Gridlines and Tracks

App2.1 AMR ENVIRONMENTAL GUIDELINES:

PROTECTING THE ENVIRONMENT

Objective: *To conduct exploration activities in ways that create minimal disturbance to the environment and people.*

Introduction

In most countries environmental law, regulations and guidelines exist to provide direction for exploration activities. Australian Minera Resources (AMR) strives to ensure our exploration meets or exceeds all regulatory requirements by applying best practice standards of environmental stewardship as summarised in the following.

Policy for development, communication and management of AMR standards

In preparing and implementing instruments for the management of environmental and socio-environmental impacts, AMR's policy is to follow established guidelines and consider the following:

a. Adopt, and make public, policies and procedures for the management of environmental and social issues;

b. Create a management and reporting structure that identifies objectives and allocates appropriate resources and responsibilities for the environmental and social aspects of exploration projects;

c. Apply relevant national regulations, home country, or international good practice guidelines for environmental management;

d. Establish procedures for management of the environmental issues that are appropriate to conditions in the exploration area;

e. Provide induction for all employees, contractors, and relevant members of local communities regarding the procedures AMR will adopt to prevent, mitigate, and ameliorate potential impacts of exploration and mining on the environment;

f. Gain assurance from contractors that they have the capacity to implement operational controls and comply with environmental policies and procedures.

Policy for Impact Assessment and Management

AMR is aware of the potential impacts of its activities and will apply appropriate management processes to avoid, manage or mitigate negative impacts. In doing so, AMR's policy is to:

a. Conduct an initial, and then periodic, assessments of the direct, indirect, and cumulative environmental and social impacts, risks, and hazards of exploration activities on the environment and people, and anticipate environmental and social effects should exploration

lead to development of a mine;

b. Conduct and document baseline environmental and social studies to establish pre-existing conditions against which changes can be monitored and share the results of such studies with the stakeholders;

c. Consult with government and the local community to identify the potential to augment or complement existing land use and development strategies or plans;

d. Wherever possible, incorporate local or traditional knowledge and practice into baseline studies and the management of environmental issues while at all times being respectful of the nature and confidentiality of such information;

e. Have in place and periodically test procedures and equipment to respond to environmental incidents;

f. Create and implement procedures for managing chance finds of archaeological sites, artefacts or cultural items;

g. Use processes that reduce the consumption of energy and water and provide for the safe storage and disposal of hazardous materials and residual wastes; and,

h. Where-ever feasible, carry out continuous remediation and reclamation of lands affected by exploration activities.

Policy for addressing Vulnerable Environments and Biodiversity

AMR's policy is to avoid impact on vulnerable environments and species, areas of significant biodiversity as well as locations with special social and cultural significance, by:

a. Respecting legally-designated protected areas and implementing practices that support biodiversity assessment;

b. Consulting with Indigenous peoples and local communities to identify valued environmental, cultural heritage and locally-importance sites, then subsequently making clear to these stakeholders how the exploration project respects these matters; and

c. Supporting the development and implementation of sound, inclusive and transparent approaches to land-use planning, biodiversity, conservation and mining based on the best available data, including traditional knowledge.

Policy for Monitoring and Reporting

AMR's policy is for Project Managers to implement processes of monitoring and reporting on environmental performance to inform management, government, local communities, shareholders, and other interested parties. In doing so, Project Managers are required to report promptly all environmental accidents or incidents to the appropriate authorities according to relevant regulations, including being transparent about plans to manage the accident or incident. Project Managers shall also consider the need to:

a. Create a community-based process for participation in environmental monitoring and verification of environmental management performance and, where necessary, provide training and resources to community participants so that such activities are meaningful and

effective; and

b. Prepare and publish regular reports on environmental performance that, wherever feasible, are validated by the community or other third-party observers or investigators.

App2.2 AMR FIELD SITE ENVIRONMENT and SAFETY INDUCTION DOCUMENT

ALL AMR PROJECTS - FOR ALL AMR PERSONNEL & CONTRACTORS

Introduction

AMR is committed to providing a safe, productive workplace as well as environmentally acceptable surrounds for all workers, contractors, workplace visitors and any other stakeholders that may be affected by the Company's activities, and the legacies of those activities. All personnel can assist AMR in achieving this goal by:

- carefully reading and understanding this document;
- following the rules of the workplace;
- complying with any reasonable direction given to you by the AMR designated person in charge for your workplace or Health & Safety Representative (HSR), and;
- showing respect to your fellow worker and behaving appropriately as required according to the legislated 'Duty of Care' provisions that apply to all persons at the workplace.
- Being mindful of the Company's environmental undertakings and responsibilities and assisting to maintain these, both with local stakeholders as well as under the Mining Management Plan approved by the current NT government agency administering the Mining Management Act.
- Being aware of our obligations under any Agreements with Aboriginal Land Councils and honouring the obligations of the company and individual workers under the agreements.
- Respecting any Aboriginal Sacred Sites that have been advised to the company and the conditions applying to entry to those areas.

The purpose of this document is to introduce new Australian Minera Resources (AMR) employees and contractors to the code of conduct (rules), hazards, and risks associated with the AMR field-based workplace in order to provide a safe working environment. This document outlines AMR's required code of conduct for all persons working within all AMR Project areas (not just the camp itself). This document also describes the general risks associated with working in the field environment, and also the specific risks associated with the type of work you will be expected to carry out. This document also describes the risk management strategies employed by AMR in order to reduce the potential for workplace accidents and incidents. These risk management strategies will be presented as rules and regulations that you must understand and agree and adhere to at all times when located in

the AMR work area or otherwise conducting work duties on behalf of AMR.

An experienced AMR representative will guide you through this induction document and at the end of the induction session you will be required to sign this document to confirm that you acknowledge and understand the risks and requirements associated with the work you will be undertaking with AMR and to demonstrate that you agree to the terms and conditions of your employment/ contract with AMR as presented in this document.

All AMR field-based operations will have a base camp or headquarters (HQ) where project staff/contractors will be accommodated and where the Project Manager will be based. In certain circumstances separate field camps will be established if work areas are too far away from the base camp/HQ and daily travel between these areas is deemed to be impracticable. In most circumstances, AMR establishes and maintains the project campsite/HQ. All equipment, including vehicles, and supplies, etc. located at the site are the property of AMR and must be treated with care and respect. Permission must be obtained from the Project Manager in order to operate any AMR vehicles, machinery, and/or other equipment. The Project Manager will further clarify the terms of use for specific high-value items such as laptop computers, sat phones, etc.

The campsite (as well as the entire project area) is controlled by AMR and comes under the authority of the designated Project Manager or other appointed AMR representative. You must comply with all reasonable requests given by the senior AMR representative on-site.

PERSONAL RISKS

It is imperative that all field-based persons are aware of the risks that are present within, and associated with, the AMR field-based work environment. Although AMR will make all attempts to manage hazards in order to minimise risks and provide a safe work environment, it is the responsibility of the individual to show duty of care by being aware of the hazards and associated risks and to take all measures necessary to minimise the risk of harm to self or others. By following the workplace rules and regulations as outlined in this document you will greatly reduce the chance of yourself or others around you being injured or worse. Risk factors may vary depending on the specific circumstances of both the individual and the project. The major risks associated with AMR's field activities that have the potential to cause death or serious injury are as follows:

- Dehydration/ Heat Stroke
- Vehicle accidents
- Human-wildlife interactions (snake bite, etc.)
- Disorientation (getting lost)
- Misuse of heavy machinery/vehicles

- Serious illness (if far from a medical facility)
- Falling from height
- Fire

Minor risks associated with AMR fieldwork are:

- Sunburn
- Negative interactions with other people (violence/abusive behaviour in the workplace)
- Minor cuts, abrasions, bruises, blisters, etc. due to bushwalking and/or other activities.
- Stress related conditions caused by isolation or other factors
- Minor illness
- Falling/slipping

Risk Management Plan for General Work Duties

The Project Manager or other senior AMR representative will provide direction regarding specific duties and all reasonable requests made by appointed AMR representatives must be obeyed. If you are unsure about the proper procedures or have limited knowledge about the tasks that you have been asked to carry out, or you are unsure about the proper safety controls, then you must mention this to your immediate supervisor so that you may be given proper instruction and/or alternative duties. In general, work duties will fall into one of the following two categories:

1) Camp/HQ maintenance/operational support, or

2) Fieldwork. A list of the specific risks and worker awareness issues for each category is given below.

1. Camp/HQ Maintenance and Operational Support Duties

Maintenance and operational support duties such as cooking, cleaning, shopping, vehicle and camp/HQ repairs and maintenance, etc. are critical for the effective implementation of the AMR work program. Although these types of duties may be considered to be 'easier' and less risky than other types of field-based jobs there are still important safety and other issues to be considered. Some of the specific potential hazards that may be encountered and issues to be aware of when conducting these duties include:

- Accidental ignition of Liquid Petroleum Gas (LPG) due to system damage/leakage.

  - LPG is commonly used in the field for cooking and water heating purposes. LPG is extremely flammable and accidental ignition may cause an explosion with the potential to cause death or serious injury. AMR must ensure that all LPG systems are properly maintained and checked by authorised agents. However all AMR field workers must check LPG system for leaks or damage before using and report any such leaks/damage to supervisor if any found. LPG should never be used if system leaking or damaged. Never smoke or ignite a flame in the vicinity of an active or dormant LPG system.

- Vehicle accidents caused by driver fatigue, improper use, hazardous driving conditions, or a collision with another vehicle;
  - Do not operate a vehicle if you are tired or otherwise suffering from fatigue. Always check that vehicle is in operable condition prior to use (pre-start checks – tyres, oil, belts, battery, general condition, etc.). Speed limits to be adhered to, seat belts to be worn, and safe driving techniques to be employed at all times. Do not attempt any advanced off-road 4WDing if you are not trained or experienced in off-road/4WD techniques. Be aware that driving on dirt roads requires specific techniques and slower speeds compared with driving on sealed roads. Slow down and give plenty of room to road trains, other large vehicles, and animals (wildlife or stock) if encountered on the road. Do not drive if visibility is low because of dust etc. because of the danger of collision. Stop the vehicle off the road and wait for the visibility to return.
- Power tool accidents;
  - Do not operate power tools without prior permission from supervisor. Be sure you are aware of proper technique required to operate power tools safely (you must read the operating manual/instruction document prior to use). If you are unsure of proper operating method then request instruction from supervisor or other qualified person, and following this if you are still not sufficiently confident to operate the tool/s safely then you may request to be assigned a different task. Correct Personal Protection Equipment (PPE or safety gear) including safety glasses, ear plugs, gloves, and safety boots must be worn when operating all power tools – see manual for tool specific PPE requirements. Chainsaws to be operated by experienced trained operators only.
- Physical contact with poisons, dangerous chemicals (battery acid, poisons, etc.) or liquid hydrocarbons (fuel, oil, etc.);
  - Ensure that you wear proper safety gear as per the manufacturers' instructions (heavy duty plastic gloves, boots, proper clothing - long pants/shirt, etc.) and are careful with the application of dangerous chemicals so they do not spill (always use a plastic spill sheet when pouring). If your skin comes into contact

with such chemicals then wash affected area under running water immediately - follow manufactures instructions as to exact washing method/time. If accidently ingested (swallowed) then read back of label for instruction, notify your supervisor or nearest available person and seek immediate medical help – emergency medical contact numbers should be posted in all camp/HQ areas.

- Camp/HQ Fire.
  - In case of camp/HQ fire sound alarm immediately (vocal – yelling) and evacuate immediately to a pre-determined muster point. Conduct head count to ensure all persons accounted for and follow further instructions from Project Manager or other most senior AMR representative on site. All residence-based HQs should be fitted with smoke detectors and both bush camps and residence-based HQs should all be fitted with sufficient fire extinguishers to be stored in an accessible and visible location that is known to all persons.
- Burns from hot oil, cooking implements, vehicle exhausts, campfire, etc.
  - Be aware of hot surfaces and treat with appropriate care. Do not attempt to extinguish oil-based fires with water or other method; you must extinguish all oil-based fires with dry chemical fire extinguisher or specified fire blanket only. In case of burns treat immediately with correct application of first-aid from a qualified person (all projects should have personnel with first-aid qualifications available on site). Report and request assistance for treatment of serious injuries immediately.
- Electrocution from misuse of electrical equipment, faulty/improper electricity supply, contact with live electrical wiring, and/or other method.
  - AMR will ensure that all electricity on site is generated and distributed (supplied) in a safe and proper manner and is compliant with all relevant laws and regulatory requirements. Whenever handling, operating or repairing any electrical equipment always follow manufactures instructions and safety recommendations and prior to undertaking any such works pre-start safety checks should be conducted to ensure that electricity is supplied in a safe and proper manner – never assume this is the case. Never leave electrical connections or exposed or internal wiring with the potential to sit in water or become blocked with dirt, leaf matter or other debris – if such a situation is observed then safely disable power supply to affected area and repair or replace deficiency before resuming normal power supply operations. Report all suspected electrical problems/concerns immediately to your supervisor.

2. Fieldwork duties.

There are several types of fieldwork duties that you may be required to undertake, including radiometric surveys (walking long-distance gridlines), soil or stream sediment sampling (walking shorter distances and collecting samples), drillers'/geologists' off-sider (assisting in operation of drill rig, preparation of core samples, mapping, and other activities as required).

A range of activities that you may be involved in for the company that involve **"substantial disturbance"** must be conducted in accordance with an a Mining Management Plan (**MMP**) that must be **approved** by the Authorities. The Company undertakes in the MMP that these activities will be conducted so as to minimise damage to the environment and in most instances requires that the "substantial disturbance" is subsequently rehabilitated to acceptable standards using approved procedures. The NT Government produces Guidelines for the conduct of certain activities and if you are involved in these activities you will be provided with Guidelines appropriate to the tasks in which you are involved. Wherever practicable, these guidelines must be adhered to. If they are not appropriate for the situation that you face in complying with the Company's responsibilities under the MMP, you must seek the guidance of the Project Manager who needs to agree with the variation to the procedure. A selection of the guidelines for common tasks in our work are included at the end of this document.

During the early exploration phase of a project walking gridline survey type work constitutes the bulk of AMR's field-based activities and therefore is extremely important to the overall success of the project. When conducting these types of duties, a person will spend most of the working day in the wilderness in small teams (often only two people) and sometimes by themselves in the case of motor bike or All-Terrain Vehicle (ATV) based surveys. Persons undertaking these types of duties must be extremely fit and will be expected to be able to operate effectively under extreme conditions (hot weather, off road driving, isolation, etc.).

A certain set of skills is required to undertake these duties, including knowledge of hand-held GPS units and compasses and topographical maps (for navigational purposes), off-road 4WDing, extremely good common sense, understanding the functions of instrumentation in use, extremely good physical fitness and endurance capacity, and a natural ability to orient yourself in the wilderness. Training will be provided for GPS, compass, map and other instrument use, however, things like fitness and common sense cannot be taught but will be expected.

The specific risks and risk management strategies associated with AMR fieldwork duties include:

- Dehydration/Heat stroke.

- All persons must carry sufficient water supplies and take regular rest breaks in the shade. This is the most important safety aspect to remember when conducting survey type duties. Dehydration due to insufficient intake of fluids (especially water) can cause dehydration, disorientation and death (heat stroke) within a very short time period, especially in hot weather and even more so if you are not used to working in such conditions. This is particularly relevant as many of AMR's projects are conducted in arid (dry) and extremely hot locations. Five to seven litres of water per person per day is the minimum amount a person should consume when doing full-time survey work but often more than this amount will be consumed! At least two to three litres of water should be carried on your person (depending on the amount of time you are away from additional supplies). A backpack based portable water system is the most efficient method to carry water (carry on your front if using a spectrometer). Electrolyte fluid replacement drinks such as Sqwincher, Gatorade, Staminade, etc. are very good for combating or preventing symptoms of dehydration, especially when sweating a lot.

- Vehicle accidents and incidents

  - Licensed operators only to use vehicles and operators' license class must be compatible with type of vehicle being operated. It is assumed that if a person is licensed to operate a particular type of vehicle that they are also able to properly and safely operate that vehicle and that no further training is required. Safe and defensive driving techniques are to be employed at all times when operating AMR vehicles. Be extra vigilant when driving in hazardous conditions and make sure that you are able to handle the conditions when driving off road and that you know how to recover a vehicle from being bogged – including use of electric winch, remembering that different types of ground surfaces require different techniques for both driving and vehicle recovery.

- Human-wildlife interactions (snake bite, etc.)

  - Avoid interactions with all potentially dangerous wildlife – keep a safe distance. All animals are unpredictable so if you are unsure of, or have little knowledge about animals then treat all wildlife and stock animals as potentially dangerous (even insects) and stay away. Never handle or approach high-risk animals such as spiders, snakes, buffalos, camels, pigs, crocodiles, etc. Remember that seven of the world's top ten most venomous snakes are present in most AMR project areas!

- Disorientation (getting lost)

  - It is easy to become disoriented and lost when working in the field, especially if you are unfamiliar with the project area. Make sure that you are

aware of your position in relation to camp/HQ at all times and take the time to familiarize yourself with prominent landmarks in the area. Make sure that you are confidently able to use your assigned navigational equipment and always carry a hand-held compass as batteries may fail in battery operated navigational systems such as spectrometers and other GPS units. If lost after dark then do not attempt to move, try to contact base-camp/HQ (satellite-based communications such as a sat-phone or a SPOT tracker, should be carried at all times), find shelter, make a fire (will keep you warm and make it easier for search party to locate your position) and wait for the morning before moving again. Learn to use a signalling mirror and carry one when venturing out.

- Misuse or malfunction of industrial equipment

  - Before operating, or approaching heavy machinery or equipment being operated, make sure that you have been briefed on the proper safety requirements associated with that particular machine/equipment. This is especially relevant when working with drill rigs and/or in the vicinity of earth moving equipment. Always assume that the operator cannot see you and take appropriate precautions to protect yourself – don't rely on others to manage your safety!

- Serious illness (far from nearest medical facility)

  - If you are feeling unwell report your symptoms and provide up-dates on your condition to your immediate supervisor. If you feel that you require medical attention let it be known and you will be taken to the nearest medical facility ASAP. In case of emergency all efforts will be made to get you to nearest appropriate medical facility as fast as possible. This may require evacuation by helicopter or light aircraft.

- Falling from height/Slipping.

  - This is an ever-present risk when conducting survey work. All survey workers will slip or fall at some point during their work. Take precautions such as wearing appropriate footwear (lace-up boots not shoes), be aware of the surface terrain as different surfaces require different walking techniques and be especially careful around loose stones (especially sandstone), and also do not attempt to navigate terrain that you consider to be too risky, i.e. do not put yourself in a situation where you may fall from a cliff or otherwise seriously injure yourself if you fall/slip. Look for alternative access to your destination.

- Sunburn/sunstroke
  - Always wear appropriate clothing such as a brimmed hat and long-sleeved shirts when working and use 30+ sunscreen on all areas of exposed skin.
- Off road driving
  - 4WD vehicles are required to access most of AMR's project areas. Getting bogged, breakdowns, and accidents are hazards presented by the use of vehicles in isolated and rugged terrain. In some areas vehicle operators will be required to keep the vehicle on pre-existing tracks, however in other project areas off track 4WDing (also known as 'bush bashing') may be allowed and may be necessary to conduct your work. It must be remembered that with both on-track and off-track 4WDing a basic knowledge of vehicle mechanics and operation is required and basic maintenance and pre-start checks on all vehicles is mandatory and will be the responsibility of every vehicle operator. THE OPERATOR is responsible for ensuring that the vehicle is fit for the work ahead and carries all accessories that might be required in the course of the work.

    Off-track 4WDing requires skill and extensive experience and/or training to become proficient – even professionals can come unstuck! Creek crossings, steep ascents /descents, crossing swampy, sandy or rocky ground, and other difficult situations will be required at most AMR projects , therefore it is necessary that all potential off-track 4WD operators of AMR vehicles be trained and/or experienced enough to satisfy the standards of the project supervisor/manager before being allowed to operate vehicles in an off-track environment. If required site specific training in off-track 4WDing will be provided by a qualified person. Until such training and approval is received, personnel are not to operate vehicles off-track.

The minor risks associated with AMR fieldwork are:

- Sunburn
- Negative interactions with other people
- Minor cuts, abrasions, bruises, blisters, etc. due to walking or other activities.
- Stress related conditions caused by isolation or other factors
- Minor illness

Please be aware of the risks associated with any activity you are undertaking on behalf of AMR and take appropriate care to protect yourself and your fellow workers at all times. Remember that the safe work methods presented in this induction document and other

training that you may undertake cannot compensate for any lack of care or awareness on your part, and you must show such care to yourself and to others in order to comply with your 'Duty of Care' obligations as stipulated in Australian statutory law, therefore it is the responsibility of every person to ensure that they are conducting themselves in a safe manner at all times.

1. General Workplace Conduct

- Implement 'Duty of Care' obligations at all times;
- Maintain a clean and tidy living/work area, always ensuring unrestricted access and egress for any particular location – both in the field or in a bush camp or residence-based HQ;
- In consideration of others that share these facilities with you, ensure that communal facilities are clean after use – showers, toilets, washing machines, eating and other common areas, etc;
- Smoking is a fire and a health hazard and therefore is not allowed in food preparation areas or areas where people consume food. No smoking in tents, residence or office buildings, and other enclosed spaces;
- Show respect for your fellow worker, violent, rude or abusive behaviour towards other persons (violence in the workplace) will not be tolerated and serious or repeat offences will result in dismissal;
- When operating vehicles within the camp areas vehicle speed must be kept to a minimum in order to prevent dust from entering the camp/HQ area. Speed limit on minor dirt roads/tracks is 60 km/h and safe driving techniques must be employed at all times;
- Respect private property at all times. Never take another persons' property or consume another persons' food, beverages, or cigarettes without the owners' express permission. Such incidents will be treated seriously and will be considered as stealing and may result in a written warning or even dismissal;
- Do not physically or verbally abuse fellow workers. Sexist and/or racist attitudes and comments will not be tolerated in the AMR workplace;
- Always show respect for the environment during the conduct of your work, remembering that you are representing AMR and your actions can and do have the potential to impact on the public profile of the company. It is expected that all AMR workers and contractors will understand and accept AMR's environmental values in order to maintain and respect the natural environment and will not undertake any actions that may compromise or otherwise do not conform to AMR's environmental policy and the Company's obligations under the MMP that applies to project

activities (a copy of AMR's environmental policy document is provided to all employees upon engagement, and site specific MMP obligations will be discussed during induction and at Toolbox Meetings when these are changed);

Workplace Health & Safety Toolbox Meetings

Workplace Health & Safety Toolbox meetings will be conducted on a weekly basis and must be attended by all persons currently working at a particular site. The purpose of these meetings is to discuss any safety or other relevant issues that any person on site wishes to raise in order to improve on-site safety or efficiency. These meetings will be chaired by the senior onsite representative of AMR.

Campsite Facilities and Layout/Planning

The Project Manager shall strive to implement the following criteria in all AMR camps:

- Toilet locations – holes for toilets to be flagged and screened off (prior to usage). Ensure that toilet is located a reasonable distance from any recreational or sleeping area;
- All persons to be instructed on the handling and usage of hazardous materials, including garden lime (toilets). Material Safety Data Sheets (MSDS) are available for all hazardous substances (including garden lime) present in the work are. These MSDS must be read and instructions carefully followed at all times by all persons prior to handling of any hazardous material;
- Sleeping and office tents to be located in safe and suitable areas, i.e. away from overhanging branches, old rotting trees, fire hazards, toilets, crocodile and mosquito habitat, etc.;
- Core logging and processing area to be located at least 30 metres from the camp living areas;
- At least one vehicle must remain in camp at all times – unless camp is uninhabited;
- First Aid Kit locations to be known, identified (signage), and accessible to all persons at all times;
- Fire extinguisher locations to be known, identified (signage/flagging) and accessible to all persons at all times;
- Satellite phones (satphones) to be available at all project camps/HQs. Direct all requests for use of satphone to project manager or other most senior AMR representative;

- Drinking (potable) water locations to be known and accessible to all persons at all times;
- Electricity generation and distribution sufficient to provide power to both common (camp/HQ) and personal areas (tents/rooms);
- Ablution facilities to be available to all site personnel. The scope of these will depend on the local factors, but should be adequate for personnel using the site, who should be involved in the planning and installation of the facilities wherever possible.
- Recreational facilities such as internet, television, games, etc. may be available at some project locations and are accessible during off-time only. Usage rules and conditions to be determined by Project Manager. Failure to comply with rules may result in access privileges being temporarily or permanently denied. These facilities may depend on very expensive satellite communications and abuse of these facilities may result in pecuniary penalties to assist recovery of costs, which could amount to thousands of dollars.
- AMR projects will ideally be manned by a dedicated cook as a permanent team member, otherwise cooking and clean-up duties will be undertaken by **all** AMR personnel on a rotation basis. Food and cooking facilities will be provided to all authorised persons on all projects, unless alternative arrangements have been approved by the Project Manager.

Waste Management

- All non-industrial and non-recyclable waste to be put in the appropriate bins, taken to the camp dump and ignited/burnt on a daily basis or otherwise dealt with according to the agreements in force with local land managers;
- Industrial/recyclable materials must be contained separately and disposed of at appropriate waste disposal facilities (see 'waste disposal section'). These items include tyres, batteries, metal, glass, used filters, etc.;
- Hydrocarbon waste is not to be dumped on-site. For example used oil from servicing machinery is to be transported off-site and disposed of correctly, i.e. handed over to a licensed recycling facility;
- All drilling contractors **MUST** remove all their industrial waste from the AMR site (broader work area), including oil or oil contaminated materials (i.e. oil filters) and empty drilling consumable containers**. IT IS THEIR RESPONSIBILITY AND LEGAL OBLIGATION TO DO THIS**;
- Alcohol containers: If in a bush camp where alcohol consumption is permitted, it is environmentally desirable that beer be purchased in cans rather than glass. Crushed

cans are easier to store and it is preferable to recycle aluminium rather than glass. Enquiries can be made with local charities or schools if they wish to take advantage of the NT Container Deposit Scheme refunds and the company is pleased to cooperate in participation in these should the scheme be implemented by the local charity.

Alcohol & Drugs

- Moderate Alcohol consumption is permitted in AMR camps unless specifically stated otherwise. It is required that the consumption of alcohol will be done in a responsible manner. AMR does not supply alcohol to its employees or contractors but retains the right to control its consumption. Irresponsible actions by a person as a result of excessive alcohol consumption may result in dismissal from the project camp and/or company, and/or blanket restrictions being placed on further alcohol consumption at the site;
- If alcohol consumption is not permitted on a particular site, for example, because of an agreement with an Aboriginal Land Council, then no person entering the project area shall possess or consume alcohol. Penalties will be as stipulated in the applicable agreement, which may include removal from worksite and dismissal.
- The possession and use of Illegal drugs is prohibited and may lead to removal from the camp (in the case of contractors) or from the Company (in the case of AMR employees). Other action (including legal) may also be taken;
- If a person appears to be intoxicated or under the influence of drugs then that person will be deemed not fit for work on the day. That person will not be paid for the day lost and further disciplinary actions may also be taken;
- Any person driving company vehicle **MUST** have zero blood alcohol level.

Project Area Conduct

The land on which AMR carries out its exploration programs could be Freehold, Leasehold or Crown land, and in most areas where AMR is operating, the land is used for farming and/or grazing. In some instances, you may be operating on Aboriginal Freehold Land, and if so a separate induction will apply with considerably different rules. It is current practice to have a written agreement with all landholders that govern the conduct of explorers, but the details of these vary. Any specific arrangements affecting a project area will be notified during the induction and the operation of the arrangements will be discussed at Tool Box meetings. I general terms, the following procedures will always be followed on the Company's projects:

- **Always** make contact with land owners prior to going on the land and let them know what your activities will consist of and where you will be operating. This applies to each and every entry. Ask them if there is anything you can get for them if travelling off site and returning.
- Take note of any specific requests/instructions that the land owner conveys to you and either follow them to the letter or ask for clarification and negotiate with them an acceptable procedure if their requests don't at first seem practicable; always make sure both parties are clear about their expectations of the other. Normally you should not pursue any situation that threatens to be confrontational but try to refer the situation to the Project Manager for resolution with the land manager.
- Drive safely and according to the land owners/managers instructions at all times; if there is a dirt road around the homestead, for safety and to mitigate dust and noise, do not exceed 20kph when driving past the homestead. Watch out for children pedestrians and pets. Be aware that pedestrians may be intoxicated and behave unpredictably including placing themselves in the vehicles path.
- Do not damage any infrastructure on the property – gates, fences, etc. Keep an eye out for wandering stock and take care not to disturb them. Make sure you have permission if you want to use bores, camp etc. Supply appropriate fuel if you do. Always leave gates as you find them. If gates are open, then leave them open. Let the land owner know if gates are found open – just in case! Also advise them of stock wandering on fenced roads, or observations of behaviour that may affect the welfare of stock.
- Do not travel on dirt roads, tracks after rain. Land owners get upset if their access is damaged. Allow at least several hours for roads to dry out; perhaps somewhat longer, depending on local conditions.
- Follow instructions with fire. There can be severe penalties for lighting fires particularly in fire bans. Company personnel have lost their jobs on the spot over this. Be sure your camping arrangements and campfres will comply with requirements.
- Weed identification and management information information relevant to your project area will be provided to you so you can be on the lookout for weed infestations. Many pastoralists have problems with the spread of noxious weeds and may request a wash down procedure when entering (or leaving) a part or all their land. They will have instructions to follow and may have fixed facilities that they request you use. Please be sure to follow these instructions with care even if you believe the risk of contamination from your vehicle is zero. The wash-down requirements should be established in advance. AMR has suitable equipment for this if it is required, but often the pastoralist will want you to use their facilities.

Aboriginal People and Land

Most land in the NT is either covered by the Native Title Act or the Commonwealth Aboriginal Land Rights Act (ALRA). Most of AMR's activities in the NT are conducted on land, which is covered by the Native Title Act.

The organisations that deal with Indigenous Australian issues in the NT are the:

- Northern Land Council (NLC),
- The Central Land Council (CLC) and
- The Aboriginal Areas Protection Authority (AAPA).

The land councils are autonomous elected bodies governed under the ALRA. The AAPA deals with sacred site identification and heritage issues on land not under the jurisdiction of the land councils and is an agency of the NT Government.

AMR usually deals with these organisations to carry out searches of the sacred sites register (AAPA), conduct site surveys (all organisations) or assist in liaising with Traditional Owners. The country which AMR explores in the NT may be the subject of Land Claims, which are administered by the Native Title Tribunal or the Aboriginal Land Commissioner, depending on the legislation governing the claim.

- It is imperative that field personnel familiarise themselves with the locations and conditions attached to all sacred sites that have been identified to the Company within the project area and access. Very serious penalties can attach to infringements of Sacred Sites laws and these will never be knowingly requested or condoned.
- Sacred sites, heritage sites (e.g. aboriginal paintings) and aboriginal artifacts (stone implements, etc.) are protected by law and cannot be interfered with. Any breaches of this law can incur heavy penalties such as fines and / or jail sentences.

2. VEHICLES AND VEHICLE USAGE

- Pre-Start checks are mandatory every time a vehicle is engaged – regularly check fluid levels (oil, water, windscreen washers, brake fluid and fuel), tyres (inflation, tread, fitting, sufficient spares with correct and functioning tyre changing tools, including adequate operable jacks), electrical (battery connections free from corrosion build up and properly secured), lights, indicators, windscreen wipers, fire extinguishers, special vehicle lighting if required at particular sites etc. The operator is personally responsible for the state of the vehicle, even if he has delegated this task to another person. **Remember to always take a large container of drinking**

water with you on every trip no matter how far or for how long you intend to go – you may be on your own for much longer if problems are encountered;

- Regularly check under side of vehicle for sticks, grass, fluid leaks, etc.; particularly, watch out for buildup of grass, particularly spinifex around drive trains and on steel guard plates. These can quickly lead to vehicle fires that can result in vehicle destruction.
- Have a checklist for recovery equipment – tick off before going anywhere. If going into remote country have a tool kit (including tyre levers), shovel, mattock, axe, 'Hi-Lift' jack and base plate, snatch strap, tyre repair kit (including tubes and tubeless plugs if appropriate). Be sure that you know how to safely use the 'Hi-Lift' jacks;
- Check water tank. Take extra drinking water containers (full);
- Make sure your vehicle is fitted with a fire extinguisher and check that it's sufficiently charged;
- Make sure that the winch is operating correctly and you know how to set up and use it safely;
- Don't run fuel tanks down to empty or near empty; many vehicle problems are caused by dirty fuel. Be aware how to clean a fuel line.
- Inform the Project Manager if you suspect there is a problem with a vehicle or if you think that repairs are required;
- Be aware of vehicle service dates and report any vehicle that is due or past due for a service;
- Report any new vehicle accidents, incidents or damage;
- Drive vehicles according to the conditions – keep within posted statutory speed limits. Slow down on bush tracks and **take extreme care and go very slowly when driving off track ('bush bashing'): this should normally be conducted in 4WD Low Range**; look for and try to avoid obstacles (stakes in particular) that may damage tyres.
- When approaching the campsite slow down to 20 kph speed limit to keep dust to a minimum. If possible avoid driving within the camp confines;
- Park in designated parking area at campsite;
- All persons must have zero blood alcohol when operating AMR vehicles;
- No smoking in all AMR work vehicles.

3. FIRST AID

- It is desirable to have a current 'Apply First Aid' certificate. It is AMR's recommendation that at least two persons on any particular project site have a current valid First Aid certificate;
- Ensure that contractor's representatives have valid First Aid certificates;
- If working remotely, or as part of a drill crew, it is advisable that at least two persons have current First Aid certificates;
- Locations of First Aid kits should be signposted and accessible and all personnel should be aware of their location. At least one large First Aid kit should be in the office/kitchen area of the camp. All vehicles/drill rigs should be equipped basic First Aid kits.
- Take note of any contents removed from the First Aid kits (keep a list) and add these items to the 'shopping list' and replace them ASAP so that the kit is always up to date.

4. COMMUNICATIONS

Equipment

Ensure that all personnel (contractors included) are aware of the following:

- The locations of, and how to operate, the various types of communication equipment in the camp and vehicles (satphones, radios, SPOT II satellite trackers, etc.). All persons must ensure that battery is fully charged, equipment is operational and that they understand how to operate it properly before proceeding to take any communications (or other) equipment to the field.
- **All Important Phone Numbers and Emergency Phone Numbers must be posted in several visible and accessible places around the campsite.** Ensure each vehicle is equipped with such a phone list (laminated – in glove box or behind seat).
- Who to call in the case of an emergency:
- Emergency services (000) or nearest hospital directly;
- Notify AMR site or HQ management who has a statutory duty to notify agencies such as Mines Operations and WorksafeNT;
- Notify Police of any accident involving a motor vehicle where another vehicle, property are involved and/or if any injury has been sustained;
- Poisons Information Hotline in case of poisoning.

- **Drillers must have appropriate and functioning communication equipment at the drill site.** A satphone is mandatory especially when the drillers are working at distance from the base camp.

5. PERSONNEL MOVEMENTS

Personnel **MUST** record/relay their movements out of the camp irrespective of whether they are going to work in the field or are driving to town (i.e. Darwin, Alice Springs). If driving to town then ensure that the camp is contacted on arrival at destination.

A **Personnel Movements Board** is set up for the purpose of recording movements of people/ vehicles in and out of the camp.

The Notification Board will record:

- Name(s) of persons;
- Work areas and/or specific location. This can be expressed as MGA94 coordinates and/or marked on a map that will be left at camp;
- Time left camp and estimated time of return;
- Which vehicle you will be using;
- Number of the satphone in vehicle.

In the case of person(s) not returning to camp or making contact at or near the specified time, a search will be activated. Initially this will comprise two persons mounting a search from the camp to the working area as indicated on the map or as per the GPS coordinates. If the person is not located within a time period as specified by the Project Manager (or other most senior AMR representative) then Emergency Services/Police will be notified.

Emergency Situations & Evacuation

- The '**Emergency Procedure'** will be posted at several locations around the campsite. This procedure applies **ONLY** to situations involving a **serious injury** or the immediate threat of injury. Relevant emergency phone numbers and contact persons are recorded on the 'Emergency Procedure' document and on the separate Important Phone Numbers list.

- An emergency evacuation of the campsite may also be required. For example this would apply in situations where an out of control fire was approaching the camp and/or there was the risk of an explosion from a gas cylinder, fuel or other source. In such circumstances the AMR emergency procedure must be followed and any directions given by the Project Manager or other AMR representative in charge must be obeyed.

A **WARNING SIGNAL** (to be determined) will be sounded.

A **MUSTER POINT** will be established for each campsite or location.

ENSURE THAT THERE IS A VEHICLE IN CAMP AT ALL TIMES IN CASE OF EMERGENCY.

6. FIRE

Fire Types / Potential Causes

- Wildfires from lightning or deliberately or accidentally lit by a person;
- Vehicles can catch on fire themselves and they can cause wildfires through ignition of grass build-up underneath vehicle, sparks, hot exhaust, etc; Always check under vehicles regularly for grass build-up if travelling cross- country.
- Earth moving equipment can cause fires caused by sparks from blades or bucket hitting rocks;
- Gas cookers / Gas bottles;
- Out of control camp fires and rubbish pit burns;
- Cigarettes / lighters / matches;
- Fuels;
- Electrical.

Risk Alleviation / Prevention of Wildfires

- Always assume that there will be a fire sometime during the season;
- Ensure adequate fire breaks around campsite, essential infrastructure (fuel storage, generator, etc.) and equipment (vehicle parking area, drill rig, etc.);
- Preferably have a pressurised water source with hose at camp or alternatively a firefighting trailer (tank, pump, hose) available on site;
- Have several water-container backpacks at strategic points around campsite;
- Have several fire extinguishers placed around camp in accessible locations – hooked up to trees or other dedicated stand. Location of all fire extinguishers or other Fire Fighting Equipment (FFE) must be known to all persons and clearly sign posted.

Campfires

- OK if region burnt out or have created a sufficient fire break (10 metres);
- Campfire for cooking – in a depression surrounded by large cleared area (6 - 10 metres);
- **No campfires** on **Fire Ban** days;
- Fires at drill sites must be contained in approved containers;
- A fire blanket is required to be close at hand for cooking fires (ignited hot oil).

Flammable liquids

- Ensure proper storage of flammable liquids – away from naked flames and operating motors – especially if unleaded petrol (ULP);
- Area where fuels are stored should be indicated with correct signage, such as 'FLAMMABLE' , 'NO SMOKING', etc;
- Area where fuels or any other flammable liquids are stored should be surrounded by an adequately cleared area (fire break) and bunded to locally contain any spills. Commercially available fuel storage aids are encouraged.

Gas for Cooking and Hot Water

- Ensure that gas bottles are placed away from heat sources (fires, engines, etc.);
- Placed at least one (1) metre away from cooking area / showers;
- Ensure both gas bottles and regulators are regularly serviced and are 'in date'/valid and in good working condition.

7. Training & Pre-Work Safety Requirements

AMR is committed to provide a safe workplace for all of its employees and contractors. Properly trained workers/contractors who understand and obey all AMR safety procedures and guidelines are more likely to conduct themselves in a safe and proper manner, and thereby fulfil their 'Duty of Care' obligations as an employee.

As mineral exploration activities are classified as a hazardous activity under the Workplace Health and Safety Act 2011 in the Northern Territory a Job Risk Assessment (JRA) must be conducted by an appropriately qualified, experienced and skilled person/s for all jobs required to be undertaken on a particular project and the outcome of the JRA will determine what level/type of safety precautions/training will be required prior to a worker being given clearance to undertake that job.

All persons will undergo a Site Safety Induction immediately upon arrival to a new AMR field-based worksite (project area). Furthermore prior to any work being undertaken on a job by any person for the first time in a new work area[1] the appropriate (job specific) JSEA must be reviewed, and if necessary modified, then a Pre-Work Safety Check must be completed and attached to the JSEA. If available, Safe Work Method (SWM) documentation for a particular job must also be reviewed, understood and signed by all persons undertaking that job.

[1] Definition of Work Area in this context describes the entire area of control under a particular AMR project, not just an individual tenement but also includes area outside of AMR's tenements that may be accessed in order to conduct work duties, i.e. driving to town for supplies, etc.

In addition to the above mentioned requirements all AMR field personnel and contractors will be required to undergo some field-based training to be conducted by an experienced, qualified and skilled person and signed off prior to undertaking any of the following tasks. The type of training required will be determined by the outcome of the completed JSEA. The following paragraphs provide examples of the type of training that may be required:

- **Emergency Evacuation Procedure**, all persons will be made aware of the site specific emergency evacuation procedure & trained according their role/obligations within this procedure (i.e. bushfire management - prevention, fighting, etc.);
- **Geological & Geophysical Surveys**, training to cover Workplace Health & Safety aspects, survey techniques, orientation in the field (maps & compass and GPS use), and equipment use (including, as appropriate, Instruments, GPS, SatPhones, SPOT II satellite trackers, etc.);
- **Drillers' or Geologists' Offsider**, training includes explanation and demonstration of Safe Work Methods (SWM) for working on an operating drill rig, core-cutting saw (electrical circular saw with water lubricated diamond blade), and training for other tasks as required;
- **Advanced 4WD'ing,** training includes pre-recorded video presentation, emergency situation scenarios, breakdowns, hazards – recognition & avoidance, driver awareness & driving techniques (speed, gearing, potential tyre punctures – causes, avoidance & repair, etc.), vehicle limitations, creek crossings, vehicle recovery (with and without a winch), vehicle maintenance, etc.;
- **Chainsaw use**, including pre-recorded video presentation and practical demonstration from start to finish (including maintenance and repair). SWM for chainsaw use will be explained to and signed by all persons prior to being granted clearance to use a chainsaw at a AMR workplace.

Additional training may also be required and conducted as determined by the Project Manager/ Safety Manager. A Registered Training Organisation (RTO) must be engaged in order to conduct training for courses such as Apply First Aid, Radiation Safety Officer (RSO), heavy machinery operator's certificate, etc.

8. ENVIRONMENT (INCLUDING HUMAN-WILDLIFE INTERACTIONS)

AMR has a formal environmental policy (provided to you); all AMR personnel and contractors working on behalf of AMR should familiarise themselves with this policy and should conduct their work activities in an environmentally responsible manner – i.e. in a manner that is compliant with AMR's environmental policy. This is especially relevant when working in areas that are recognised as having High Conservation Values (HCV) or are

sensitive to disturbance, or when conducting work that has the potential to contaminate water supplies (ground or surface water), or otherwise have a negative environmental impact (pollution, noise, etc.).

A Job Safety & Environmental Analysis (JSEA) must be reviewed by all persons (and signed off by the Project Manager) prior to conducting any work in a new work area for the first time. Any potential negative environmental impacts that may occur as a result of undertaking a particular job should already be listed in the JSEA, however the purpose of reviewing the document is twofold, firstly to familiarise yourself with the potential for negative environmental impacts that could potentially result from undertaking this job and what action/s (if any) are required to mitigate or minimize these potential negative environmental impacts, and secondly, by reviewing and editing the JSEA (though the deletion of out of date or irrelevant information and the addition of new appropriate information), the JSEA and therefore AMR's overall environmental and safety management program has the potential to be continually improved. For example if you can think of any aspect of your planned job activity that has the potential to cause a negative environmental impact then you should share this thought with your supervisor, and if agreed, modify the JSEA accordingly.

Animals – Stock and Wildlife

Native and feral wildlife present in the AMR work area that have the potential to be fatal or cause serious injury to humans include:

- Insects and arachnids (wasps, bees, spiders, scorpions, etc);
- Snakes (seven of the ten most dangerous snakes in the world are possible in our work areas);
- Dingoes (documented to have caused human deaths);
- Crocodiles –present in most waterways in the 'Top End' of Australia (northern NT, WA and QLD);
- Some feral animals including pigs, buffalo (mostly 'Top End'), horses, camels, cattle, etc.

Hazards, Risk Minimisation & Treatments:

- Bites from insects with consequent allergic reactions – Appropriate use of PPE including clothing, footwear and use of insect repellent should negate the risk of insect bites. However if allergic reaction occurs administer appropriate First-Aid to affected area/s immediately;
- Snake Bites - In the event of snakebite, emergency services will be notified immediately and first aid applied using the pressure immobilisation technique, as described below.
  - Apply firm pressure over the bite, using your hand if necessary.

- Apply a crepe roller bandage to maintain pressure over the area of the bite.
- For a bite on the leg or arm, use a second crepe roller bandage starting at the toes or fingertips and working upwards to cover as much of the limb as you can. Apply the bandage as tightly as you would for a sprained ankle but not so tight as to cut off circulation below the bandage.
- Immobilise the affected limb with a splint to reduce muscle movement. Help the victim to rest if possible and do not let the victim stand or walk. Bring transport to the victim, unless this will cause a delay of 2 hours or more.
- Do not remove the bandages until the victim has reached medical care.

- Crocodiles – DO NOT swim in any waterways in the Top End. Crocodiles can inhabit very small creeks far from the coast;
- Buffalo, camels, cattle, horses, dingoes, and pigs are all potentially dangerous. Stay well away from then if encountered in the field;
- All large animals are a road hazard; be alert when driving, especially at night, which should only be undertaken in the bush in vehicles with adequate driving lights and bull bars. Be aware that they may turn back on their path, or there may be a "follower", or two. Be aware that many fatalities are the result of loss of control of vehicles at speed in attempting to avoid animals, and a quick assessment is necessary of the best chances of survival if an impact is impending. In most cases impact may be the preferable action, at as slow a speed as possible. Loss of control of the vehicle is usually to be avoided. Always drive with the possibility of sudden animal hazards in mind, and wear seatbelts.

Prevention:

- Be vigilant and wear correct PPE (gaiters/snake protectors, long pants, etc.) at all times;
- Keep tents zipped up (closed) at all times to prevent unwanted guests (snakes, scorpions, centipedes, etc.) from entering;
- Always check inside your boots before putting them on – turn over and bang on ground;
- If in the Top End be vigilant for crocodiles when near watercourses – **No Swimming!**;
- Always wear footwear and use a torch at night around the camp (snakes);
- Keep camp refuse in secure bins and out of reach of animals (pigs, dingoes);
- Drive at night **ONLY** if absolutely necessary.

9. RADIATION MANAGEMENT

AMR has a Radiation Management Plan that must be read, understood, and adhered to by all AMR personnel and contractors conducting work on behalf of AMR if working in a situation where radiation may be encountered. However it

should be noted that survey-based work presents very little risk above and beyond what could be considered normal in everyday life. AMR recognises that people may have particular concerns about radiation management and therefore a Radiation Safety Officer (RSO) will be present on all projects and will be available to answer any questions or queries that you may have.

Acknowledgment of Field Induction

I certify that I have received a verbal briefing covering the Field Site Safety Induction and that I understand what is contained in the document.

I also certify that I received a verbal briefing on radiation safety if it applies to the Project & general activities.

NAME OF WORKER:

……

COMPANY: ……

Any previous Mining, or naturally occurring radioactive materials (NORM) Project work, including uranium or mineral sands? -- If so, where and when?

……

……

SIGNATURE OF WORKER:

……

Copies of both the Induction and Radiation Safety Documents are kept at the camp and are available for reference.

AMR REPRESENTATIVE: .....

SIGNATURE: .....

DATE: .....

(This receipt must be retained by Instructor, Project Manager or other person in charge

App2.3 NT Weed Management Handbook

Northern Territory Government

Northern Territory

Weed Management Handbook

www.nt.gov.au/weeds

About this Manual

This manual has been developed to provide detailed information about weed control in the Northern Territory.

Weed Control Option Tables are available that detail herbicide recommendations and optimum treatment times for most problem weeds. Other control methods, which can assist in weed management, have also been described.

It should be noted that this document has been designed to provide information for the control of weeds in non-crop situations.

Disclaimer

While care has been taken to ensure that the information provided was true and correct at the time of publication, changes in circumstance after the time of publication may impact on the accuracy of this information. The Northern Territory of Australia gives no warranty or assurance and makes no representation as to the accuracy of any information or advice contained, or that it is suitable for your intended use.

The Northern Territory of Australia accepts no liability for any losses or damages, including incidental or consequential damages, resulting from use of the material.

Users of agricultural (or veterinary) chemical products must always read the approved label and any APVMA Permit, before using any product and strictly comply with the directions on the label and any conditions on the Permit. Users are not absolved from compliance with the directions on the label or conditions of the Permit by reason of any statement made in or omission from this publication.

Weed Management Branch

Phone: 08 8999 4567
Fax: 08 8999 4445
Email: weedinfo@nt.gov.au
Web: www.nt.gov.au/weeds

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If you suspect poisoning, please contact the Poisons Information Centre Emergency on 13 11 26 (24-hour) and/or call an ambulance.

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Weeds in the Northern Territory

Weeds severely impact the Northern Territory's (NT) environmental, economic, social and cultural values.

Environmental values such as biodiversity and ecological function are impacted, through the invasion and replacement of native plant communities and wildlife habitat. Weed infestations can also harbour feral animals, and hinder their control.

Weed infestations can reduce the availability of traditional foods and other resources used by Indigenous people by displacing native plants and animals. Weeds can influence the social well being of Indigenous landowners by disrupting their spiritual and physical connections to country.

Weed populations can also result in restricted access to and recreational use of natural landscapes. Hunting, fishing, camping and bushwalking can all be affected by weeds. Weed monocultures, such as those created by mimosa, significantly diminish the aesthetic values of the natural landscape.

Weeds in the NT cost land managers millions of dollars per year, through costs of control and lost production. The following information has been taken from the *2010 Pastoral Industry Survey Northern Territory Wide*. It shows the spending, per property, in each of the major cattle producing regions of the NT.

Table 1 – Amount spent annually on weed control per property and per square kilometre

Region	Average $/property	Median $/property	Maximum $/km^2
Alice Springs	1 332	0	0.00
Barkly	38 384	15 000	2.40
Katherine	11 938	6 500	4.80
Top End	52 947	30 000	45.50
NT Wide	20 884	5 000	3.90

Legislative Responsibilities

The NT *Weeds Management Act* (The Act) applies to all owners, managers and occupiers of land, and all other land users in the NT. To view the complete Act and the Weeds Management Regulations please go to: www.nt.gov.au/dcm/legislation

Once a weed is declared in accordance with section 7 of the Act there is a requirement for all land holders, land managers and land users to comply with the declaration classification. There are three classification types in the NT, these being:

- Class A: To be eradicated.
- Class B: Growth and spread to be controlled.
- Class C: Introduction into the Territory is to be prevented.

All Class A and Class B weeds are also considered Class C. For information on the classification of individual species please refer to the Weed Control Options Tables or visit www.nt.gov.au/weeds

Weed Prevention

Both owners and occupiers of land are required to take all reasonable measures to prevent their land being infested with a declared weed.

Spread Prevention

All land users are required to prevent the spread of a declared or potential weed. This requirement applies on and off your own property.

Advising of Outbreaks

Where a declared weed is identified on land where it has not previously been, or known to have been present, the person responsible for the land must notify the Weed Management Branch (WMB) of its presence within 14 days – see contact details on the inside cover of this document.

Weed Disposal

It is illegal to transport declared weeds. You should dispose of any weed material on site. Burning will destroy vegetative plant material and also render most seeds unviable. As some hard coated seeds may survive, on-site deep burial may also be required. On site burial of seeds, and/or plant material, is an effective option if material is placed at a depth sufficient to prevent emergence of vegetative shoots or seedlings.

Compliance with a Weed Management Plan

The owner and occupier of land on which a declared weed or potential weed is present must comply with any relevant weed management plan approved by the Minister in accordance with section 10 of the Act.

At the time of printing Weed Management Plans were in force for gamba grass, mimosa, bellyache bush, cabomba, prickly acacia, chinee apple and mesquite.

Monitoring by Government Officials

The Minister may appoint a Weed Management Officer or authorised person (‘Officer’), who is empowered to investigate suspected breaches of the Act. Officers have a number of powers under the Act, including entering and searching properties, documenting findings and, if necessary, ordering the owner or occupier of the land to control or eradicate declared or potential weeds. They are also able to order the owner or person in control of vehicle, boat or animal to remove or destroy any weed material.

Can I be Fined?

Penalties of between 77 and 770 penalty units ($11 473 and $114 730) for individuals and between 385 and 3850 penalty units ($57 365 and $573 650) for a body corporate apply for failure to comply with this plan*.

* Penalty units are determined by the Penalty Units Act. As at 24 September 2014 the Penalty Units Regulations prescribed the monetary value of a penalty unit as $149.

Strategic and Planned Approaches to Weed Management

Different levels, types and locations of weed infestation require different levels of investment, in terms of financial input, human resources and time. This document aims to assist landholders to determine the most appropriate course of action for their property. Effective management should involve:

- preventing introduction;
- preventing or suppressing reproduction, including prevention of seed production and vegetative expansion;
- preventing spread through dispersal of propagules, including seeds and viable vegetative sections;
- eradicating new/isolated outbreaks, particularly those high in the catchment and close to water sources; and
- where eradication is not possible, containing established populations.

These can be achieved by:

- developing/implementing a property management plan which complements other plans within the catchment;
- developing a budget for your weed management control;
- planning to exploit any known weakness in the weed's life-cycle or ecology;
- integrating all appropriate control methods e.g. biological, chemical, and mechanical;
- integrate weed control with other management actions e.g. managing grazing regimes, fire and feral animals;
- implementing a rehabilitation program e.g. revegetation; and
- implementing a monitoring and evaluation program.

Property Management Planning

Developing a property management plan for your property is about identifying and prioritising what needs to be achieved, within a set time frame. A plan should aim to systematically contain, reduce and in some instances, eradicate weed infestations, while protecting unaffected country. Ideally property management plans should take into consideration the weed's current distribution, the potential for spread (consider mechanisms for spread with respect to topography, proximity to water courses, proximity to access tracks/roads) and potential impacts on land use and other values such as biodiversity.

Property management plan templates are available from the Weed Management Branch (see contact details on the inside cover of this document). Weed Management Officers from the Branch, can provide assistance with the development of property management plans and can provide advice on all facets of weed management, including control techniques, biological control, legislative responsibilities, monitoring, reporting and regional planning.

Mapping

Any plan will need to address how big the problem is and where the problem is. Good plans should also take into consideration weed infestations in neighbouring areas.

The Weed Management Branch has produced the *Northern Territory Weed Data Collection Manual.* This manual describes what information to collect when mapping, controlling and monitoring weed infestations in the NT. The manual can be downloaded from www.nt.gov.au/weeds The manual is based on the national guidelines published in *A Field Manual for Surveying and Mapping Nationally Significant Weeds*.

The supply of weed data to the Weed Management Branch by individuals and groups using the manual is important to increase our knowledge of weeds within the NT. The collection of data in accordance with the *Northern Territory Weed Data Collection Manual* will result in improved and consistent data quality. Increased quality and quantity of weed infestation data across all parts of the NT is fundamental in planning and delivering strategic and coordinated weed management to protect the Territory's assets.

Coordinated Management

As weeds do not recognise property, tenure or state boundaries, it is imperative that land owners work together to coordinate a systematic management approach across catchments to contain weed spread. The responsibilities of individual land owners should be determined and clearly communicated. Complementary property management plans should be developed, administered and evaluated.

Monitoring and Evaluation

A property management plan should include realistic time frames and goals, recognising that achievements, particularly with regards to established populations, may only become evident in the long term. It is important to document weed occurrences and the control methods used so that success, or failure, can be critically analysed. Accurate records can enable a management program to be reworked or fine tuned depending on the need. Above all, continual maintenance is imperative otherwise reinfestation may only be one growing season away.

Weed Management Plans

Section 10 of the NT *Weeds Management Act* determines that the Minister may approve species specific Weed Management Plans for a range of purposes including:

- preventing entry of a species to the NT;
- managing a species within the NT; and/or
- managing a species within an area of the NT.

Weed Management Plans have been developed for a number of high priority species in the NT. Management requirements identified are consistent with those identified at the catchment, regional, NT and national levels. Information contained within this guide will assist in meeting requirements identified in statutory Weed Management Plans. Further information regarding the availability of these plans is available from Weed Management Branch.

Further Information and Resources

Detailed information regarding the management and identification of individual weed species are available from the Weed Management Branch. Examples of resources include Weed Notes, Weed Identification Tables and Best Practice Management Guides. Please visit the website www.nt.gov.au/weeds or email the Branch directly weedinfo@nt.gov.au for information.

Prevention

The easiest and cheapest form of weed control is prevention. Weeds can invade through a number of mechanisms and pathways, but invasion can be combated by applying a few basic principles:

- know what weeds are in your region and ensure they are not inadvertently brought in via items contaminated with seed (e.g. vehicles, machinery, hand tools, soil, feed, mulch and livestock);
- be able to recognise existing and potential weeds which threaten the NT. Early identification of an outbreak could save millions of dollars;
- use established roads and tracks and avoid weed-infested sites;
- if areas containing weeds are encountered, clean all equipment, vehicles and machinery prior to leaving;
- check boats, propellers and trailers before entering and leaving waterways;
- contact landowners before entering properties to see if they have any preventative measures in place;
- dispose of weed plant material and seeds by burning and/or burying at an appropriate depth;
- check the weed status of commercially available garden plants before planting on your property;
- never dispose of aquarium contents into drains or waterways; and
- control any weed infestations before they spread.

See Appendix A for information on the prevention of weed seed spread, including vehicle hygiene requirements.

Weed Control Methods

Physical Removal

Hand-pulling, although laborious, is effective for recent outbreaks prior to seed set. All root material should be removed from the soil and the plant destroyed to prevent re-sprouting. Grubbing is similar to hand-pulling but employs tools such as mattocks and spades.

Slashing by hand with a brush-cutter or using a tractor and blade can be an effective means of controlling weed growth and suppressing flower and seed development.

Chaining woody weeds can remove the roots and provide efficient rows for burning. This option is best implemented at the end of the wet season when soil moisture is sufficient to allow efficient root removal. Blade-ploughing can be used to push over some woody shrubs and sever their roots underground. The cultivation method is designed to expose the roots and then bury the plant deep enough that it cannot re-sprout.

Note: Disturbance of soil can facilitate weed growth, for this reason follow-up and regeneration work should form part of a management program. Physical removal should not be undertaken when a weed is actively producing seeds, as seeds are likely to spread and subsequently set in disturbed ground.

Control Using Fire

Fire is most effective as part of an integrated management plan.

In areas with a high fuel-load capable of sustaining a slow, concentrated fire, burning may be used to remove woody weed debris, destroy emergent seedlings and kill seeds. However it should be noted that cooler fires may actually scarify seed inducing germination.

Controlled fire can be used as part of an integrated weed control program to control grasses and non-woody species. When used as a management tool fire can kill seedlings, reduce seed production and encourage new foliage growth prior to herbicide control. Burning (or slashing) dense infestations prior to herbicide application can reduce herbicide costs, improve herbicide uptake and reduce application time. Burning can also improve access for other control methods.

Generally following an initial burn, fire should be excluded to provide other desirable plants with optimal conditions to establish and compete with any emerging weed seedlings.

Poorly managed or unmanaged fires can increase weed establishment by burning hot and fast. These fires cause minimal damage to the soil-stored weed seed bank, but can significantly damage native vegetation, hence stimulating prolific post-fire weed regeneration.

Note: Any management incorporating burning must be in accordance with the *Bushfires Act* and the *Fire and Emergency Act*. Please contact your local fire station for permits to burn if you live within a Northern Territory Fire and Rescue Service Emergency Response Area (NTFRS ERA). If you live outside a NTFRS ERA, contact your local Volunteer Fire Brigade Captain or local area Fire Warden through the Bushfires Council on Darwin 8922 0844 or Batchelor 8976 0098.

Biological Control (Biocontrol)

When an exotic weed is introduced, it arrives without the enemies and natural plant competitors that are present in its native range. Biocontrol is a method of weed management that attempts to regain the ecological balance that a weed would have in its native range. Release of biological control agents, such as insects or plant diseases, can decrease weed infestations to manageable levels, enabling other forms of control to be implemented. Biocontrol is a long-term approach and agents are only released after rigorous scientific trial and research to ensure that they will not damage native plants.
See Appendix B for additional information on specific biological control research and developments in the NT.

Chemical Control

Herbicides are commonly used for controlling weeds in both agricultural and non-agricultural situations. Numerous forms of application techniques and equipment are available to apply herbicides. The options chosen should be determined by the size of the infestation, the available resources, access and personal preferences. Detailed information on herbicide control options and correct usage procedures is included in this document.

Note: Users of agricultural (or veterinary) chemical products must always read the label and any Permit, before using the product and strictly comply with the directions on the label and any conditions of any Permit.

Integrated Weed Control

Integrated weed management combines the use of complementary weed control methods resulting in more effective, long term weed management outcomes. Integrated control requires planning, as often the timing of one control method can enhance the effect of another. An example of integrated weed management is the

- release of biological control agents to reduce vigour in a dense weed infestation **plus**
- use of herbicides to control satellite infestations of the weed elsewhere on the property **plus**
- management of a buffer zone around the dense infestation using physical/chemical control techniques **plus**
- reduction of grazing pressure in areas where weed eradication has been successful **plus**
- exclusion of grazing from areas with severe weed problems **plus**
- the implementation of preventative weed management strategies for the remainder of the property.

Land Management

Degraded or disturbed land is known to be far more susceptible to weed invasion. For this reason weed control cannot be viewed in isolation from other land management practices.

- Large feral animals, such as buffalos and pigs, can facilitate weed seed spread and germination through behaviours, such as roaming, wallowing and rooting. An effective weed management program should incorporate a feral animal control or exclusion program.
- Fire can be used as an efficient management tool for weed control or, conversely, uncontrolled fire can reduce land condition and facilitate weed establishment and spread.
- The management of clean buffer zones around affected areas can assist in managing outbreaks and containing large infestations.
- Continued maintenance of fire breaks, fence lines and roads can decrease the probability of seed spread and the development of new weed infestations.
- Appropriate stocking rates on suitable native and introduced pastures will allow maximum pasture growth to compete with weed seedlings. Weeds will flourish on over-grazed country.
- Hygiene practices are vital in order to maximise the effort of control methods. Land managers should use weed-free seed and hay, clean machinery, maintain quarantine areas for cattle which may be carrying seed and, where possible, eradicate or isolate infestation sources on the property.

Table 2 – Control Options

Infestation level	Biological	Chemical	Mechanical	Physical
Low (Canopy cover between 1% - 10%)	Not suitable.	Spot spraying by hand with a registered herbicide.	Not suitable.	Hand grubbing (remove roots and burn plant).
Medium (Canopy cover between 11% - 50%)	Release of biological control agents.	Spot spraying by hand with a registered herbicide.	Chaining, rolling, raking or back-ploughing, then burning.	Follow up control of seedlings – could include physical removal.
High (Over 50% canopy cover)	Inspect infestation to see if and what biocontrol agents are already present. If necessary, release biological control agents and monitor their progress.	Aerial spraying with a registered herbicide (provided there are no constraints against aerial spraying).	Attack with chaining, rolling or raking. Use fire to kill any regrowth and break seed dormancy.	Follow up control of seedlings – could include physical removal.

Using Herbicides Correctly

A person who uses a chemical product has a duty of care to ensure the use does not result in harm to the health of the general public, animals, the environment or domestic or export trade in agricultural produce.

The Australian Pesticides and Veterinary Medicines Authority (APVMA) register pesticides and herbicides for use in Australian States and Territories according to the provisions of the *Agvet Code Act*. In addition, the use of agricultural chemical products in the NT is controlled under the *Agricultural and Veterinary Chemical (Control of Use) Act* and regulations, including *Schedule 7 (Dangerous Poisons)* and *Restricted Chemical Products*. Herbicides must be used according to the directions for use on the APVMA registered label.

The following demonstrates a typical product label format. **It is illegal not to follow the label's instructions.**

MAIN PANEL

SIGNAL HEADING *(poisons schedule)*
TRADE NAME/DISTINGUISHING NAME
ACTIVE CONSTITUENT(S)
(chemical ingredient, concentration and formulation)
MODE OF ACTION
(eg: Group C Herbicide – see Appendix E)
STATEMENT OF CLAIMS FOR USE
(purpose for which product is registered)
PROHIBITION AND RESTRICTION STATEMENTS *(eg: do not apply by air)*
NET CONTENTS *(volume of container)*

ANCILLARY PANEL/S

DIRECTIONS FOR USE:
Restraints

Crop Pest State Rate Comments

NOT TO BE USED FOR ANY PURPOSE OR IN ANY MANNER CONTRARY TO THIS LABEL UNLESS AUTHORISED UNDER AN APPROPRIATE LEGISLATION.

OTHER LIMITATIONS *(eg: where the herbicide can be used, who the herbicide can be used by)*

WITHHOLDING PERIOD *(minimum interval that should elapse between herbicide application and harvesting, grazing, cutting, slaughtering or the collection of milk and eggs for human consumption)*

GENERAL INSTRUCTIONS
Mixing and application – *(eg: mix only with clean water, pre-dissolve and agitate)*

COMPATIBILITY *(may provide examples of chemicals which should not be mixed together)*
PROTECTION OF WILDLIFE, FISH, CRUSTACEAN AND THE ENVIRONMENT *(eg: some chemicals may not be registered for use in specific areas, such as watercourses)*
STORAGE AND DISPOSAL *(see appendix F for information on drumMUSTER and ChemClear)*
SAFETY DIRECTIONS *(this will include necessary personal protective equipment – PPE)*
FIRST AID *(appropriate actions and contact details will be provided)*
EMERGENCY INFORMATION *(will include contact number)*
REFERENCE TO MSDS *(material safety data sheet, this supplements information on the label)*

COMPANY WARRANTY STATEMENT
COMPANY NAME, ADDRESS AND AUSTRALIAN COMPANY NUMBER
Batch No: Date of manufacture: Expiry date *(for veterinary and some agricultural products)*
Dangerous good symbol *(if required)*.

A permit allows a person or organisation to use an agricultural chemical product in a way that is not in accordance to label direction and would otherwise be in contravention of the Agricultural and Veterinary Chemical (Control of Use) Act. Applications can be made to the APVMA for permits to use a registered product in another situation, different species, higher rates of application or an application method that is not allowed. See the APVMA website for application forms and further details on minor use, emergency use and research permits, and for current minor use permits www.apvma.gov.au/index.asp

Herbicide Toxicity

A herbicide can be defined as a chemical substance used to destroy or inhibit the growth of plants, especially weeds. Herbicides need to be biologically active or toxic, to be effective against the plants that they are intended to kill. In addition to the active ingredient, herbicide formulations may contain other chemicals, such as surfactants and carriers, which may also be toxic. Herbicides can have both immediate (acute) effects and chronic (long-term) effects on the health of people who are exposed to them. Correct administration procedures must be implemented to avoid adverse health effects.

Acute Toxicity

Poisonings resulting from acute exposure to herbicides can result in a symptoms varying from fatigue, headache, sweating and dizziness to numbness, changes in heart rate, difficulty in breathing and excessive salivation. Advanced poisoning cases may result in convulsions and coma which could lead to death.

Chronic Toxicity

The effect of long-term exposure to a chemical/s is referred to as chronic toxicity. Effects of chronic toxicity due to long term herbicide exposure include:

- neurotoxic effects (toxic effects on the brain and central nervous system);
- reproductive system effects - The Australian College of Occupational Medicine recommends that women who are pregnant, or likely to become pregnant, protect themselves against chemical exposures that may have adverse reproductive effects. Pregnant women should check herbicide label advice before spraying or using any chemicals.
- carcinogenicity (causing cancer); and
- endocrine (hormone) disruption.

Routes of Exposure

Chemicals can enter the human body through the skin, lungs, mouth and eyes. Extreme care should be taken to prevent exposure to herbicides, the following should be considered:

- The exposure risk is highest when handling the concentrated version of a product. The most hazardous phase of application is mixing and loading the concentrated product.
- A respirator may be required when mixing/loading or applying herbicides in an enclosed space (such as a shed), if the herbicide is highly volatile and liable to be breathed as a vapour (such as 2,4-D ester) and if application carries the risk of inhaling the spray mist. The herbicide label should be checked for any personal protection requirements.
- Ingestion or swallowing is a risk to users who don't wash their hands after handling chemicals, particularly before eating and drinking. Smoking during chemical preparation and application is not recommended for this reason.

The acute or immediate toxicity of herbicide is required by law to be communicated in the Poisons Schedule (or poison warnings) which appear on the label of a product. Herbicides are classified into four categories on the basis of their potential toxicity to the user. Each schedule has a corresponding signal heading, which appears in large contrasting lettering on the label of the herbicide product. The Poison Schedule will largely determine the safety directions and first aid instructions that appear on the label. **If you suspect poisoning, contact the Poisons Information Centre, emergency phone 13 11 26 (24-hour) and/or call an ambulance.**

Table 3 – Poisons Schedule

Poison schedule	Toxicity	Signal Heading
Unscheduled	Very low toxicity	No heading required
Schedule 5	Slightly toxic	Caution
Schedule 6	Moderately toxic	Poison
Schedule 7	Dangerous	Highly toxic poison

Re-entry Intervals

Once applied, herbicides can remain on sprayed plants in the form of foliar aerosol particles. These residues can readily be dislodged and absorbed through the skin. The re-entry interval is the time that must lapse between applying the herbicide and re-entry into the sprayed area in order to avoid post application exposure. Re-entry intervals appear on the labels of products that have been subject to a technical review by the APVMA. If a re-entry period is not specified on the label, the general rule is to wait 24 hours after application or until the plants are dry, whichever is the longer. Re-entry in the prescribed timeframe should always be avoided if possible, and if re-entry is necessary, personal protective equipment should be worn. Sprayed areas should never be re-entered when the plants are wet i.e. from dew or light rain, irrespective of the time elapsed, unless appropriate personal protective equipment is worn.

Withholding Periods

The withholding period is the minimum mandated interval that should elapse between the last application of herbicide to any crop, pasture or animal and the harvesting, grazing, cutting, slaughtering or the collection of milk and eggs for human consumption. Observance of the withholding period stated on the registered label is a legal requirement and is part of the direction of use.

Modes of Action

Modes of action refer to how different groups of herbicides kill plants.

Plants are complex organisms with defined structures in which many vital processes occur in well ordered sequences. Plants are made up of organs (roots, leaves etc), which consist of tissues (photosynthetic, meristematic and structural tissue etc), that in turn are made up of cells. Within these cells metabolic processes such as photosynthesis, protein synthesis and respiration occur. Other processes include cell growth and differentiation, seed formation, translocation of molecules and transpiration. Herbicides are designed so that they disrupt one or more of these processes and kill the plant.

In simple terms, the following describe the various modes of action:

- growth regulators;
- amino acid synthesis inhibitors;
- lipid synthesis inhibitors;
- seedling growth inhibitors;
- photosynthetic inhibitors;
- cell membrane disrupters; and
- pigment inhibitors.

For further information see Appendix E.

Herbicide Resistance

Herbicide resistance is the ability of a plant to survive, grow and reproduce after exposure to a dose of a particular herbicide that would normally be lethal. In certain plant populations herbicide resistance may occur naturally or may be a result of genetic engineering.

Herbicide resistance may emerge as a problem due to the continual use of a particular herbicide, or group of herbicides with the same mode of action, on a population of plants. When resistant individuals within a population survive and reproduce, the population may become dominated by individuals able to survive the particular herbicide, or group of herbicides with the same mode of action.

The development of herbicide resistance can be reduced by minimising use of “high resistance risk” herbicides (e.g. group A and B herbicides), see Appendix E, and ensuring that herbicides with the same mode of action are not used repeatedly on the same population of weeds.

Herbicide Control Techniques

Foliar Spraying

Foliar spraying is the use of herbicide diluted with water, at a specific rate, and sprayed over the foliage to the point of runoff (until every leaf is wet but not dripping). Spraying should be undertaken when a plant is actively growing to maximise the effectiveness of the herbicide. Foliar spraying can be efficient and cost effective; however there may be the potential for spray drift and off-target damage. Foliar spraying can be done a number of ways, depending on the size of the weed plant and/or the infestation.

Plate 1 - Foliar spraying of gamba grass

Blanket spraying using a boom spray from a tractor or 4-wheel drive vehicle can be used to treat large areas completely infested with weeds, especially with selective herbicides. For large infestations that need targeted applications of herbicide, a hose and handgun can be used to spray solution from a herbicide tank and pump carried by a tractor or vehicle. Smaller infestations can be sprayed using a backpack spray unit. Spot spraying is used to treat individual weed plants or areas that have only small clumps of weed infestations.

Reducing herbicide spray drift

When applying herbicides the aim is to maximise the amount reaching the target and to minimise the amount reaching off-target areas. Sprayed herbicides can drift as droplets, as vapours or as particles.

- **Droplet drift** is the easiest to control because under good spraying conditions, droplets are carried down by air turbulence and gravity, to collect on plant surfaces.
- **Particle drift** occurs when water and other herbicide carriers evaporate quickly from the droplet leaving tiny particles of concentrated herbicide.
- **Vapour drift** is confined to volatile herbicides such as 2,4-D ester. Vapours may arise directly from the spray or evaporation of herbicide from sprayed surfaces.

Any herbicide can drift. The drift hazard, or off-target potential of herbicide, in particular situations depends on the following factors:

- **Volatility of the formulation applied:** volatility refers to the likelihood that the herbicide will evaporate and become a gas. Esters volatilise (evaporate) more readily than amine formulations.
- **Formulation of the product:** formulations such as emulsifiable concentrates have a tendency to produce small droplets.
- **Type of adjuvant:** non-ionic surfactants and penetrants added to the spray solution will produce smaller droplets than oils.

In areas where there is a range of land uses, there is potential for conflicts to arise. People using herbicides have a moral and legal responsibility to prevent drift and/or contamination which may impact on health, the environment or neighbouring crops.

Before Spraying

- determine the most appropriate method of application and equipment for the situation;
- always check for sensitive areas in the vicinity, such as houses, schools, crops and riparian areas;
- check for predicted weather conditions, only proceed if these are favourable;
- notify neighbours of your spraying intentions; and
- prepare to record all necessary details of the herbicide usage.

During Spraying

- always monitor weather conditions carefully and understand their effect on ‘drift hazard’;
- don’t spray if conditions are not suitable, and stop spraying if conditions change and become unsuitable;
- record weather conditions, herbicide and water rates, and operating details;
- supervise all spraying, even when a contractor is employed. Provide a map marking the areas to be sprayed, buffers to be observed, sensitive crops and areas;
- spray when temperatures are at their coolest;
- minimise spray release height (lowest possible boom height);
- use the largest droplets which will give adequate spray coverage;
- always use the least-volatile formulation of herbicide available;
- maintain a down-wind buffer e.g. keep a boom width from the downwind edge of the sprayed area; and
- if sensitive crops are in the area, use herbicide which is the least damaging.

Unfavourable Weather Conditions

Unfavourable weather conditions include:

- midday turbulence: up-drafts cause rapidly shifting wind directions (spraying should stop by 11 am);
- high temperatures, particularly when using herbicides which are highly volatile or susceptible to drift;
- low humidity;
- high humidity – this extends droplet life and can greatly increase the drift hazard of fine droplets;
- still (stable) conditions;
- high winds; ideal safe wind speeds are 7–10 km/h; and
- periods during, before or immediately after rain; excess water will reduce the effectiveness of your application.

For information on spray equipment calibration refer to Appendix C.

Rope or Wick Applicators

This method of applying herbicide consists of a wick (or rope) soaked in herbicide from a reservoir (usually attached to handle). Herbicide is pumped to the wick with 12-volt equipment. The saturated wick is used to wipe or brush herbicide over the weed. Commercially available equipment such as Weed Wand and Weed Wiper can be used to kill weeds in this way. It is sometimes necessary to provide some resistance for the wiper when the weed leaf or stem is soft. Stem swiping involves using a knife to provide resistance down the back of the stem or leaf, while wiping herbicide down the front.

Basal Bark Application

This method involves mixing an oil soluble herbicide in diesel and spraying the full circumference of the trunk or stem of the plant. Diesel helps the herbicide move through the bark. Basal bark spraying is suitable for thin-barked woody weeds and undesirable trees. Basal bark spraying is also an effective way to treat saplings, regrowth and multi-stemmed shrubs and trees. This method works by allowing the herbicide to enter underground storage organs and slowly kill the targeted weed.

The whole circumference of the stem or trunk should be sprayed or painted with herbicide solution from ground level to a height of 30 cm. It is important to saturate the full circumference of the trunk, and to treat every stem or trunk arising from the ground. It may be necessary to go higher on bigger trees.

Plate 2 - Basal bark herbicide application to young mimosa

Basal bark spraying is a very effective control method, and a good way to tackle inaccessible areas such as steep banks. It is a well targeted form of spraying, having little or no drift. This method will usually destroy difficult-to-kill weeds at any time of the year, as long as the bark is not wet or too thick for the diesel to penetrate.

Refer to the product label for further details on application. As a general rule, the larger the plant, the greater the area of bark that needs treating. The basal bark technique can become less effective in a few species once the basal diameter is greater than 5-10 cm.

ThinLine Method

This method is a form of basal barking using higher concentrations of herbicide but only for use on stems up to 5cm in diameter. Spray involves mixing an oil soluble herbicide in diesel and spraying the full circumference of the trunk or stem of the plant. The whole circumference of the stem or trunk should be sprayed or painted with herbicide solution from ground level to a height of 5 cm. It is important to saturate the full circumference of the trunk, and to treat every stem.

Stem Injection Methods

These methods involve drilling or cutting through the bark into the sapwood tissue in the trunks of woody weeds and trees. Herbicide is immediately placed into the hole or cut. The aim is to reach the sapwood layer just under the bark (the cambium growth layer), which will transport the chemical throughout the plant. It is essential to apply the herbicide immediately (within 15 seconds of drilling the hole or cutting the trunk), as stem injection relies on the active uptake by the plant to move the chemical through its tissues.

Drill and Fill Method

This stem injection method is used for trees and woody weeds with stems or trunks greater than 5 cm in circumference. This method uses a battery-powered drill to make downward-angled holes into the sapwood approximately 5 cm apart. The placement of herbicide into the hole is usually made using a backpack reservoir and syringe that can deliver measured doses of herbicide solution. Stem injection methods kill the tree or shrub where it stands, therefore only trees and shrubs that can be safely left to die and rot should be treated this way. If the tree or shrub is to be felled, allow it to die completely before felling.

Axe Cut Method

This method involves cutting through the bark into the sapwood tissue in the trunk, and immediately placing herbicide into the cut. As with the drill and fill method, the aim is also to reach the tissue layer just under the bark (the cambium layer), which will transport the chemical throughout the plant. The axe cut method can be used for trees and woody weeds with stems or trunks greater than 5 cm in circumference. Using an axe or tomahawk, horizontal cuts are made into the sapwood around the circumference of the trunk at waist height. While still in the cut, the axe or tomahawk is leaned out to make a downward angled pocket, which will allow herbicide to pool. The herbicide is then immediately injected into the pocket. Cuts should be made no farther than 3 cm apart.

This method – using an axe to make the cut – is often referred to as frilling or chipping. It is important not to entirely ringbark the trunk, as this will decrease the uptake of the herbicide into the plant.

Cut Stump

Here the plant is cut off completely at the base (no higher than 15 cm from the ground) using a chainsaw, axe, brush-cutter or machete (depending on the thickness of the stem or trunk). The herbicide solution is then sprayed or painted on to the exposed surface of the cut stump emerging from the ground, with the objective of killing the stump and the root system. It is imperative that the herbicide solutions are applied as soon as the trunk or stem is cut. A delay of more than 10 seconds for water-based herbicides and 1 minute for diesel soluble herbicides between cutting and applying the chemical will give poor results. For this reason two operators working as a team can use this method effectively. The herbicide can be applied from a backpack, or with a paintbrush, drench gun or a hand spray bottle. It is a good idea to use a brightly coloured dye in the solution to mark the stumps that have been treated. This method has the appeal of removing the weed immediately, and is used mainly for trees and woody weeds. Many species will sucker if not treated using this method.

Plate 3 – Cut stump technique – herbicide application to mimosa

Using Adjuvants, Surfactants and Oils with Herbicides

Some herbicides need assistance to spread across and penetrate the leaf surface of target weeds. An adjuvant is an additive to herbicide, intended to improve its effectiveness. Adjuvants can be classified as surfactants, crop oils, penetrants and acidifying buffering agents.

‘Wetting Agents’ or Surfactants

These are products that increase the spread of droplets, aiding the wetting of waxy or hairy leaf surfaces. The most commonly used surfactants are non-ionic, these remain on the leaf once dry and allow ‘rewetting’ after rain, permitting additional herbicide uptake.

Crop Oils

Most crop oils contain emulsifiers which allow them to mix with water. Some contain various levels of surfactants. Some claims regarding oil adjuvants include reduced rain-fast periods, more uniform droplet size (drift reduction), less spray evaporation and better penetration of herbicide into waxy leaves.

Mineral oils are usually a blend of mineral oil and non-ionic surfactant. Products such as Ad-Here® have low levels of surfactant, whilst Uptake® and Supercharge® have higher levels.

Vegetable oils contain a wide range of products. Products containing esterified vegetable oil and surfactants are the most commonly used. They have claims for superior wax-modifying characteristics and penetrating ability. They should be used strictly according to the label with selective herbicides. Hasten® is an example of this product type.

Penetrants

These are compounds that help dissolve waxy cuticles.

Acidifying Buffering Agents

These help lower the pH of the spray solution, making solutions more acidic. Most herbicides are most stable when the pH of the solution is between 6 and 7 (neutral or slightly acidic).

Compatibility Agents

Compatibility agents are materials that reduce the likelihood of antagonism from other agents in the spray solution. The most commonly used compatibility agent is ammonium sulfate. It is also used to neutralise the effect of hard water on amine formulations such as glyphosate. An example of this product is Liquid Boost®. Some products combine a number of the above roles, for instance Hot-up® contains a surfactant, a compatibility agent and oil.

There is also a range of other adjuvants that are added to herbicides during formulation to improve efficacy, increase crop safety, or improve the ease of herbicide use. These include thickeners, spreaders, stickers, anti-foamers and safeners.

Factors Affecting Adjuvant Use

Adjuvants are usually added to increase the effectiveness of herbicides. However, use of the wrong type or rate can reduce effectiveness. It should also be noted that the addition of an adjuvant can reduce herbicide selectivity. This is not an issue for fallow and pre-emergent herbicides. Hard water can lead to poor mixing of the chemical with water. This particularly occurs with emulsifiable concentrates. High levels of calcium and magnesium ions bind with amine formulations, causing them to be less soluble and therefore less effective.

Records of Use

Some users of agricultural chemical products in the NT are required to keep detailed records of use for a minimum of two years and include:

- name and address of person who used the product;
- name of the product;
- rate and amount used;
- method of application;
- expiry date of the product;
- date and time the product was used;
- exact location of where the product was used;
- date and time of when the product was used;
- type of crops, pastures or plants in the area;
- temperature and wind speed/direction;
- name of target pest or disease; and
- withholding period.

It is the land manager's responsibility to determine recording requirements.

Go to www.nt.gov.au/d/ for more information.

Disposal of Excess Chemicals and Used Chemical Containers

Empty chemical containers and any unused chemicals must be disposed of in an environmentally responsible manner. For information on how to responsibly dispose of chemicals please refer to Appendix F.

Chemical Handling Training

It is strongly recommended that all persons using herbicides complete a chemical safety training course. Chemical handling training is a legislative requirement for schedule 7 chemicals. Training in the safe and effective use of chemicals is provided by various registered training organisations. Please refer to Appendix D for information on courses relevant to chemical application in the NT. The APVMA website has further details at www.apvma.gov.au/index.asp

Weed Control Option Tables

This publication is presented only as a guide to assist in planning weed control. The following must be taken into consideration when planning your weed management program.

Users of Agricultural (or veterinary) chemical products must always read the label and any Permit, before using the product and strictly comply with the directions on the label and any conditions of any Permit. Users are not absolved from compliance with the directions on the label or conditions of the Permit by reason of any statement made in or omission from this publication.

The product trade names in this publication are supplied on the understanding that no preference between equivalent products is intended and that the inclusion of a product does not imply endorsement by the NT Government's Department of Land Resource Management, over any other equivalent product from another manufacturer.

Any management incorporating burning must be in accordance with the *Bushfires Act* and the *Fire and Emergency Act*. Please contact your local fire station for permits to burn if you live within a Northern Territory Fire and Rescue Service Emergency Response Area (NTFRS ERA). If you live outside a NTFRS ERA, contact your local Volunteer Fire Brigade Captain or local area Fire Warden through the Bushfires Council on Darwin 8922 0844 or Batchelor 8976 0098.

Table 4 – Abbreviations and Terms

Abbreviations and terms	Definitions
/ha	per hectare (10 000m^2)
mL / l	millilitres per litre
m^2	metres squared
g / kg	grams per kilogram
g / l	grams per litre
WMB	Weed Management Branch
Various trade names	A number of products can be purchased that contain this active ingredient for control of this weed.
Various trade names and formulations	A number of products can be purchased that contain this active ingredient, some with different concentration formulations, registered for control of this weed.

Note: Rates are given for water unless otherwise stated

Athel pine – *Tamarix aphylla (Class A, Class B and Class C - refer to www.nt.gov.au/weeds for details)*

OPTIMUM TREATMENT TIMES
darker colour indicates preferred treatment times

JAN	FEB	MAR	APR	MAY	JUN
JUL	AUG	SEP	OCT	NOV	DEC

Chemical and concentration	Rate	Weed growth stage, method and comments
Fluroxypyr 200 g/L * Starane 200***** Plus other registered products	1 L / 100 L	**Seedling** Foliar spray – < 50 cm tall
Fluroxypyr 333 g/L * Starane™ Advanced Plus other registered products	600 mL / 100 L	**Seedling** Foliar spray – < 50 cm tall
Triclopyr 600 g/L * Garlon™ 600 Plus other registered products	1 L / 100 L 1 L / 60 L (diesel)	**Juvenile – 50 cm - 2 m in height** Foliar spray Cut stump/basal bark/foliar spray application

Non-chemical applications: Seedlings can be removed by hand.
Large trees can be removed by ripping and bulldozing. The root system must be removed.

***Important notice** – these chemicals and rates are specified by **APVMA permit PER9936** which allows minor use of an agvet chemical product to control seedlings athel pine in non-crop areas in and near dry ephemeral waterways.
The permit expires on 30 June 2015 and is pending extension at the time of writing.

Critical Use Comments: DO NOT contaminate streams, rivers or waterways with the chemical or used container.

Withholding Period: Garlon™ 600 Herbicide (or equivalent): Not required when used as directed.
Fluroxypyr products: DO NOT graze or cut for stock food for 7 days after application.

Persons who wish to prepare for use/or use the products for the purposes specified above must read, or have read to them, the permit, particularly the information included in the DETAILS OF PERMIT and CONDITIONS OF PERMIT. Contact the Weed Management Branch for further information.

Barleria – *Barleria prionitis (Class A and Class C) and Barleria lupulina*

OPTIMUM TREATMENT TIMES
darker colour indicates preferred treatment times

JAN	FEB	MAR	APR	MAY	JUN
JUL	AUG	SEP	OCT	NOV	DEC

Chemical and concentration	Rate	Weed growth stage, method and comments
2, 4-D amine 625 g/L Various trade names	320 mL / 100 L	**Seedling or adult (individuals or infestation):** Foliar spray – apply when actively growing
Fluroxypyr 200 g/L Various trade names	500 mL / 100 L	**Seedling or adult (individuals or infestation):** Foliar spray – apply when actively growing For boom rate contact WMB

Non-chemical applications: Easily removed by hand and burnt.

Bellyache bush – *Jatropha gossypiifolia (Class A, Class B and Class C - refer to www.nt.gov.au/weeds for details)*

OPTIMUM TREATMENT TIMES
darker colour indicates preferred treatment times

JAN	FEB	MAR	APR	MAY	JUN
JUL	AUG	SEP	OCT	NOV	DEC

Chemical and concentration	Rate	Weed growth stage, method and comments
Fluroxypyr 200 g/L Various trade names	500 mL / 100 L 3 L / 100 L (diesel)	**Seedling (individuals or infestation):** Foliar spray – apply when actively growing **Adult (individuals):** Cut stump or basal bark For boom rate contact WMB
Fluroxypyr 333 g/L Various trade names	300 mL / 100 L 1 L / 100 L (diesel)	**Seedling (individuals or infestation):** Foliar spray – apply when actively growing **Adult (individuals):** Cut stump or basal bark For boom rate contact WMB
Metsulfuron-methyl 600 g/kg Various trade names	10 g / 100 L 10 g / 100 L	**Seedling (individuals or infestation):** Foliar spray - apply when actively growing, wetting agent required **Adult (infestation):** Foliar spray For broadscale application contact WMB

Non-chemical applications: Individual plants can be removed by hand, however slashing or mulching is more efficient for larger infestations. Mechanical control prior to flowering/seeding will reduce spread, whereas implementation during the dry season, when plants are moisture stressed, will result in a higher kill rate of mature plants. In either instance, follow up control for regenerating plants and seedlings will be necessary. Fire can be used as part of an integrated control program to kill young bellyache bush seedlings and improve access for other control methods, however multiple burns may be required to kill mature infestations. Follow up control may require hand removal.

Brazilian pepper – *Schinus terebinthifolius (Class A, Class B and Class C - refer to www.nt.gov.au/weeds for details)*


Photo credit Rod Ensbey

OPTIMUM TREATMENT TIMES
darker colour indicates preferred treatment times

JAN	FEB	MAR	APR	MAY	JUN
JUL	AUG	SEP	OCT	NOV	DEC

Chemical and concentration	Rate	Weed growth stage, method and comments
Aminopyralid 8 g/L + Triclopyr 300 g/L + Picloram 100 g/L Grazon™ Extra	350 mL / 100 L	**Seedling (individuals and infestations under 2 m):** Foliar spray, apply when actively growing + non-ionic wetting agent required
Triclopyr 300 g/L and Picloram 100 g/L Various trade names	350 mL / 100 L	**Seedling (individuals and infestations up to 2 m):** Foliar spray, apply when actively growing + non-ionic wetting agent required
Triclopyr 600 g/L Various trade names	1 L / 60 L (diesel) 1 L / 60 L (diesel)	**Seedling (individuals):** Basal bark < 5 cm stem diameter **Adult (individuals or infestation):** Cut stump > 5 cm stem diameter
Fluroxypyr 333 g/L Starane™ Advanced	1.8 L / 100 L (diesel) 1.8 L / 100 L (diesel)	**Seedling (individuals):** Basal bark < 15 cm* stem diameter, treat up to 45 cm from ground **Adult (individuals or infestation):** Cut stump > 15 cm stem diameter
Triclopyr 240 g/L + **Picloram 120 g/L** Access™	1 L / 60 L (diesel) 1 L / 60 L (diesel)	**Seedling (individuals):** Basal bark < 15 cm* stem diameter **Adult (individuals or infestation):** Cut stump > 15 cm stem diameter
Picloram 20 g/Kg Tordon™ granules	35 to 45 g / m^2	Apply granules over an area extending from the main stem to 30 cm outside the dripline to cover the main part of the root system

Non-chemical applications: Mechanical control or burning can be used to improve access to infested areas for follow up chemical control.

*It is noted that basal barking can be effective on trees of larger diameter. Basal barking, being less labour intensive than cut stumping, may be a preferable option for sparse or remote infestations. Cut stump applications may be the best management option for trees in urban/landscaped situations where the dead tree material will be removed to retain aesthetics.

Burrs – Bathurst burr – *Xanthium spinosum (Class B and Class C)* and Noogoora burr – *Xanthium strumarium (Class B and Class C)*

Bathurst burr

Noogoora burr

OPTIMUM TREATMENT TIMES
darker colour indicates preferred treatment times

JAN	FEB	MAR	APR	MAY	JUN
JUL	AUG	SEP	OCT	NOV	DEC

Chemical and concentration	Rate	Weed growth stage, method and comments
2, 4-D amine 625 g/L Various trade names	180 mL / 100 L	**Seedling or adult (individuals or infestation):** Foliar spray – apply when actively growing
Fluroxypyr 333 g/L Various trade names	45 mL / 100 L **or** 450 mL / ha (boom)	**Seedling (individuals or infestation):** Foliar spray – apply when actively growing
Glyphosate 360 g/L Various trade names and formulations	15 mL / 1L	**Seedling or adult (individuals or infestation):** Foliar spray – apply when actively growing
MCPA 340 g/L + Dicamba 80 g/L Various trade names	190 - 270 mL / 100 L **or** 2.8-4 L / ha (boom)	**Seedling or adult (individuals or infestation):** Foliar spray – use higher rates on larger plants

Non-chemical applications: Mow, slash, grub and burn plants to prevent burr formation. Biocontrol options are available.

Cabomba – *Cabomba* spp. *(Class A and Class C)*

*** Report this plant to the Weed Management Branch immediately if found**

The Territory Government currently manages the only known cabomba infestation which is limited to a small, isolated section of the Darwin River. A quarantine order remains in place for this area. For further details go to www.nt.gov.au/cabomba

Caltrop – *Tribulus cistoides and Tribulus terrestris (Class B and Class C)*

OPTIMUM TREATMENT TIMES
darker colour indicates preferred treatment times

JAN	FEB	MAR	APR	MAY	JUN
JUL	AUG	SEP	OCT	NOV	DEC

Chemical and concentration	Rate	Weed growth stage, method and comments
2, 4-D amine 625 g/L Various trade names	320 mL / 100 L **or** 1.1-2.4 L / ha (boom)	**Seedling or adult (individuals or infestation):** Foliar spray – apply when actively growing
Glyphosate 360 g/L Various trade names and formulations	10 mL / 1L	**Seedling or adult (individuals or infestation):** Foliar spray – apply when actively growing
Metsulfuron-methyl 600 g/kg Various trade names	10 g / 100 L	**Seedling or adult (individuals or infestation):** Foliar spray – apply when actively growing, wetting agent required

Non-chemical applications: Grub plants out by hand and burn.

Candle bush – *Senna alata (Class B and Class C)*

OPTIMUM TREATMENT TIMES
darker colour indicates preferred treatment times

JAN	FEB	MAR	APR	MAY	JUN
JUL	AUG	SEP	OCT	NOV	DEC

Chemical and concentration	Rate	Weed growth stage, method and comments
2, 4-D amine 625 g/L	320 mL / 100 L	**Seedling (individuals or infestation) + adult (infestation):** Foliar spray – Uptake® Spraying Oil required For boom rate contact WMB
Triclopyr 240 g/L + Picloram 120 g/L Access™	1 L / 60 L (diesel) 1 L / 60 L (diesel)	**Adult (individuals or infestation):** Basal bark < 10 cm stem diameter treat up to 30 cm from ground Cut stump > 10 cm stem diameter

Non-chemical applications: Isolated plants can be dug out and roots removed.

Castor oil plant – *Ricinus communis (Class B and Class C)*

OPTIMUM TREATMENT TIMES
darker colour indicates preferred treatment times

JAN	FEB	MAR	APR	MAY	JUN
JUL	AUG	SEP	OCT	NOV	DEC

Chemical and concentration	Rate	Weed growth stage, method and comments
2, 4-D amine 625 g/L Various trade names	320 mL / 100 L	**Seedling (individuals or infestation) + adult (infestation):** Foliar spray – apply when actively growing For boom rate contact WMB
Triclopyr 600 g/L Various trade names	1 L / 60 L (diesel) 1 L / 60 L (diesel)	**Adult (individuals or infestation):** Basal bark < 5 cm stem diameter Cut stump > 5 cm stem diameter

Non-chemical applications: Individual plants or small infestations may be removed by hand-pulling.

Chinee apple – *Ziziphus mauritiana (Class A and Class C)*

OPTIMUM TREATMENT TIMES
darker colour indicates preferred treatment times

JAN	FEB	MAR	APR	MAY	JUN
JUL	AUG	SEP	OCT	NOV	DEC

Chemical and concentration	Rate	Weed growth stage, method and comments
Aminopyralid 8 g/L + Triclopyr 300 g/L + Picloram 100 g/L Grazon™ Extra	350 mL / 100 L	**Seedling (individuals and infestations):** Foliar spray, apply when actively growing + non-ionic wetting agent required
Triclopyr 300 g/L and Picloram 100 g/L Various trade names	350 mL / 100 L	**Seedling (individuals and infestations under 2 m):** Foliar spray, apply when actively growing + non-ionic wetting agent required
Triclopyr 600 g/L Various trade names	1 L / 60 L (diesel) 1 L / 60 L (diesel)	**Seedling (individuals):** Basal bark < 5 cm stem diameter **Adult (individuals or infestation):** Cut stump > 5 cm stem diameter
Fluroxypyr 333 g/L Starane™ Advanced	1.8 L / 100 L (diesel) 1.8 L / 100 L (diesel)	**Seedling (individuals):** Basal bark < 15 cm* stem diameter, treat up to 45 cm from ground **Adult (individuals or infestation):** Cut stump > 15 cm stem diameter
Triclopyr 240 g/L + **Picloram 120 g/L** Access™	1 L / 60 L (diesel) 1 L / 60 L (diesel)	**Seedling (individuals):** Basal bark < 15 cm* stem diameter **Adult (individuals or infestation):** Cut stump > 15 cm stem diameter
Picloram 20 g/Kg Tordon™ granules	35 to 45 g / m^2	Apply granules over an area extending from the main stem to 30 cm outside the dripline to cover the main part of the root system

Non-chemical applications: Mechanical control or burning can be used to improve access to infested areas for follow up chemical control. *Basal barking can be effective on trees of larger diameter. Basal barking, being less labour intensive than cut stumping, may be a preferable option for sparse or remote infestations. Cut stump applications may be the best management option for trees in urban/landscaped situations where the dead tree material will be removed to retain aesthetics.

Coffee bush – *Leucaena leucocephala*

OPTIMUM TREATMENT TIMES
darker colour indicates preferred treatment times

JAN	FEB	MAR	APR	MAY	JUN
JUL	AUG	SEP	OCT	NOV	DEC

Chemical and concentration	Rate	Weed growth stage, method and comments
Aminopyralid 8 g/L + Triclopyr 300 g/L + Picloram 100 g/L Grazon™ Extra	350 mL / 100 L	**Seedling (individuals and infestations):** Foliar spray, apply when actively growing + non-ionic wetting agent required
Triclopyr 300 g/L and Picloram 100 g/L Various trade names	350 mL / 100 L	**Seedling (individuals and infestations under 2 m):** Foliar spray, apply when actively growing + non-ionic wetting agent required
Fluroxypyr 333 g/L Starane™ Advanced	1.8 L / 100 L (diesel) 1.8 L / 100 L (diesel)	**Seedling (individuals):** Basal bark < 15 cm* stem diameter, treat up to 45 cm from ground **Adult (individuals or infestation):** Cut stump > 15 cm stem diameter
Triclopyr 240 g/L + **Picloram 120 g/L** Access™	1 L / 60 L (diesel) 1 L / 60 L (diesel)	**Seedling (individuals):** Basal bark < 15 cm* stem diameter **Adult (individuals or infestation):** Cut stump > 15 cm stem diameter
Picloram 20 g/Kg Tordon™ granules	35 to 45 g / m^2	Apply granules over an area extending from the main stem to 30 cm outside the dripline to cover the main part of the root system
Glyphosate Various trade names	ratio 1:1 of water	**Seedling or adult (individuals or infestation):** Cut stump

Non-chemical applications: Mechanical control or burning can be used to improve access to infested areas for follow up chemical control. *Basal barking can be effective on trees of larger diameter. Basal barking, being less labour intensive than cut stumping, may be a preferable option for sparse or remote infestations. Cut stump applications may be the best management option for trees in urban/landscaped situations where the dead tree material will be removed to retain aesthetics.

Coffee senna – *Senna occidentalis (Class B and Class C)*

OPTIMUM TREATMENT TIMES
darker colour indicates preferred treatment times

JAN	FEB	MAR	APR	MAY	JUN
JUL	AUG	SEP	OCT	NOV	DEC

Chemical and concentration	Rate	Weed growth stage, method and comments
Aminopyralid 25 g/L + Triclopyr 200 g/L + Picloram 100 g/L Tordon DS ™ Tordon™ Regrowth Master	375 mL / 100 L	**Seedling or adult (individuals or infestation):** Foliar spray – apply when actively growing, non-ionic wetting agent required
Dicamba 500 g/L Various trade names	500 mL / 100 L	**Seedling or adult (individuals or infestation):** Foliar spray, wetting agent may be required
Triclopyr 300 g/L + Picloram 100 g/L Various trade names	200 mL / 100 L	**Seedling or adult (individuals or infestation):** Foliar spray – non-ionic wetting agent required: do not apply to podding plants
Aminopyralid 8 g/L + Triclopyr 300 g/L + Picloram 100 g/L Grazon™ Extra	200 mL / 100 L	**Seedling or adult (individuals or infestation):** Foliar spray – non-ionic wetting agent required: do not apply to podding plants For boom rate contact WMB

Non-chemical applications: Can be controlled by handpulling and grubbing.

Common and creeping lantana – *Lantana camara and Lantana montevidensis (Class B and Class C)*

OPTIMUM TREATMENT TIMES
darker colour indicates preferred treatment times

JAN	FEB	MAR	APR	MAY	JUN
JUL	AUG	SEP	OCT	NOV	DEC

Chemical and concentration	Rate	Weed growth stage, method and comments
Fluroxypyr 200 g/L Various trade names	500 mL – 1 L / 100 L **or** 3 L / ha (boom)	**Seedling or adult (individuals or infestation):** Foliar spray – use higher rate on plants over 1.2 m, apply when actively growing
Fluroxypyr 333 g/L Starane™ Advanced	300–600 mL /100 L	**Seedling or adult (individuals or infestation):** Foliar spray – use higher rate on plants over 1.2 m, apply when actively growing
Triclopyr 300 g/L + Picloram 100 g/L Various trade names	350–500 mL (750) / 100 L **or** 3 L / ha (boom)	**Seedling (individuals and infestation)** Foliar spray – use higher rate on plants > 1 m (highest for harder to kill varieties), apply when actively growing, non-ionic wetting agent required
Aminopyralid 8 g/L + Triclopyr 300 g/L + Picloram 100 g/L Grazon™ Extra	350–500 mL (750) / 100 L **or** 10 L / ha (aerial)	**Seedling (individuals and infestation)** Foliar spray – use higher rate on plants > 1 m (highest for harder to kill varieties), apply when actively growing, non-ionic wetting agent required
Triclopyr 240 g/L + Picloram 120 g/L	1 L / 60 L (diesel) 1 L / 60 L (diesel)	**Seedling (individuals):** Basal bark < 15 cm stem diameter **Adult (individuals or infestation):** Cut stump > 15 cm stem diameter
Triclopyr 600 g/L Various trade names	1 L / 60 L (diesel) 1 L / 60 L (diesel)	**Seedling (individuals)** Basal bark < 5 cm stem diameter **Adult (individuals or infestation)** Cut stump > 5 cm stem diameter

Non-chemical applications: Stick-raking, bulldozing, ploughing and grubbing. Fire can be used prior to mechanical or herbicide control or as follow-up.

Devil's claw – *Martynia annua (Class A and Class C)*

OPTIMUM TREATMENT TIMES
darker colour indicates preferred treatment times

JAN	FEB	MAR	APR	MAY	JUN
JUL	AUG	SEP	OCT	NOV	DEC

Chemical and concentration	Rate	Weed growth stage, method and comments
2, 4-D amine 625 g/L Various trade names	320 mL / 100 L	**Seedling or adult (individuals or infestation):** Foliar spray – apply when actively growing
Glyphosate 360 g/L Various trade names and formulations	10 mL / 1L	**Seedling or adult (individuals or infestation):** Foliar spray – apply when actively growing
MCPA 340 g/L + Dicamba 80 g/L Various trade names	320 mL / 100 L	**Seedling or adult (individuals or infestation):** Foliar spray – apply when actively growing

Non-chemical applications: Small plants can be removed by hand, larger plants can be slashed close to the ground.

Flannel weed – *Sida cordifolia (Class B and Class C)*

OPTIMUM TREATMENT TIMES
darker colour indicates preferred treatment times

JAN	FEB	MAR	APR	MAY	JUN
JUL	AUG	SEP	OCT	NOV	DEC

Chemical and concentration	Rate	Weed growth stage, method and comments
2, 4-D amine 625 g/L Various trade names	320 mL / 100 L 1.8 L / ha (boom)	**Seedling or adult (individuals or infestation):** Foliar spray – apply when actively growing
Glyphosate 360 g/L Various trade names and formulations	15 mL / 1 L	**Seedling or adult (individuals or infestation):** Foliar spray – apply when actively growing
Fluroxypyr 200 g/L Various trade names	500 mL – 1 L / 100 L **or** 3 L / ha (boom)	**Seedling or adult (individuals or infestation):** Foliar spray – use higher rate on plants over 1.2 m, apply when actively growing
Fluroxypyr 333 g/L Starane™ Advanced	300 mL / 100 L	**Seedling or adult (individuals or infestation):** Foliar spray – apply when actively growing up until flowering

Non-chemical applications: Repeated slashing and vigorous pasture competition.

Fountain grass – *Cenchrus setaceus (Class B and Class C)*

OPTIMUM TREATMENT TIMES
darker colour indicates preferred treatment times

JAN	FEB	MAR	APR	MAY	JUN
JUL	AUG	SEP	OCT	NOV	DEC

Chemical and concentration	Rate	Weed growth stage, method and comments
Glyphosate 360 g/L Various trade names and formulations	10 mL / 1 L	**Seedling or adult (individuals or infestation):** Foliar spray – apply when actively growing

Small infestations should be removed by hand or by using a mattock. Ensure the entire root is removed.

Gamba grass – *Andropogon gayanus (Class A, Class B and Class C - refer to www.nt.gov.au/weeds for details)*

OPTIMUM TREATMENT TIMES
darker colour indicates preferred treatment times

JAN	FEB	MAR	APR	MAY	JUN
JUL	AUG	SEP	OCT	NOV	DEC

Chemical and concentration	Rate	Weed growth stage, method and comments
Glyphosate 360 g/L Various trade names and formulations	10 mL / 1 L	**Seedling or adult (individuals or infestation):** Foliar spray – apply when actively growing

Effective chemical control of gamba grass relies on spraying the entire plant. For optimal uptake of the herbicide and high mortality rates gamba grass should be sprayed when actively growing and young (leaves should be at least 40 cm long). Spraying plants prior to reaching full height will reduce time and herbicide requirements. Gamba grass is still sensitive to herbicide when flowering. Once gamba grass is seeding and the leaves are drying out herbicide will not be effective.

Non-chemical applications:

Physical: Individual plants can be removed by hand or by using a mattock. Ensure the entire root mat is removed. Excess soil should be shaken or kicked off root system to ensure regrowth does not occur from the root mat.

Burning: Burning will not kill gamba grass, low intensity fires, undertaken in the Wet season, can remove rank growth improving access for slashing or spraying. Plants may need to be treated with herbicide prior to burning to create enough dry matter to carry a fire. Fire may have the ability to carry seed in hot air currents, therefore avoid using fire as a control method while plants are seeding. Check with the Bushfires NT or NTFRS about permit requirements prior to lighting any fires.

Slashing: Slashing will not eradicate gamba grass, but it can reduce the biomass, prevent seeding, create an opportunity for more desirable species to establish and provide improved access to control by other means. Slash young plants prior to seed production from January to March. Ensure equipment and machinery is cleaned prior to moving to new sites.

Grazing: In areas within the Class B declaration zone gamba grass may continue to be used in established pasture areas, however there is a requirement to disallow any further spread. Gamba being used as a pasture should be grazed with enough stock to keep grass height below 90 cm. Above this height tussocks may be avoided by stock and allowed to produce vast quantities of seed. After lightly grazing pasture in the early wet season, a stocking density of 4-5 head per hectare is required to control growth for the remainder of the wet season. Increase grazing pressure if the grass nears 90 cm. Gamba grass is not recommended for cattle production on smaller properties as it requires high stocking densities to keep it low and palatable.

Grader grass – *Themeda quadrivalvis (Class B and Class C)*

OPTIMUM TREATMENT TIMES
darker colour indicates preferred treatment times

JAN	FEB	MAR	APR	MAY	JUN
JUL	AUG	SEP	OCT	NOV	DEC

Chemical and concentration	Rate	Weed growth stage, method and comments
Glyphosate 360 g/L Various trade names and formulations	10 mL / 1 L	**Seedling or adult (individuals or infestation):** Foliar spray – apply when actively growing

Non-chemical applications: Identification of grader grass before seeding can be difficult. Small infestations should be controlled manually, preferably before seeding, and burnt on site. There is only a short window of opportunity to control grader grass as seed heads can appear within 5-6 weeks of germination, with mature seed being present after 10 weeks. If seed is present, burn it inside a drum to generate enough heat to kill the seeds. In the event that grader grass goes to seed before control, recording the location of infestations will enable early control during the next growing season. For large infestations contact the Weed Management Branch for options.

Hyptis – *Hyptis suaveolens (Class B and Class C)*

OPTIMUM TREATMENT TIMES
darker colour indicates preferred treatment times

JAN	FEB	MAR	APR	MAY	JUN
JUL	AUG	SEP	OCT	NOV	DEC

Chemical and concentration	Rate	Weed growth stage, method and comments
2, 4-D amine 625 g/L Various trade names	320 mL / 100 L	**Seedling or adult (individuals or infestation):** Foliar spray – apply when actively growing
Glyphosate 360 g/L Various trade names and formulations	15 mL / 1 L	**Seedling or adult (individuals or infestation):** Foliar spray – apply when actively growing

Non-chemical applications: Manually remove all plant material; slash to encourage competition from desirable species.

Khaki weed – *Alternanthera pungens (Class B and Class C)*

OPTIMUM TREATMENT TIMES
darker colour indicates preferred treatment times

JAN	FEB	MAR	APR	MAY	JUN
JUL	AUG	SEP	OCT	NOV	DEC

Chemical and concentration	Rate	Weed growth stage, method and comments
2, 4-D amine 625 g/L Various trade names	320 mL / 100 L	**Seedling or adult (individuals or infestation):** Foliar spray – apply when actively growing
Glyphosate 360 g/L Various trade names and formulations	10 mL / 1L	**Seedling or adult (individuals or infestation):** Foliar spray – apply when actively growing
MCPA 340 g/L + Dicamba 80 g/L Various trade names	350 mL / 100 L	**Seedling or adult (individuals or infestation):** Foliar spray

Non-chemical applications: Grub at least 5 cm of the root; vigorous pasture competition.

Lion's tail – *Leonotis nepetifolia (Class B and Class C)*

OPTIMUM TREATMENT TIMES
darker colour indicates preferred treatment times

JAN	FEB	MAR	APR	MAY	JUN
JUL	AUG	SEP	OCT	NOV	DEC

Chemical and concentration	Rate	Weed growth stage, method and comments
2, 4-D amine 625 g/L Various trade names	320 mL / 100 L	**Seedling or adult (individuals or infestation):** Foliar spray – apply when actively growing
Aminopyralid 8 g/L + Triclopyr 300 g/L + Picloram 100 g/L Grazon™ Extra	200 mL / 100 L	**Seedling (individuals and infestation)** Foliar spray – when actively growing, wetting agent required

Non-chemical applications: New infestations should be removed manually prior to seeding.

Mesquite – *Prosopis* spp. *(Class A and Class C)*

OPTIMUM TREATMENT TIMES
darker colour indicates preferred treatment times

JAN	FEB	MAR	APR	MAY	JUN
JUL	AUG	SEP	OCT	NOV	DEC

Chemical and concentration	Rate	Weed growth stage, method and comments
Aminopyralid 8 g/L + Triclopyr 300 g/L + Picloram 100 g/L Grazon™ Extra	200 mL / 100 L	**Seedling (individuals and infestation):** Foliar spray – non-ionic wetting agent required - do not spray plants bearing pods
Aminopyralid 8 g/L + Triclopyr 300 g/L + Picloram 100 g/Ls Various trade names	350 mL / 100 L	**Seedling (individuals and infestation):** Foliar spray – non-ionic wetting agent required - do not spray plants bearing pods
Triclopyr 240 g/L and Picloram 120 g/L Access™	1 L / 60 L (diesel) 1 L / 60 L (diesel)	**Adult (individuals or infestation):** Basal bark < 5 cm stem diameter Cut stump > 5 cm stem diameter

Non-chemical applications: Hand grubbing for light infestations or small, dense areas. Blade ploughing or other mechanical control aimed at removing as much of the root system as possible.

Mexican poppy – *Argemone ochroleuca (Class B and Class C)*

OPTIMUM TREATMENT TIMES
darker colour indicates preferred treatment times

JAN	FEB	MAR	APR	MAY	JUN
JUL	AUG	SEP	OCT	NOV	DEC

Chemical and concentration	Rate	Weed growth stage, method and comments
2, 4-D amine 625 g/L Various trade names	320 mL / 100 L	**Seedling or adult (individuals or infestation):** Foliar spray – apply when actively growing
Glyphosate 360 g/L Various trade names and formulations	10 mL / 1L	**Seedling or adult (individuals or infestation):** Foliar spray – apply when actively growing
MCPA 340 g/L + Dicamba 80 g/L Various trade names	350 mL / 100 L	**Seedling or adult (individuals or infestation):** Foliar spray

Non-chemical applications: Remove by hand grubbing. Take extra precautions to stop seed spread if removal is required once the plants are already seeding.

Mimosa – *Mimosa pigra (Class A, Class B and Class C - refer to www.nt.gov.au/weeds for details)*

OPTIMUM TREATMENT TIMES
darker colour indicates preferred treatment times

	JAN	FEB	MAR	APR	MAY	JUN
FOLIAR SPRAY	JUL	AUG	SEP	OCT	NOV	DEC

	JAN	FEB	MAR	APR	MAY	JUN
BASAL BARK	JUL	AUG	SEP	OCT	NOV	DEC

	JAN	FEB	MAR	APR	MAY	JUN
PELLET GRANULAR	JUL	AUG	SEP	OCT	NOV	DEC

Chemical and concentration	Rate	Weed growth stage, method and comments
Tebuthiuron Various trade names	1 g / m^2	**Seedling or adult (individuals or infestation):** Granulated herbicide - ground applied Do not use within 30 m of desirable trees or apply to continuous area > 0.5 ha Do not use if fire is eminent Apply when there is soil moisture or prior to rain
Fluroxypyr 200 g/L Various trade names	300 mL / 100 L 3 L / 60 L water / ha 1:60 (diesel)	**Seedling or adult (individuals or infestation):** Foliar application when actively growing Wetting agent Uptake® required - 500 mL / 100 L **Seedling or adult (infestations):** Aerial control **Seedling or adult:** Basal bark or cut stump application method Foliar application when actively growing
Fluroxypyr 333 g/L Starane™ Advanced	180 mL / 100 L 1.8 L / 60 L water / ha	**Seedling or adult (individuals or infestation):** Foliar application when actively growing Wetting agent Uptake® required - 500mL / 100 L **Seedling or adult (infestations):** Aerial control
Metsulfuron-methyl Various trade names	60 g / 60 L water / ha	**Seedling or adult (infestations):** Aerial control Non-ionic wetting agent required 100 mL / 100 L
Dicamba Various trade names	6 L / ha 400 mL / 100 L	**Seedling or adult (infestations):** Aerial control – Use the wetting agent LI700® **Seedling or adult (individuals or infestation):** Foliar application when actively growing
Glyphosate Various trade names	ratio 1:1 of water	**Seedling or adult (individuals or infestation):** Cut stump

Non-chemical applications: Hand grubbing for single plants or small outbreaks, ensure removal of the root system. Bulldozers can clear debris post-chemical control and fire can be used to kill surface seed or at least break the dormancy stage. Biocontrol options available.

Mission grass - annual – *Cenchrus pedicellatus* formerly *Pennisetum pedicellatum*

OPTIMUM TREATMENT TIMES
darker colour indicates preferred treatment times

JAN	FEB	MAR	APR	MAY	JUN
JUL	AUG	SEP	OCT	NOV	DEC

Chemical and concentration	Rate	Weed growth stage, method and comments
Glyphosate 360 g/L Various trade names and formulations	10 mL / 1L	**Seedling or adult (individuals or infestation):** Foliar spray – apply when actively growing

Non-chemical applications: Annual mission grass can be controlled by slashing prior to seeding (repeated slashing may be required). Adult plants will not persist to the following year.

Mission grass - perennial – *Cenchrus polystachios (Class B and Class C)* formerly *Pennisetum polystachion*

OPTIMUM TREATMENT TIMES
darker colour indicates preferred treatment times

JAN	FEB	MAR	APR	MAY	JUN
JUL	AUG	SEP	OCT	NOV	DEC

Chemical and concentration	Rate	Weed growth stage, method and comments
Glyphosate 360 g/L Various trade names and formulations	10 mL / 1L	**Seedling or adult (individuals or infestation):** Foliar spray – apply when actively growing

Non-chemical applications: Small infestations can be hand pulled. Slashing can prevent seed formation. Regrowth can then be treated with herbicide.

Mossman River grass – *Cenchrus echinatus (Class B and Class C)*

OPTIMUM TREATMENT TIMES
darker colour indicates preferred treatment times

JAN	FEB	MAR	APR	MAY	JUN
JUL	AUG	SEP	OCT	NOV	DEC

Chemical and concentration	Rate	Weed growth stage, method and comments
Glyphosate 360 g/L Various trade names and formulations	10 mL / 1L	**Seedling or adult (individuals or infestation):** Foliar spray – apply when actively growing

Non-chemical applications: Cultivation, pulling by hand or burning off before plants reach seed set.

Neem – *Azadirachta indica (Class B and Class C)*

OPTIMUM TREATMENT TIMES
darker colour indicates preferred treatment times

JAN	FEB	MAR	APR	MAY	JUN
JUL	AUG	SEP	OCT	NOV	DEC

Chemical and concentration	Rate	Weed growth stage, method and comments
Aminopyralid 8 g/L + Triclopyr 300 g/L + Picloram 100 g/L Grazon™ Extra	350 mL / 100 L	**Seedling (individuals and infestations under 2 m):** Foliar spray, apply when actively growing + non-ionic wetting agent required
Triclopyr 300 g/L and Picloram 100 g/L Various trade names	350 mL / 100 L	**Seedling (individuals and infestations up to 2 m):** Foliar spray, apply when actively growing + non-ionic wetting agent required
Triclopyr 600 g/L Various trade names	1 L / 60 L (diesel) 1 L / 60 L (diesel)	**Seedling (individuals):** Basal bark < 5 cm stem diameter **Adult (individuals or infestation):** Cut stump > 5 cm stem diameter
Fluroxypyr 333 g/L Starane™ Advanced	1.8 L / 100 L (diesel) 1.8 L / 100 L (diesel)	**Seedling (individuals):** Basal bark < 15 cm* stem diameter, treat up to 45 cm from ground **Adult (individuals or infestation):** Cut stump > 15 cm stem diameter
Triclopyr 240 g/L + **Picloram 120 g/L** Access™	1 L / 60 L (diesel) 1 L / 60 L (diesel)	**Seedling (individuals):** Basal bark < 15 cm* stem diameter **Adult (individuals or infestation):** Cut stump > 15 cm stem diameter
Picloram 20 g/Kg Tordon™ granules	35 to 45 g / m^2	Apply granules over an area extending from the main stem to 30 cm outside the dripline to cover the main part of the root system

Non-chemical applications: Mechanical control or burning can be used to improve access to infested areas for follow up chemical control.

*It is noted that basal barking can be effective on trees of larger diameter. Basal barking, being less labour intensive than cut stumping, may be a preferable option for sparse or remote infestations. Cut stump applications may be the best management option for trees in urban/landscaped situations where the dead tree material will be removed to retain aesthetics.

Olive hymenachne – *Hymenachne amplexicaulis (Class B and Class C)*

OPTIMUM TREATMENT TIMES
darker colour indicates preferred treatment times

JAN	FEB	MAR	APR	MAY	JUN
JUL	AUG	SEP	OCT	NOV	DEC

Chemical and concentration	Rate	Weed growth stage, method and comments
Glyphosate 360 g/L Various trade names and formulations	10 mL / 1 L	**Seedling or adult (individuals or infestation):** Foliar spray – apply when actively growing

Non-chemical applications: Heavy grazing in the dry season can decrease seed production. Mechanical or physical removal is ineffective due to highly effective vegetative reproduction from small fragments. The use of heavy earth moving machinery to remove hymenachne from drains has met with some success in north Queensland. Aim to reduce plant bulk prior to wet season flooding and drown it. For large infestations contact WMB.

Paddy's lucerne – *Sida rhombifolia (Class B and Class C)*

OPTIMUM TREATMENT TIMES
darker colour indicates preferred treatment times

JAN	FEB	MAR	APR	MAY	JUN
JUL	AUG	SEP	OCT	NOV	DEC

Chemical and concentration	Rate	Weed growth stage, method and comments
2, 4-D amine 625 g/L Various trade names	320 mL / 100 L	**Seedling or adult (individuals or infestation):** Foliar spray – apply when actively growing
Glyphosate 360 g/L Various trade names and formulations	15 mL / 1L	**Seedling or adult (individuals or infestation):** Foliar spray – apply when actively growing
Fluroxypyr 200 g/L Various trade names	1 L / 100 L	**Seedling or adult (individuals or infestation):** Foliar spray – apply when actively growing
Fluroxypyr 333 g/L	600 mL / 100 L **or** 2.4 L / ha (boom)	**Seedling or adult (individuals or infestation):** Foliar spray – apply when actively growing

Non-chemical applications: Grub plants out. Slashing before flowering will prevent seed production temporarily and produce new growth for spraying.

Parkinsonia – *Parkinsonia aculeata (Class B and Class C)*

OPTIMUM TREATMENT TIMES
darker colour indicates preferred treatment times

JAN	FEB	MAR	APR	MAY	JUN
JUL	AUG	SEP	OCT	NOV	DEC

Chemical and concentration	Rate	Weed growth stage, method and comments
Aminopyralid 8 g/L + Triclopyr 300 g/L + Picloram 100 g/L Grazon™ Extra	350 mL / 100 L **or** 3 L / ha	**Seedling (individuals and infestation)** Foliar spray – avoid spraying if plants are stressed or bearing pods – Uptake Spraying Oil required Foliar spray – plants up to 2 m or 2 years old - Uptake Spraying Oil required
Triclopyr 240 g/L + Picloram 120 g/L Access™	1 L / 60 L (diesel) 1 L / 60 L (diesel)	**Seedling or adult (individuals or infestation)** Basal bark < 5 cm stem diameter Cut stump > 5 cm stem diameter
Tebuthiuron 200 g/kg	1.5 g / m^2	**Seedling or adult (individuals or infestation):** Granulated herbicide - ground applied Do not use within 30 m of desirable trees or apply to continuous area > 0.5 ha Do not use if fire is eminent Apply when there is soil moisture or prior to rain

Non-chemical applications: Blade-ploughing, stick-raking, bulldozing and chaining can be effective if the root layer is removed from the soil. Cultivation of pasture or native vegetation after mechanical control will help to prevent re-sprouting and seedling establishment. Fire destroys seed in the soil surface and can be used as a follow-up to remove seedlings after other control efforts. Fire may also be used to manage mature trees. Hand grubbing for single plants or small outbreaks, ensure removal of the root system. Biocontrol options are available with Uu establishing slowly in some areas.

Parthenium weed – *Parthenium hysterophorus (Class A and Class C)*

*** Report this plant to the Weed Management Branch immediately if found**

OPTIMUM TREATMENT TIMES
darker colour indicates preferred treatment times

JAN	FEB	MAR	APR	MAY	JUN
JUL	AUG	SEP	OCT	NOV	DEC

Chemical and concentration	Rate	Weed growth stage, method and comments
2, 4-D amine 625 g/L Various trade names	320 mL / 100 L	**Seedling or adult (individuals or infestation):** Foliar spray – apply when actively growing
Glyphosate 360 g/L Various trade names and formulations	10 mL / 1 L	**Seedling or adult (individuals or infestation):** Foliar spray – apply when actively growing
MCPA 340 g/L + Dicamba 80 g/L Various trade names	350 mL / 100 L **or** 5.2 L / ha (boom)	**Seedling or adult (individuals or infestation):** Foliar spray
Metsulfuron-methyl 600 g/kg Various trade names	10 g / 100 L	**Seedling or adult (infestations):** Foliar spray – apply when actively growing

Landholders are urged not to attempt to control or dispose of parthenium themselves. Contact the Weed Management Branch for assistance.

Pond apple – *Annona glabra (Class A and Class C)*

*** Report this plant to the Weed Management Branch immediately if found**

OPTIMUM TREATMENT TIMES
darker colour indicates preferred treatment times

JAN	FEB	MAR	APR	MAY	JUN
JUL	AUG	SEP	OCT	NOV	DEC

Chemical and concentration	Rate	Weed growth stage, method and comments
Glyphosate 360 g/L Various trade names and formulations	15 mL / 1L	**Seedling (individuals or infestation):** Foliar spray - apply when actively growing
Triclopyr 240 g/L + Picloram 120 g/L Access™	1 L / 60 L (diesel) 1 L / 60 L (diesel)	**Seedling or adult (individuals or infestation)** Basal bark < 5 cm stem diameter Cut stump > 5 cm stem diameter
Fluroxypyr 200 g/L Various trade names	1.5 L / 100 L (diesel) 1.5 L / 100 L (diesel)	**Adult (individuals or infestation):** Basal bark < 10 cm stem diameter, treat up to 45 cm from ground Cut stump > 10 cm stem diameter
Fluroxypyr 333 g/L Starane™ Advanced	900 mL / 100 L	**Adult (individuals or infestation):** Basal bark < 10 cm stem diameter, treat up to 45 cm from ground

Landholders are urged not to attempt to control or dispose of pond apple themselves. Contact the Weed Management Branch for assistance.

Prickly acacia – *Vachellia nilotica (Class A and Class C)*

OPTIMUM TREATMENT TIMES
darker colour indicates preferred treatment times

JAN	FEB	MAR	APR	MAY	JUN
JUL	AUG	SEP	OCT	NOV	DEC

Chemical and concentration	Rate	Weed growth stage, method and comments
Fluroxypyr 200 g/L Various trade names	750 mL / 100 L	**Seedling (individuals or infestation) + adult (infestation):** Foliar spray - Uptake® Spraying Oil required
Fluroxypyr 333 g/L Starane™ Advanced	450 mL / 100 L	**Seedling (individuals or infestation) + adult (infestation):** Foliar spray - Uptake® Spraying Oil required
Metsulfuron-methyl 600 g/kg Various trade names	10 g / 100 L	**Seedling (individuals or infestation) + adult (infestation):** Foliar spray – apply when actively growing, need wetting agent
Hexazinone 250 g/L Various trade names	4 mL / spot 1 spot for each metre in height	**Seedling (individuals or infestation) + adult (infestation):** Spot application - apply at the base of plant
Tebuthiuron 200 g/kg Various trade names	1.5 g / m^2	**Seedling (individuals or infestation) + adult (infestation):** Granulated herbicide: ground applied – do not use within 30 m of desirable trees or apply to single continuous area > 0.5 ha Use higher rate on dense growth or heavy clay soils
Triclopyr 240 g/L + **Picloram 120 g/L** Access™	1 L / 60 L (diesel) 1 L / 60 L (diesel)	**Adult (individuals or infestation):** Basal bark < 5 cm stem diameter Cut stump > 5 cm stem diameter
Fluroxypyr 333 g/L Starane™ Advanced	900 mL / 100 L (diesel) 900 mL / 100 L (diesel)	**Adult (individuals or infestation):** Basal bark < 10 cm stem diameter, treat up to 45 cm from ground Cut stump > 10 cm stem diameter
Triclopyr 600 g/L Various trade names	1 L / 120 L (diesel) 1 L / 120 L (diesel)	**Adult (individuals or infestation)** Basal bark < 5 cm stem diameter Cut stump > 5 cm stem diameter

Non-chemical applications: Before seed pods have dropped: hand grubbing (small plants), cutting the root < 30 cm below the soil surface (blade ploughing), stick-raking and chaining (larger plants or infestations) can be effective. Fire is useful for mass seedling control if there is a sufficient fuel load.

Prickly pears – *Opuntia* spp.

OPTIMUM TREATMENT TIMES
darker colour indicates preferred treatment times

JAN	FEB	MAR	APR	MAY	JUN
JUL	AUG	SEP	OCT	NOV	DEC

Chemical and concentration	Rate	Weed growth stage, method and comments
Triclopyr 600 g/L Garlon™ 600	800 mL / 60 L (diesel)	**Seedlings, juvenile, adults (individuals or infestations):** Foliar spray entire plant surface, ensuring all plant surfaces are completely covered with spray-mix to the point of runoff. Avoid spraying plants that appear stressed.
Triclopyr 240 g/L + Picloram 120 g/L Access™	1 L / 60 L (diesel)	**Seedlings, juvenile, adults (individuals or infestations):**Foliar spray entire plant surface, ensuring all plant surfaces are completely covered with spray-mix to the point of runoff. Avoid spraying plants that appear stressed.

Rat's tail grass – *Sporobolus* spp.

OPTIMUM TREATMENT TIMES
darker colour indicates preferred treatment times

JAN	FEB	MAR	APR	MAY	JUN
JUL	AUG	SEP	OCT	NOV	DEC

Chemical and concentration	Rate	Weed growth stage, method and comments
Glyphosate 360 g/L Various trade names and formulations	1.5 L / 100 L	**Seedling or adult (individuals or infestation):** Foliar spray – apply when actively growing

Non-chemical applications: Slashing can trigger seed production in rats tail grass varieties. Slashing can also be a major seed transport mechanism. To stop seed production, rats tail grass would need to be slashed approximately every two weeks before seed matures.

Rubber bush – *Calotropis procera* (Class B South of 16°30'S latitude and Class C)

OPTIMUM TREATMENT TIMES
darker colour indicates preferred treatment times

JAN	FEB	MAR	APR	MAY	JUN
JUL	AUG	SEP	OCT	NOV	DEC

Chemical and concentration	Rate	Weed growth stage, method and comments
Triclopyr 300 g/L + Picloram 100 g/L Conqueror® **+ Aminopyralid 8 g/L** Grazon™ Extra	750 mL / 100 L (water) 500-750mL / 100 L (water)	**Seedling (individuals or infestation):** Foliar spray. Check label for recommneded adjuvant product. More effective on plants <2m as thorough coverage on all leaves is required.
Triclopyr 240 g/L + Picloram 120 g/L Access™	1 L / 60 L (diesel) 1 L / 10 L (diesel) 1 L / 60 L (diesel)	**Adult (individuals and infestation):** Basal bark < 5cm stem diameter. Spray all stems. Spray to point of runoff. ThinLine up to 5cm stem diameter Cut stump > 5cm stem diameter
Tebuthiuron (200g/kg) Graslan *Pending registration. Please check with Weed Management Branch for status confirmation.*	1.5-2g/m^2	**Seedling or adult:** Application to black clay soils in conjunction with seasonal rainfall. Spread granules according to density of the infestation.
Fluroxypyr (333g/L) Starane™ Advanced	3 L / 100 L (diesel)	**Adult:** Cut stump method for plants up to 10cm diameter and 3m high.

Non-chemical applications: This plant is difficult to eradicate as the deep roots survive almost any treatment. Maintenance of a dense pasture sward will assist in preventing invasion.

Rubber vine – *Cryptostegia* spp. (Class A and Class C)

*** Report this plant to the Weed Management Branch immediately if found**

OPTIMUM TREATMENT TIMES
darker colour indicates preferred treatment times

JAN	FEB	MAR	APR	MAY	JUN
JUL	AUG	SEP	OCT	NOV	DEC

Chemical and concentration	Rate	Weed growth stage, method and comments
Triclopyr 300 g/L + Picloram 100 g/L Various trade names	350 - 500 mL / 100 L	**Seedling (individuals and infestation) + adult (infestation):** Foliar spray – use higher rates on stands > 1.5 m when flowering, spray leaves and stems to the point of run-off and apply to base
Triclopyr 240 g/L + Picloram 120 g/L Access™	1 L / 60 L (diesel) 1 L / 60 L (diesel)	**Adult (individuals or infestation):** Basal bark < 5 cm stem diameter Cut stump > 5 cm stem diameter
Triclopyr 600 g/L Various trade names	1 L / 60 L (diesel) 1 L / 60 L (diesel)	**Adult (individuals or infestation):** Basal bark < 5 cm stem diameter Cut stump > 5 cm stem diameter
Tebuthiuron 200 g/kg Various trade names	1.5 g / m^2	**Seedling or adult (individuals or infestation):** Granulated herbicide - ground applied Do not use within 30 m of desirable trees or apply to continuous area > 0.5 ha. Do not use if fire is eminent Apply when there is soil moisture or prior to rain

Non-chemical applications: Fire can destroy seeds, seedlings and adult plants with sufficient fuel loads. Blade or disk ploughing can be effective and will open up dense infestations for access. Slashing reduces vigour but may not kill plant.

Saffron thistle – *Carthamus lanatus (Class B and Class C)*

OPTIMUM TREATMENT TIMES
darker colour indicates preferred treatment times

JAN	FEB	MAR	APR	MAY	JUN
JUL	AUG	SEP	OCT	NOV	DEC

Chemical and concentration	Rate	Weed growth stage, method and comments
2, 4-D amine 625 g/L Various trade names	320 mL / 100 L **or** 1.1 - 2.4 L / ha	**Seedling or adult (individuals or infestation):** Foliar spray – apply when actively growing Foliar spray – use lower rate on seedlings
Glyphosate 360 g/L Various trade names and formulations	15 mL / 1 L	**Seedling or adult (individuals or infestation):** Foliar spray – apply when actively growing

Non-chemical applications: Improved perennial or native pastures will prevent establishment. Avoid heavy grazing as it will encourage growth. Slashing shortly before flowering can also effectively prevent seed production – but not too early as plants can re-sprout and produce new flower heads.

Salvinia – *Salvinia molesta (Class B and Class C)*

Non-chemical applications: Remove small infestations by hand, ensuring all of the plant is removed and destroyed. Biocontrol options are available.

Sicklepod – *Senna obtusifolia (Class B and Class C)*

OPTIMUM TREATMENT TIMES
darker colour indicates preferred treatment times

JAN	FEB	MAR	APR	MAY	JUN
JUL	AUG	SEP	OCT	NOV	DEC

Chemical and concentration	Rate	Weed growth stage, method and comments
Aminopyralid 25 g/L + Triclopyr 200 g/L + Picloram 100 g/L Tordon™ Regrowth Master	375 mL / 100 L	**Seedling or adult (individuals and infestation):** Foliar spray – apply when actively growing, non-ionic wetting agent required
Dicamba 500 g/L Various trade names	500 mL / 100 L	**Seedling or adult (individuals or infestation):** Foliar spray, wetting agent may be required
Aminopyralid 8 g/L + Triclopyr 300 g/L + Picloram 100 g/L Various trade names	200 mL / 100 L **or** 3 L / ha (boom)	**Seedling or adult (individuals and infestation):** Foliar spray – non-ionic wetting agent required: do not apply to podding plants

Non-chemical applications: Slashing can reduce old plants to a manageable size. Slashing should always be done prior to seed set, preferably when plants are flowering. Rotary hoeing or discing infested areas and immediately sowing with improved pastures can be effective, if the grasses are well managed. Avoid grazing paddocks containing sicklepod or senna, especially when mature seed is present. A constant, dense sward of grass will exclude sunlight and help to maintain soil moisture.

Snake weeds – *Stachytarpheta* spp. *(Class B and Class C)*

OPTIMUM TREATMENT TIMES
darker colour indicates preferred treatment times

JAN	FEB	MAR	APR	MAY	JUN
JUL	AUG	SEP	OCT	NOV	DEC

Chemical and concentration	Rate	Weed growth stage, method and comments
2, 4-D amine 625 g/L Various trade names	320 mL / 100 L	**Seedling or adult (individuals or infestation):** Foliar spray - apply when actively growing
Fluroxypyr 200 g/L Various trade names	750 mL / 100 L	**Seedling (individuals or infestation):** Foliar spray - Uptake® spraying oil required
Fluroxypyr 333 g/L Starane™ Advanced	450 mL / 100 L	**Seedling (individuals or infestation)** Foliar spray - Uptake® spraying oil required

Non-chemical applications: Slash before seed set and re-establish pasture grass for competition.

Spinyhead sida – *Sida acuta (Class B and Class C)*

OPTIMUM TREATMENT TIMES
darker colour indicates preferred treatment times

JAN	FEB	MAR	APR	MAY	JUN
JUL	AUG	SEP	OCT	NOV	DEC

Chemical and concentration	Rate	Weed growth stage, method and comments
2, 4-D amine 625 g/L Various trade names	320 mL / 100 L	**Seedling or adult (individuals or infestation):** Foliar spray - apply when actively growing
Metsulfuron-methyl 600 g/L Various trade names	10g / 100 L	**Seedling or adult (individuals or infestation):** Foliar spray - apply when actively growing, wetting agent required
Fluroxypyr 200 g/L Various trade names	1 L / 100 L	**Seedling (individuals or infestation):** Foliar spray - Uptake® spraying oil required
Fluroxypyr 333 g/L Starane™ Advanced	900 mL / ha + Uptake 1 L / ha	**Seedling (individuals or infestation)** Foliar spray - Uptake® spraying oil required Boom application - apply when actively growing

Non-chemical applications: Repeated slashing and cultivation; vigorous pasture competition. Biocontrol options are available.

Thornapples – *Datura ferox (Class A and Class C), Datura* spp. *(Class C)*

OPTIMUM TREATMENT TIMES
darker colour indicates preferred treatment times

JAN	FEB	MAR	APR	MAY	JUN
JUL	AUG	SEP	OCT	NOV	DEC

Chemical and concentration	Rate	Weed growth stage, method and comments
2, 4-D amine 625 g/L Various trade names	320 mL / 100 L	**Seedling or adult (individuals or infestation)** Foliar spray - apply when actively growing
Glyphosate 360 g/L Various trade names and formulations	15 mL / 1L	**Seedling or adult (individuals or infestation):** Foliar spray – apply when actively growing
MCPA 340 g/L + Dicamba 80 g/L Various trade names	350 mL / 100 L	**Seedling or adult (individuals or infestation):** Foliar spray
Fluroxypyr 200 g/L Various trade names	1 L / 100 L	**Seedling (individuals or infestation):** Foliar spray - Uptake® spraying oil required
Fluroxypyr 333 g/L Starane™ Advanced	450 mL / ha (boom)	**Seedling (individuals or infestation)** Foliar spray - Uptake® spraying oil required Boom application - apply when actively growing

Non-chemical applications: Easily removed by hand, collect and burn mature seeds.

Thatch grass – *Hyparrhenia rufa (Class A and Class C)*

OPTIMUM TREATMENT TIMES
darker colour indicates preferred treatment times

JAN	FEB	MAR	APR	MAY	JUN
JUL	AUG	SEP	OCT	NOV	DEC

Chemical and concentration	Rate	Weed growth stage, method and comments
Glyphosate 360 g/L Various trade names and formulations	2 L / 100 L	**Seedling or adult (individuals or infestation):** Foliar spray – apply when actively growing
Glyphosate 450 g/L Various trade names and formulations	1.6 L / 100 L	**Seedling or adult (individuals or infestation):** Foliar spray – apply when actively growing
Glyphosate 540 g/L Various trade names and formulations	1.4 L / 100 L	**Seedling or adult (individuals or infestation):** Foliar spray – apply when actively growing

Non-chemical applications: Small infestations can be hand pulled. Slashing can prevent seed formation. Regrowth can then be treated with herbicide.

Water hyacinth – *Eichhornia crassipes (Class A and Class C)*

*** Report this plant to the Weed Management Branch immediately if found**

If you think you may have seen water hyacinth or have this weed on your property do not attempt to control it, contact the Weed Management Branch for assistance.

Water mimosa – *Neptunia plena and N. oleracea (Class A and Class C)*

*** Report this plant to the Weed Management Branch immediately if found**

If you think you may have seen water mimosa or have this weed on your property do not attempt to control it, contact the Weed Management Branch for assistance.

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Websites

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- Australian Weeds Strategy, A national strategy for weed management in Australia, www.weeds.org.au/docs/The Australian Weeds Strategy.pdf.
- Commonwealth Scientific and Industrial Research Organisation (CSIRO): www.csiro.au – search ‘weeds’
- Co-operative Research Centre for Tropical Savannas: savanna.cdu.edu.au - search ‘weeds’
- Invasive Plants and Animals Committee http://www.pestsmart.org.au/connect/ipac/
- *Northern Territory Weeds Management Act* www.nt.gov.au/dcm/legislation/current.htmL
- Weed Identification Tool: www.weeds.org.au/ntmap.htm
- Weed Management Branch, Land Resource Management: www.nt.gov.au/weeds
- Weeds of National Significance (WoNS): www.weeds.org.au/natsig.htm

Acknowledgements

Some sections of this manual have been directly reproduced, with permission, from the NSW Noxious and Environmental Weed Handbook (3rd edition) 2007 by Rod Ensbey and Annie Johnson.

Appendix A – Preventing Weed Seed Spread

Vehicle Hygiene

Vehicles, including quad bikes, boats and farm machinery can easily spread weed seed if a high level of vigilance is not maintained. Ideally a strict inspection regime should be implemented before and after all travel, especially when travelling to areas known to be infested with weeds.

It should also be noted that many plants have developed special adaptations to facilitate their spread. Many have hooks or burrs which catch readily in clothing, footwear or in animal hair, so people and animals should be checked prior to moving into clean areas.

The checklist below can be used as a guide to establish a checking program for your property.

Before Travel

- Before travelling check clothing and shoes are free of mud and seeds.

Inside the Vehicle

- Check the foot wells and mats to make sure that no weed seed has fallen off your shoes.

Engine

- Check radiator and grill.

Around the Vehicle

- Check along wheel trims, mud flaps, tyres and tray of the vehicle for mud and weed seed.

Quad Bikes/Machinery

- Check around the wheels and where mud or weed seed may be caught.

Underneath the Vehicle

- Check the undercarriage and guards to ensure that there is no mud or weed seed.

Washing Down Procedures

- Establish a designated location to wash down your vehicle.
- Monitor plants growing in this area.
- Control all weed growth immediately.

Rubber bush seeds are easily transported.

Burrs stuck to sock.

Mimosa seed pods.

Bellyache bush fruit ready to burst.

Rat's tail grass seeds.

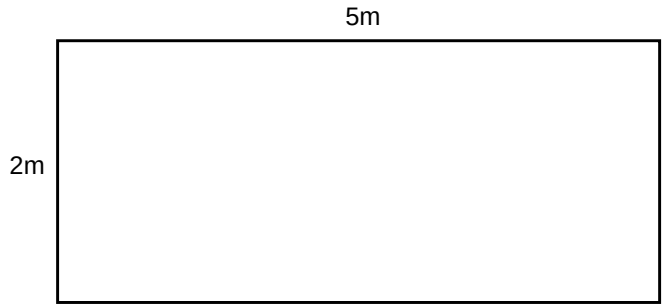
Appendix B –
Research and Development of Biological Control Agents in the NT

Weed	Agent	Type of agent	first released	plant part attacked	Established?
Mimosa (*Mimosa pigra*)	*Acanthoscelides puniceus*	beetle	1983	mature seed	yes
	Acanthoscelides quadridentatus	beetle	1983	mature seed	no
	Chlamisus mimosae	beetle	1985	leaves and stems	yes
	Neurostrota gunniella	moth	1989	pinnae and tips	yes
	Carmenta mimosa	moth	1989	large stems	yes
	Coelocephalapion aculeatum	weevil	1992	flower buds	no
	Coelocephalapion pigrae	weevil	1994	flower buds and leaves	yes
	Phloeospora mimosae-pigrae	fungus	1995	leaves , stems and pods	no
	Chalcodermus serripes	weevil	1996	green seed and tips	yes
	Diabole cubensis	fungus	1996	leaves	yes
	Sibinia fastigiata	weevil	1997	green seed and flowers	no
	Malacorhinus irregularis	beetle	2000	Leaves, roots and nodules	yes
	Macaria pallidata	moth	2002	leaves	yes
	Leuciris fimbriaria	moth	2005	leaves	yes
	Nesaecrepida infuscata	beetle	2007	roots and leaves	yes
Bellyache bush (*Jatropha gossypiifolia*)	*Agonosoma trilineatum*	bug	2003	fruit	no
Parkinsonia (*Parkinsonia aculeata*)	*Eueupethicia cisplatensis*	moth	2013	leaves	yes
	Rhinacloa callicrates	bug	1989	leaves and flower buds	no
	Mimosestes ulkei	beetle	1995	seed	no
	Penthobruchus germaini	beetle	1995	seed	yes
Salvinia (*Salvinia molesta*)	*Cyrtobagous salviniae*	weevil	1981	leaves, roots	yes
Sida (*Sida acuta*)	*Calligrapha pantherina*	beetle	1989	leaves	yes
	Eutinobothrus sp.	weevil	1997	stems	no
	Eutinobothrus pilosellus	weevil	1997	stems	no
Noogoora Burr (*Xanthium strumarium*)	*Epiblema strenuana*	moth	1982	stems	yes
	Puccinia xanthii	fungus	~1975	leaves	yes

Appendix C – Calibrating Spray Equipment

Hand gun calibration

1. Mark out an area 5 m x 2 m = 10 m^2 = **1/1000th** of 1 hectare (representative of the area to be treated)



2. Time taken in **seconds** to spray **10 m^2**
3. Measure output in litres/seconds taken to spray 10 m^2
4. Multiply **output x 1000** = L/ha

Boom sprayer calibration

1. Record **output** from each nozzle for 1 minute (replace if flow rate varies ± 10% or if spray pattern is visually faulty)
2. Record total **spray output** (add **output** for all nozzles) as **litres per minute**
3. Measure effective **spray width** and record in metres
4. Determine actual ground speed by timing in seconds the **time taken** to travel **100 metres**

$$\text{* Actual ground speed} = \frac{\textbf{100 metres} \times 3.6}{\textbf{Time taken} \text{ (seconds)}} = \text{km/h}$$

Note: 3.6 is a conversion factor to convert seconds to hours

5. Determine **water application rate** by using steps 2-4

$$\textbf{*Water application rate} = \frac{\textbf{spray output} \text{ (L/minute)} \times 600}{\textbf{spray width} \text{ (m)} \times \textbf{ground speed} \text{ (k/h)}} = \text{L/hectare}$$

Appendix D - Courses Relevant to Chemical Application in the NT

Charles Darwin University

Chemical training courses offered:

- AHCPMG301A Control weeds (may be run in conjunction with the AQF3 SMARTtrain Accreditation course)
- AHCPMG201A Treat weeds (may be run in conjunction with AQF2 Apply chemicals course)
- AHCPMG202A Treat plant pests, diseases and disorders - self paced or on request
- AHCPMG302A Control plant pests, diseases and disorders - self paced or on request
- HLTFA301C First Aid course - on request

The following courses meet requirements for some pest control or ground spray application licenses:

- RTC3401 Control weeds
- RTC2401 Treat weeds
- RTC3404 Treat pest and disease
- RTC2404 Control pest and disease
- RTC2704A First Aid course

Chainsaw operations course - many companies are using chainsaws and chemicals together for bush clearing or woody weed control.

- Operate chainsaws - (2 days) - basic chainsaw skills.
- Tree felling course - (2 days) - more advanced for controlled felling of trees.

Please contact Charles Darwin University directly for current information on courses offered on (08) 8946 7513 or email hort_aqua@cdu.edu.au

Appendix E – Modes of Action

Modes of Action (Barrett, M. and Reed, G., 1997)

Resistance Risk	Mode of Action Group	Typical Actives
High	A - Inhibitors of acetyl co-enzyme A Carboxylase (lipid synthesis, cell membranes)	diclofop-methyl clethodim fluazifop-P haloxyfop propaquizafop sethoxydim
	B - Inhibitors of acetolactase synthase (ALS) (amino acid synthesis)	chlorsulfuron halosulfuron-methyl imazapyr metsulfuron-methyl triasufuron iodosulfuron
Moderate	C - Inhibitors of photosynthesis at photosystem II	atrazine diuron fluometuron prometryn
	D - Inhibitors of tubulin formation	pendimethalin trifluralin
Low	E - Inhibitors of mitosis	Carbetamide Triallate bensulide
	F - Inhibitors of carotenoid biosynthesis	norflurazon
	G - Inhibitors of chlorophyll biosynthesis	oxyfluorfen
	H - Inhibitors of protein synthesis	thiobencarb
	I - Disruption of plant hormone action	2,4-D 2,4-DB dicamba triclopyr fluroxypyr MCPA picloram
	J - Inhibitors of fat synthesis	flupropanate
	K - Herbicides with diverse sites of action	metolachlor MSMA
	L - Inhibitors of photosynthesis at photosystem I	diquat paraquat
	M - Inhibitors of aromatic amino acid synthesis	glyphosate glyphosate-trimesium
	N - Inhibitors of glutamine synthetase	glufosinate-ammonium

In Australia, the letters (A, B, C etc) are used to identify the different Mode of Action groups whereas overseas, the numbers (1, 2, 3 etc) are used.

Appendix F – Appropriate Disposal of Chemicals and Containers

drumMUSTER

To solve the problem of what to do with used, non-returnable chemical containers, Croplife Australia, the NFF (National Farmer's Federation), the Veterinary Manufacturers and Distributors Association (VMDA) and local governments developed the national collection and recycling scheme, drumMUSTER.

drumMUSTER is Australia's most extensive environmental program for the collection and recycling of agricultural and veterinary chemical containers.

Contact 1800 008 707 for further information. As more collection sites are set up, you can check on the locations through the drumMUSTER website : WWW.drummuster.com.au

From 1 February 1999, land managers and farmers have paid a 4c per litre or kilogram levy on non-returnable chemical containers, with capacities greater than 1 L or 1 kg, which funds drumMUSTER and ChemClear programs.

The levy funds local government to:

- pay staff to inspect returned containers;
- process the returned containers; and
- publicise local collection sites and times;
- provide collection services for the ChemClear program.

Since drumMUSTER's inception in late 1998, drumMUSTER has collected and recycled more than 23 million empty agvet chemical containers and transformed them into practical items such as fence posts, wheelie bins and road signs. Once councils enter into an agreement with drumMUSTER, land managers are able to deliver cleaned (that is, triple or pressure-rinsed) containers to designated collection points run by participating councils.

At these collection points, the delivered containers are inspected and either accepted or rejected.

Check the drumMUSTER website www.drummuster.com.au for the location of collection points in the Northern Territory.

Since the inception of the ChemClear program in 2003 more than 397 tonnes of unwanted chemical has been collected and disposed of in an appropriate manner.

For more information on ChemClear visit : www.chemclear.com.au

Cleaning Containers for Collection

When rinsing, the personal protective equipment specified on the label for application and/or mixing and loading the pesticide should be worn. This is because the chemical remaining in a container is the concentrate - the most toxic form of the chemical.

To triple-rinse containers:

- remove the cap, invert the container and allow it to drip drain into the mixing tank for 30 seconds;
- add rinse water 20%;
- replace cap and shake vigorously for 1 minute;
- remove cap, Invert and drip drain into mixing tank for 30 seconds;
- repeat twice; and
- wash cap separately and leave off the container to allow it to dry.

Triple-rinsing is only suitable for small containers up to 20 L. Rinsing is most effective immediately after using the chemical. The longer the residue has time to dry and cake on the inside of the container, the more difficult it is to remove. This is the reason for rinsing during mixing and loading. If rinsing is done during mixing and loading, the rinsate can be emptied into the spray or mixing tank of the application equipment. Using the rinsate avoids the need to dispose of the container residues separately.

An alternative to manually triple-rinsing small containers is using a pressure rinsing nozzle. There are two main types. One has a rotating spray head that can be used to rinse an inverted container in the induction hopper or directly over the tank. The other has a hardened, pointed shaft to pierce drums, and the hollow shaft itself has four holes at 90 degrees to spray the water around the container.

To pressure rinse a container up to 20 L:

- remove the cap, invert the container and allow it to drip drain into the mixing tank for 30 seconds;
- ensure clean rinse water is between 35 and 60 psi;
- Insert pressure-rinsing probe, either through the container opening or through the pierced base of the container (depending upon the type of nozzle);
- Invert container over mixing tank and rinse for 30 seconds or longer if the water coining from the container neck is not clear, moving the probe about to ensure all inner surfaces are rinsed;
- wash cap in clear rinse water from container;

- turn off water, remove probe and drip drain container into mixing tank for 30 seconds; and
- leave the lid off the container to allow it to dry.

ChemCLEAR - Disposal of unwanted chemicals

ChemClear® is the national program for the collection and disposal of unwanted currently registered agvet chemicals. The objective of the program is to minimise the accumulation of unwanted agvet chemicals held in storage which may create potential risks to the environment, public health and trade.

There are two categories of agvet chemicals ChemClear® collects:

- Group 1 chemicals are currently registered products manufactured by participating companies signed to the Industry Waste Reduction Agreement. These products are collected free of charge by virtue of having been included in the drumMUSTER levy.
- Group 2 chemicals are products manufactured by non-participating companies, or, deregistered, unknown, mixed or out of date products. A per litre/kilogram fee for disposal applies.

Registrations are essential and can be made at www.chemclear.com.au or 1800 008 182.

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www.nt.gov.au/weeds

App2.4 Construction and Rehabilitation of Exploration Drill Sites

Construction and Rehabilitation of Exploration Drill Sites

1. Introduction

This purpose of this Advisory Note is to assist exploration operators in the construction, rehabilitation and closure of drill sites to minimise the disturbance footprint and ensure the protection of the environment.

Drilling activities have the potential to impact on the environment in a variety of ways, including contamination of aquifers through the ingress of contaminants from the surface, interconnection between aquifers, contamination of surface water, loss of flora and fauna, soil contamination from hydrocarbons and drill fluids, and soil erosion. In addition, open holes pose a danger to people and wildlife and inhibit future exploration and pastoral vehicles traversing the area.

Likewise, bores used to access groundwater for exploration or mining activities can constitute a hazard to public health and safety, and can adversely affect the quality and flow of groundwater resources if abandoned without due concern. Therefore, it is imperative that drill sites are remediated and bores are adequately prepared for abandonment when they are no longer required.

2 Legislation

The purpose of the *Mining Management Act* is to ensure the protection of the environment on mining sites and for related purposes, including exploration. Under the *Mining Management Act,* every person has an obligation to take care of the environment and ensure the rehabilitation of areas impacted by their activities.

3 Requirements

Drill pads and benches are to be constructed with minimum disturbance to the environment and remediated in such a way as to reinstate the natural land surface, promote rapid revegetation and prevent the initiation of soil erosion. Prior planning is required, as this helps to minimise the cost of rehabilitation and to reduce negative impacts on the environment.

Drillholes and bores that are abandoned to restore, as close as possible, the controlling geological conditions that existed prior to drilling. In the Northern Territory exploration drillholes must be backfilled to the surface with a suitable medium (eg concrete or drill cuttings). At a minimum, drillholes are required to be plugged in the manner described in the diagrams below. It should be noted that the use of Octoplugs is not endorsed.

Special consideration for the protection of groundwater may be required where an exploration drillhole intersects an aquifer.

3.1 Construction of drill pads, benches and drillholes

- Prepare drill pads and benches with the minimum of disturbance and earthworks required. Drilling, excavation or clearing must not occur with 25m of a watercourse or 125m of a major road or railway.
- Minimise vegetation removal by avoiding large trees and leave rootstock in the ground to assist with stabilisation and natural regeneration.
- Clear and level the minimum area necessary for the work to be carried out safely.
- The dozing of earth and excavated material down steep slopes from which it cannot be readily recovered is to be avoided.
- The creation of hard bare rock areas which cannot support vegetation is to be avoided.
- If excavations are required, remove topsoil and stockpile for re-spreading on completion of the drilling program.
- Sumps are required to be situated away from the drip line of trees to avoid impacts on the root zone.
- Sumps require the construction of a slope to allow for fauna egress.
- The use of an excavator to assist in the construction of the pads is recommended on steep slopes to minimise earthworks and enable the storage of topsoil and subsoil for later rehabilitation operations.
- The use of tracked drill rigs is strongly recommended at sites on steep terrain.
- Drillholes that are likely to intersect artesian aquifers must be pre-collared and have a pressure cementing casing of adequate strength and to a sufficient depth, to enable bore control procedures to be carried out in the event of a blow-out.

3.2 Rehabilitation

3.2.1 Rehabilitation of drill pads and benches

- Dependent on site conditions and surrounding landscape, it may be necessary to conduct earthworks to stabilise and reshape the site. The site is required to be remediated to as near original condition as possible, following the completion of the drilling program.
- Ground which has become compacted by the use of heavy machinery and traffic is to be ripped along contour, not down slope, to loosen soil, promote water infiltration, aid revegetation and minimise soil erosion.
- Earth and overburden that was excavated from the pads and benches is required to be pushed, raked or pulled back over. The stockpiled topsoil and vegetation should be re-spread over the site.
- All sample bags, waste materials and contaminants must be removed from site and disposed of in an appropriate manner, following the completion of the drilling program.
- Drill cuttings that are acidic, radioactive or of a substantially different colour to the surface soil must be backfilled in the drillhole, sump or other excavation. All other cuttings are required to be dispersed around the site or raked over.
- Drill sumps must be backfilled with the excavated material and respread with stored topsoil.
- Permanent survey markers should be kept to a minimum and wooden pegs should be used in preference to steel pegs.
- Tracks constructed to access the drill site must be remediated as per the department's Advisory Note for the Clearing and Rehabilitation of Exploration Gridlines and Tracks.

3.2.2 Capping and plugging of drillholes intersecting a single unconfined aquifer

Collared holes

- PVC collars may be readily cut below ground level to a minimum depth of 0.4 metres using a powered brush cutter modified with a diamond masonry blade or an internal pipe cutter. The cut section of collar may be removed from the hole using chain tongs or an oil filter remover if necessary.
- A non-degradable plug, bridge (metal plate) or casing cap should be installed above the cut off casing at a minimum of 0.4 metres below ground level. The plug may be fitted with a length of wire rope and a tag as an indicator, if required.
- Alternately, drillholes may be either backfilled with drill cuttings, clean fill or cement, allowing for settlement.
- The soil backfill should be compacted and mounded over the hole to allow for subsidence and to limit the pooling of surface water.
- Please refer to **Figure 1**.

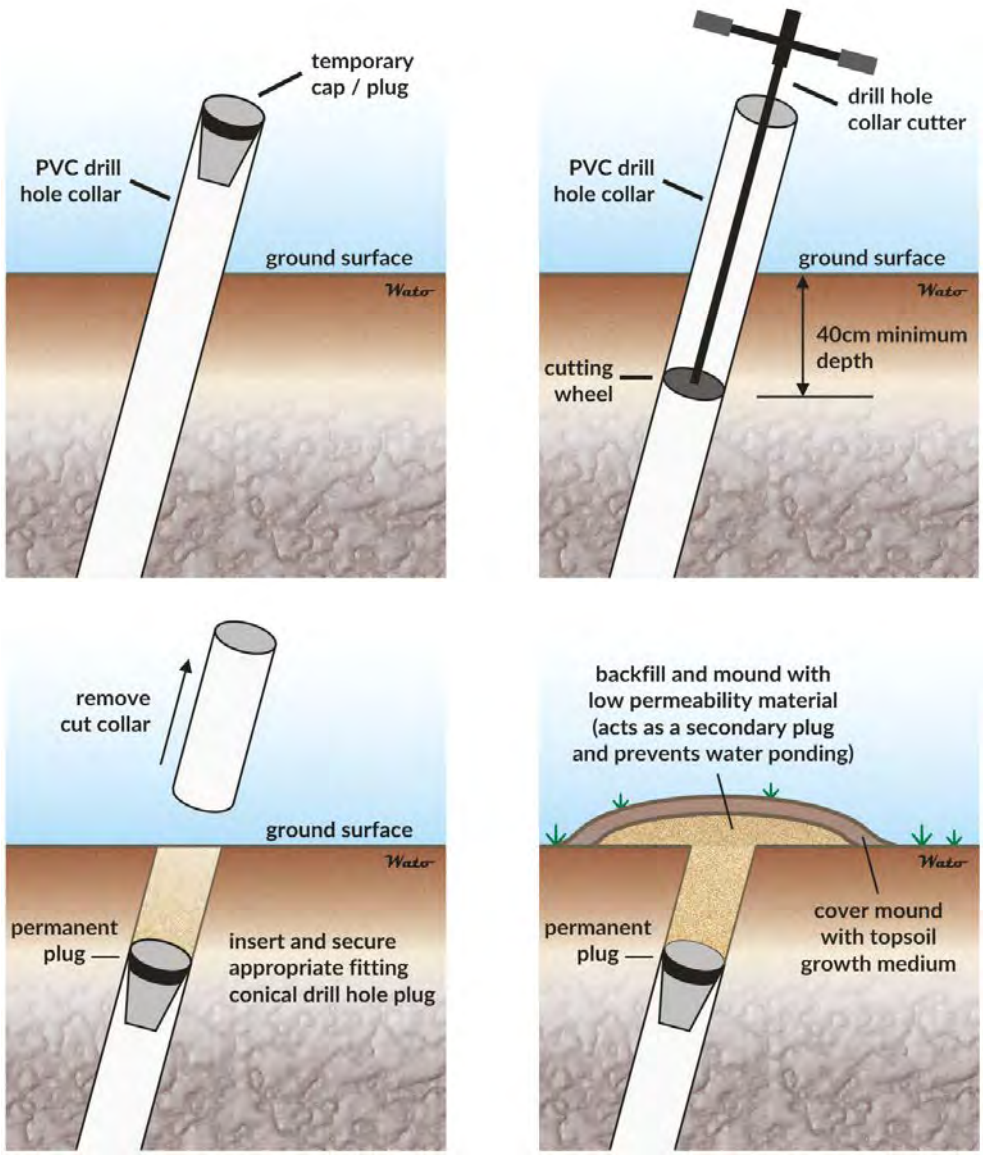


Figure 1: Capping and plugging of collared and uncollared drillholes.

Uncollared holes

- Drillholes should be plugged at least 1 metre below ground level with a non-degradable plug or bridge. The plug is to be at least 50 millimetres larger than the diameter of the drillhole, but depending on the nature of the ground, must be of sufficient size as to remain firmly in position.
- To enable the placement of the plug the drillhole may need to be reamed-out to 1 metre depth with hand tools or counter-bored by the drill rig with a larger drill bit.
- Alternately, holes may be either backfilled with drill cuttings, clean fill or cement, allowing for settlement.
- The soil backfill should be compacted and mounded over the hole to allow for subsidence and limit the pooling of surface water.
- The intention is that water shall not ingress the hole, causing erosion. Particular care is required to ensure the long term effectiveness of the plugging procedure.

3.2.3 Capping and plugging of drillholes intersecting a single confined aquifer

- The main objective in sealing drillholes in single confined aquifers is to contain water in the aquifer.
- Drillholes should be plugged across the aquifer confining bed interface for a thickness of about 4 metres (2 metres above the interface and 2 metres below); and then backfilled or plugged as outlined previously.
- Please refer to **Figure 2**.

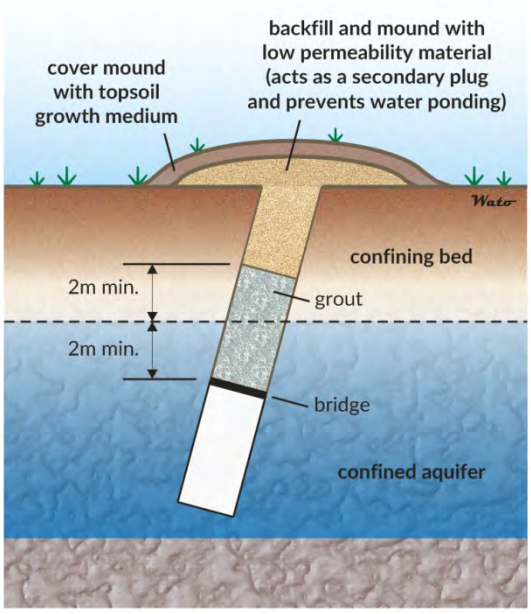


Figure 2: Capping and plugging of drillholes intersecting a single confined aquifer.

3.2.4 Capping and plugging of drillholes intersecting multiple aquifers

- Major aquifers should be sealed to prevent inter-aquifer flow.
- Grout plugs should be positioned at the interfaces between aquifers and the overlying confining beds. The grout should be at least 4 metres thick, with 2 metres above and 2 metres below the interface.
- Holes should then be backfilled or plugged as outlined previously, with compaction and mounding of backfilled material.
- Shallow drillholes can be backfilled from the base of the hole to the surface with grout.
- Please refer to **Figure 3.**

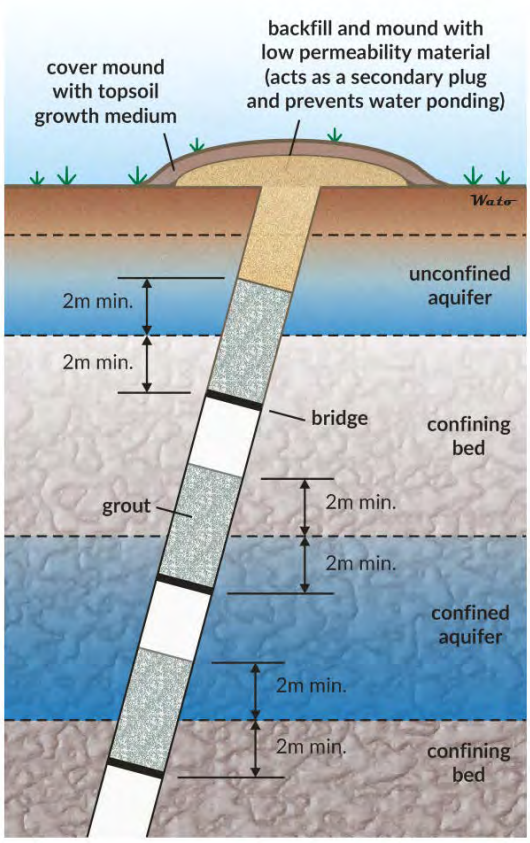


Figure 3: Capping and plugging of drillholes intersecting multiple aquifers.

3.2.5 Bore decommissioning

- If decommissioning a bore at a mine site, please contact the department's Environmental Monitoring Unit (08 8984 4234) or Mining Compliance (08 8999 6528) to ensure the department no longer requires the bore for monitoring.
- All bores that are to be permanently decommissioned must be sealed completely and filled in a manner that prevents vertical movement of water within the bore.
- The sealing material must not pose any potential human or environmental health risk and should be more impervious than the material through which the bore was drilled. Concrete, cement grout or bentonite grout should be used as the primary sealing material and should be placed from the base of the hole upwards.
- Fill material should consist of clean or disinfected sand, coarse stone, clay or drill cuttings.
- Bores with high flows and pressure should be sealed exclusively with cement grout to a depth of at least 20 metres (unless the flow originates from less than 20 metres).

- All bores should be sealed with an approved sealing material from a depth of 5 metres to around 30 centimetres below the ground surface. Topsoil should be placed above this to assist in full rehabilitation. Surface casings may be left in place if they have been pressure cemented or if they have been determined to be sound, in which case they must be bridged with cement grout.
- Grout bridges may be used where it is not practicable to grout a bore fully. A minimum of 10 metres is required for a bridge (20 metres for a flowing bore). These will be set in impermeable strata immediately above and below each aquifer formation in the bore.
- Records should be complete and accurate regarding the location of abandoned bores and the procedure used for decommissioning and rehabilitation.
- Please refer to **Figures 4 to 7**.

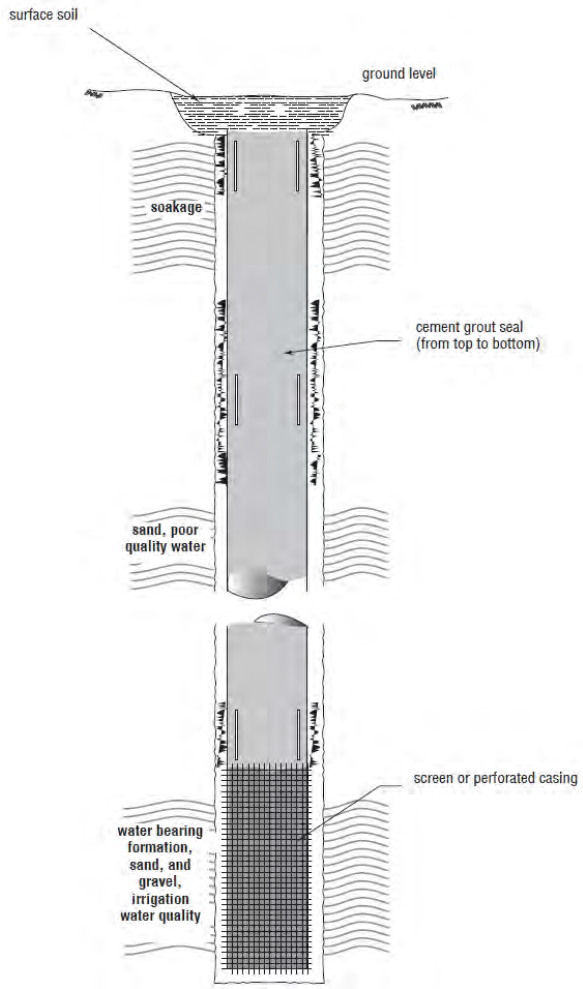


Figure 4: Requirements for decommissioning a non-flowing bore. Source: National Uniform Drillers Licensing Committee (NUDLC) 2012.

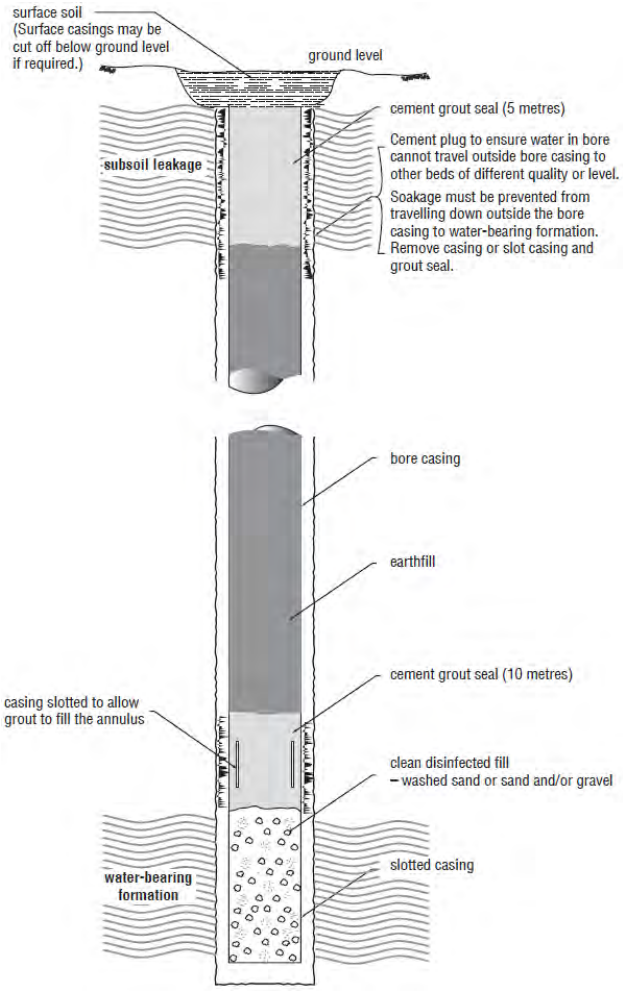


Figure 5: Requirements for decommissioning a single aquifer non-flowing bore. Source: NUDLC 2012.

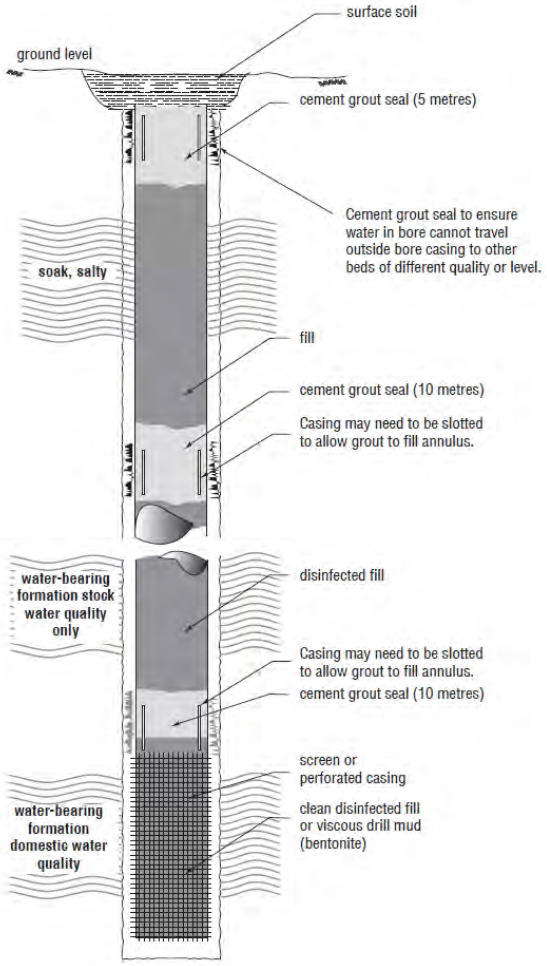


Figure 6: Requirements for decommissioning a multiple aquifer non-flowing bore. Source: NUDLC 2012.

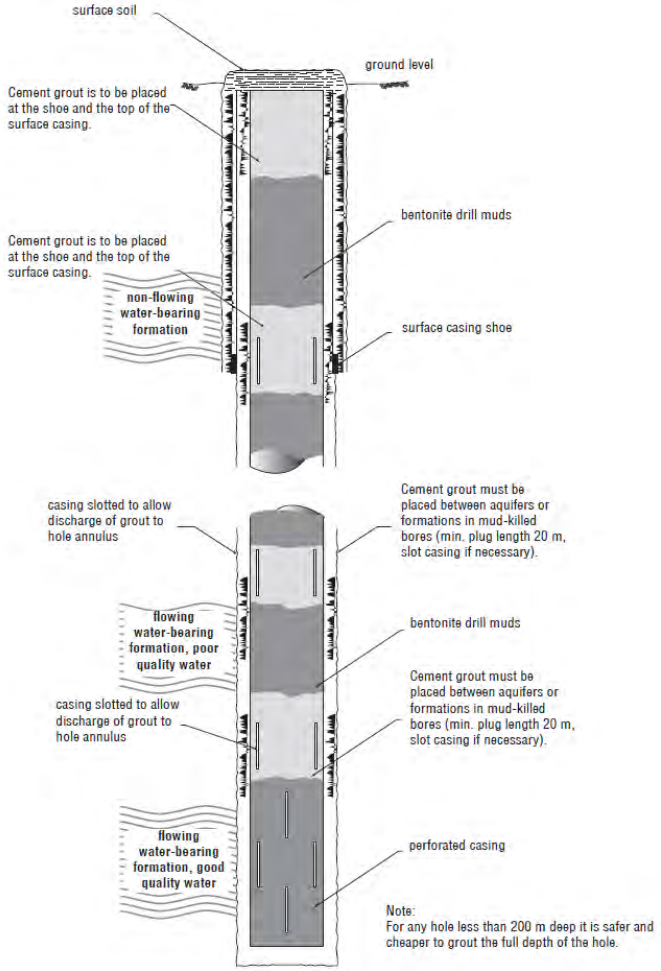


Figure 7: Requirements for decommissioning a flowing bore. Source: NUDLC 2012

4 Glossary of Terms

TERM	DESCRIPTION
Confined Aquifer	Confined aquifers are under pressure, have a confining layer of impervious strata above, and the water will rise above the level at which it is cut.
Environment	Means land, air, water, organisms and ecosystems on a site and includes: • the well-being of humans • structures made or modified by humans • the amenity values of the site • economic, cultural and social conditions.
Environmental Impacts	Any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organisation's environmental aspects.
Operator	Means the operator for a mining site referred to in Mining Management Act section 10.
Unconfined Aquifer	An aquifer in which the water is under atmospheric pressure, and generally the water remains at the level at which it was cut.

5 Further Information

National Uniform Drillers Licensing Committee, 2012. *Minimum Construction Requirements for Water Bores in Australia (Third edition).* http://aditc.com.au/wp-content/uploads/2014/06/Minimum-Construction-Req-Ed-3-2.8MB.pdf

Department of Primary Industry and Resources. *Mining Forms, Procedures and Guidelines* - www.minerals.nt.gov.au/mining

6 References

National Uniform Drillers Licensing Committee, 2012. *Minimum Construction Requirements for Water Bores in Australia (Third edition).* http://aditc.com.au/wp-content/uploads/2014/06/Minimum-Construction-Req-Ed-3-2.8MB.pdf [accessed September 2016].

App2.5 Clearing and Rehabilitation of Exploration Gridlines and Tracks

Clearing and Rehabilitation of Exploration Gridlines and Tracks

1.0 Introduction

Explorers are required under the *Mining Management Act* to rehabilitate areas impacted by their exploration activities and to minimise environmental impacts resulting from these activities.

The main goal in environmental management of exploration activities is to minimise or prevent unnecessary impacts and rehabilitate sites where disturbance cannot be avoided. Well designed and executed construction, maintenance and rehabilitation works can avoid creating future environmental impacts and additional costs.

Tracks and gridlines are to be cleared with a minimum of disturbance to the environment and be rehabilitated in such a way as to reinstate the natural land surface, promote rapid revegetation and prevent the initiation of soil erosion.

On major projects with longer timeframes, tracks and gridlines are required to be appropriately designed, constructed and routinely maintained to prevent degradation during the life of the project.

2.0 Requirements

2.1 Track Construction and Maintenance

When designing and constructing tracks, adverse environmental impacts can be minimised by implementing simple best practice measures, such as:

- Locating tracks to minimise impact upon, or avoid if possible:
  - environmentally sensitive areas, heritage areas and culturally sensitive sites
  - soils with high erosion risk, steep slopes and long slope lengths
  - creek crossings, floodplains and broad drainage lines; and
  - areas already degraded by soil erosion, over-grazing, fire or weeds
- Minimising vegetation clearing by choosing routes that avoid densely vegetated areas and the clearing of large mature trees.
- Minimising soil disturbance by using a stick rake or the ‘blade up’ method and wherever possible driving vehicles across unprepared terrain.
- Keeping the width of tracks to the minimum required to safely meet the needs of the largest vehicle.
- Minimising disruption to natural drainage lines by crossing creeks at right angles and maintaining the natural level of the creek bed at crossings.
- Minimise the concentration and channelling of natural surface water flows by avoiding the formation of windrows at the sides of tracks.
- Carefully planning and constructing tracks on sloping ground as they are susceptible to erosion. Minimise the risk of soil erosion by implementing erosion control techniques, such as using switch-backs (changes in direction), and erosion control structures such as diversion banks or whoa-boys (**Figure 1**), placed at suitable intervals.
- Maintaining tracks that are frequently used over long periods. Minimise impacts by routinely inspecting and maintaining tracks to prevent small problems turning into large ones. Regular remedial works addressing issues such as deep rutting, formation of bulldust, and soil erosion should help reduce repair time and costs at the end of a project.

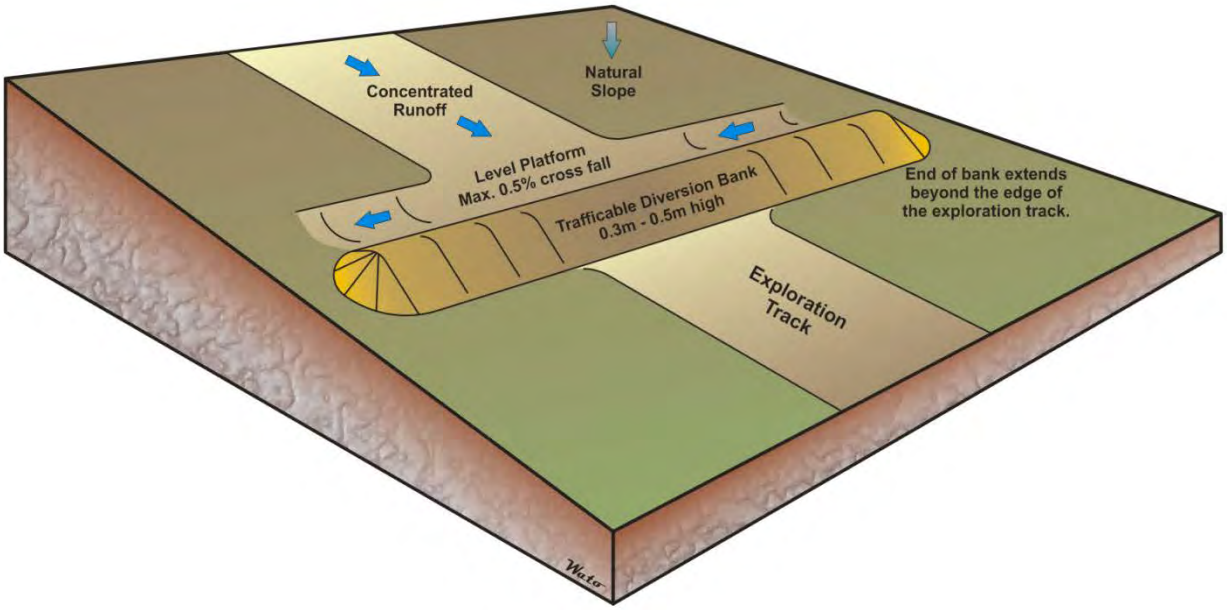


Figure 1: Diversion bank (Whoa-boy) diverting concentrated water off a track or gridline. The bank allows the natural cross flow of water from upslope to down slope and minimises the potential for soil erosion.

2.2 Track Rehabilitation

Rehabilitation of tracks is required on all exploration licences. Rehabilitation success can be significantly improved by implementing measures such as:

- Rehabilitating tracks progressively or as soon as possible after they are no longer required. This will minimise the risk of erosion and promote revegetation.
- Grading any windrows and associated vegetation back onto access tracks.
- Removing any obstructions from creek beds, and in-filling ruts or any areas of soil erosion.
- Deep ripping tracks that have become compacted or deeply rutted and where the topsoil is significantly disturbed. Ripping across the slope, or cross-ripping, is recommended. Avoid ripping directly down-slope.
- Installing erosion control structures, such as whoa-boys, on tracks that are deeply rutted or eroded. This protects rehabilitation works and ensures long term soil stability of the area.

2.3 Transfer of Liability to Landholders

If a landholder(s) requires tracks to be left on an exploration licence, a number of matters must be resolved, including:

- Providing detailed written evidence from the landholder outlining the tracks to be transferred (including maps of specific tracks). The landholder is required to accept liability for future management of transferred tracks.
- Demonstrating that tracks are in a suitable location and appropriately constructed to remain open. Erosion control measures may be required in some locations. Evidence of installation of control measures to provide for long term stability may be requested.

2.4 Gridlines

When constructing and rehabilitating exploration gridlines, environmental impacts may be minimised by:

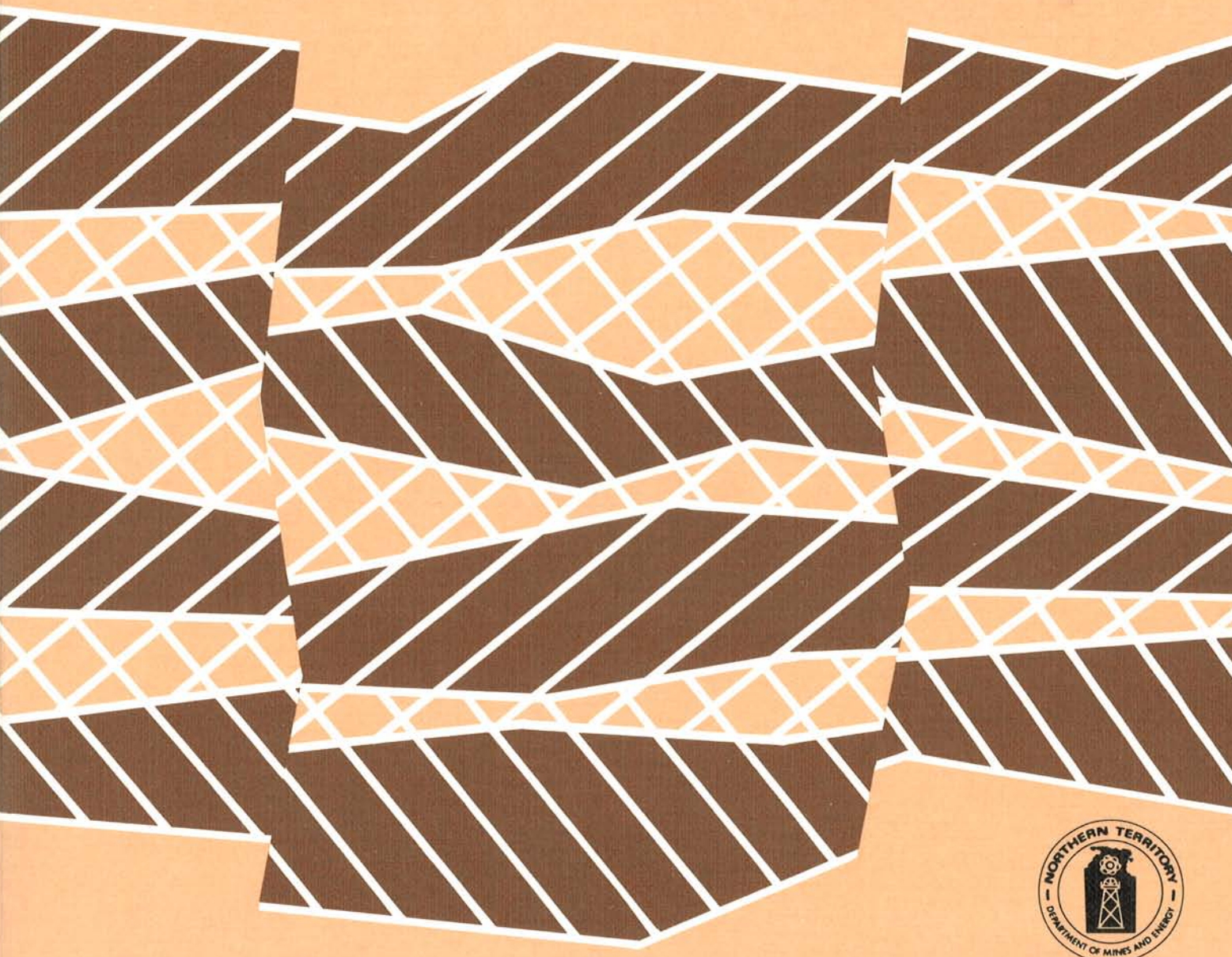
- Keeping vegetation clearing and soil disturbance to a minimum by using a stick rake or the 'blade up' method. Stick raking and blade up clearing removes vegetation whilst retaining rootstock, topsoil and seed to encourage rapid revegetation.
- Avoiding windrows on the sides of gridlines. Even on gently sloping ground, these have the potential to intercept and channel surface water flows, leading to significant soil erosion. Pull any windrows and vegetation back onto gridlines at the time of rehabilitation.
- Avoid natural drainage lines where possible. If crossing drainage lines is unavoidable, ensure minimal disturbance to the banks, maintain the natural creek bed level, and ensure that watercourses are not altered or blocked.
- Ripping gridlines if the soil surface has become compacted or the topsoil has been substantially disturbed. At the time of rehabilitation, the grid line should be deep ripped across the slope, or cross-ripped. This will promote water infiltration, seed capture and rapid revegetation.
- Removal of all grid pegs and survey markers prior to relinquishment of the exploration licence or at completion of exploration activities for the site.

Appendix 3: Geological Map Series Explanatory Notes

NORTHERN TERRITORY GEOLOGICAL SURVEY

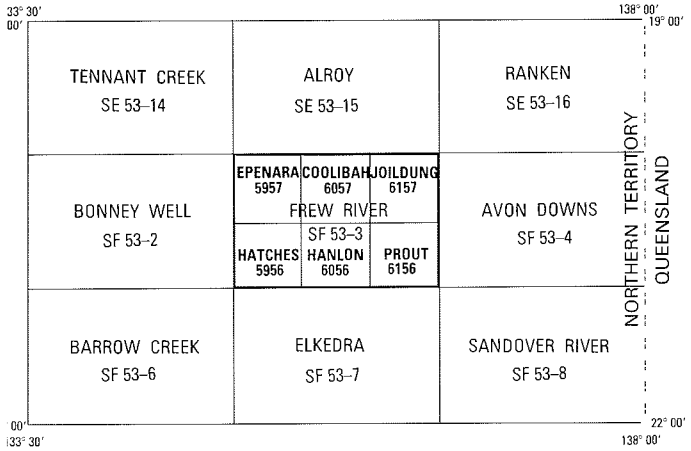
1:250 000 Geological Map Series Explanatory Notes

FREW RIVER SF53-3



NORTHERN TERRITORY — DEPARTMENT OF MINES AND ENERGY

DEPARTMENT OF MINES AND ENERGY
NORTHERN TERRITORY GEOLOGICAL SURVEY



1:250 000 GEOLOGICAL MAP SERIES

EXPLANATORY NOTES

FREW RIVER SF53-3

A. M. WALLEY
GEOPHYSICS by B. A. SIMONS

Government Printer of the Northern Territory
Darwin 1987

NORTHERN TERRITORY DEPARTMENT OF MINES AND ENERGY
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MAP

1:250 000 Geological Map of Frew River (SF53-3) *in pocket*

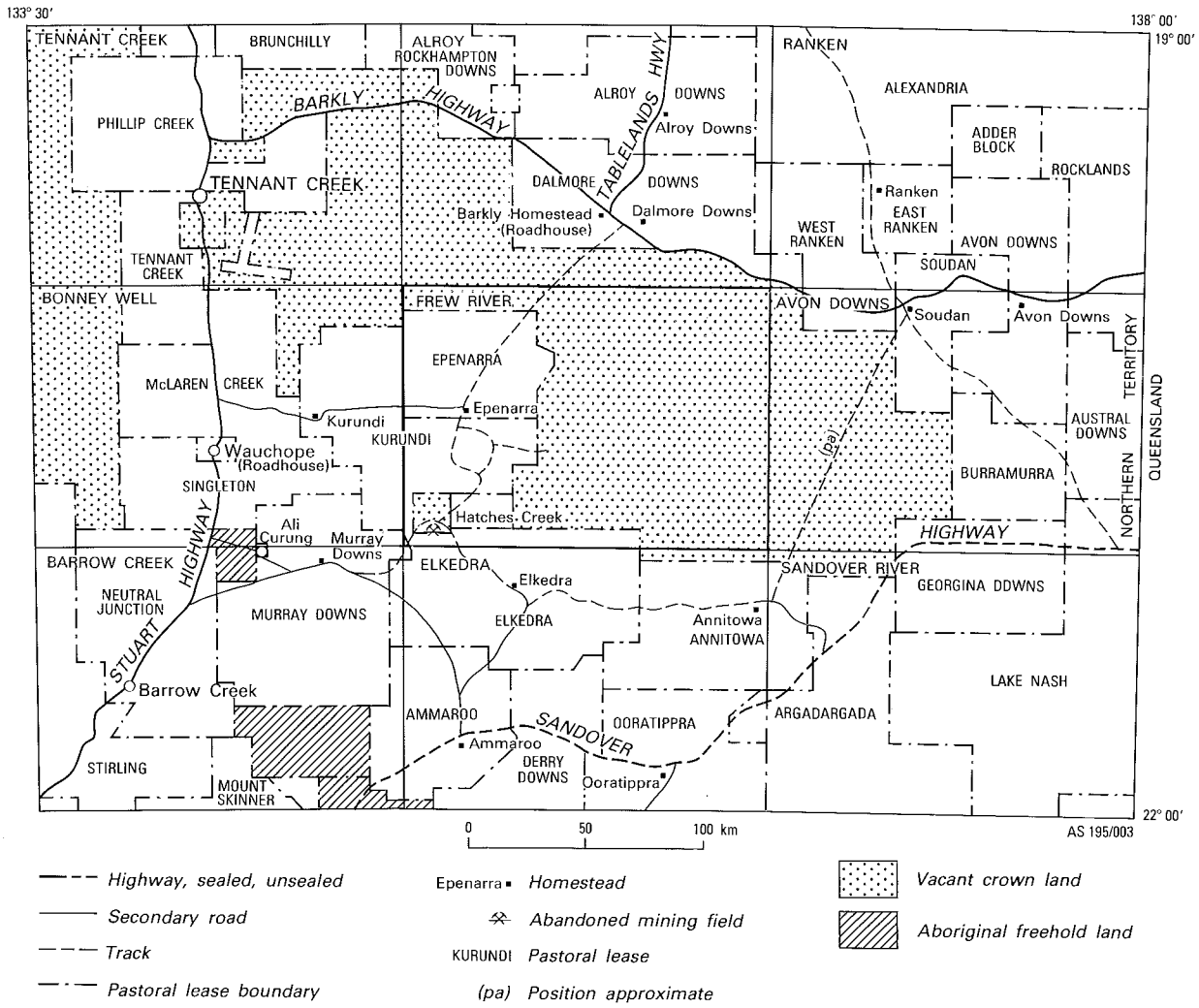

Figure 1 Location and access.

ABSTRACT

Field work for the second edition of FREW RIVER* occurred in two stages. The Bureau of Mineral Resources (BMR) and Northern Territory Geological Survey (NTGS) jointly mapped all Proterozoic rocks in the 'Hatches Creek Region'† during 1981-1982. The NTGS covered the remainder of the map sheet area in 1984. FREW RIVER was compiled by the NTGS during 1985, incorporating data for the Proterozoic published by the BMR.

Southwestern FREW RIVER has a bevelled upland relief which is an exhumed land surface of at least Early Cambrian age. The remainder of the map area is semi-desert, with sandy plain, dune fields and stony rises.

The oldest rocks are greywackes, siltstones and volcanics of the early Proterozoic Warramunga Group, which were deformed at about 1810 Ma and are unconformably overlain by shallow-water sedimentary and volcanic rocks of the ensialic Hatches Creek Group. Mafic and felsic sills intruded the Hatches Creek Group prior to its deformation and at about 1640 Ma the Group was folded, metamorphosed to greenschist facies and intruded by granites.

Early to early Middle Cambrian sediments of the Georgina Basin sequence unconformably overlie the Proterozoic units. In the Davenport Range, the basal Cambrian unit is an alluvial fan sequence, the Andagera Formation, overlain, probably conformably, by the shallow-marine Gum Ridge Formation, which extends over much of northern and eastern FREW RIVER.

Deep weathering profiles, with silcrete and ferricrete duricrusts, developed during the Tertiary throughout FREW RIVER. Quaternary deposits cover much of the sheet area.

The Proterozoic rocks contain tungsten, copper, bismuth and gold which have been mined intermittently on a small scale since 1913. Most exploration has been confined to the Proterozoic basement, but between 1982 and 1985 licences were taken out in eastern FREW RIVER. The Gum Ridge Formation may be prospective for phosphorite, particularly in northeastern FREW RIVER. The petroleum potential of the sheet area is considered to be low.

INTRODUCTION

FREW RIVER lies between longitudes 135° E and 136° 30'E and latitudes 20° S and 21° S (Figure 1). The sheet area is named after the Frew River, which traverses the western third of the sheet, draining from SSW to NNE.

Habitation and access

Pastoral leases cover the western one-third of the area, but the remainder is not developed. The nearest town is Tennant Creek, 207 km by road from Epenarra homestead. Access from Alice Springs or Tennant Creek is via the Stuart Highway to the Epenarra turn-off, 25 km north of Wauchope. All roads in FREW RIVER are unsealed and there are no tracks in the eastern half of the sheet area (Figure 1).

The only station homestead in the sheet area is Epenarra. There is a small Aboriginal settlement at Canteen Creek, east of Kurundi pastoral lease, with access by track from Epenarra.

Climate

The area has an arid tropical climate. There are long hot summers and short mild winters. Frosts are rare. Average annual rainfall over the western part of the sheet area is approximately 300 mm (Smith, 1964a), most of which falls between October and March. There are no rainfall recording stations in the eastern half of FREW RIVER.

Southeasterly trade winds prevail, particularly during the period April-October. Temperatures commonly exceed 40° C during the summer and fall to below 10° C in winter. Slatyer (1962) discusses the climate of the region in more detail.

Vegetation

Vegetation is dominated by drought-resisting plants, particularly trees and shrubs of *Acacia* species and spinifex grasses (Perry and Lazarides, 1962). Spinifex is the most common vegetation cover on sandplains and dune fields, although low trees and shrubs are very dense in some areas of sandy plain. In alluvial areas and where water lies at shallow depth there is a greater variety of trees, including *Eucalyptus* species, and grasses. Shallow depressions, which become waterlogged after periods of high rainfall, commonly support a dense vegetation of shrubs and trees.

Physiography

FREW RIVER lies within the 'Northern Plains and Uplands' physical region described by Mabbutt (1962). The SW quadrant is part of the Davenport Range, whereas the northern and eastern portions of the sheet area are part of the plains (Figure 2).

The Davenport Range consists of 'long and commonly sinuous, steep-sided, narrow to broad, ridges and valleys' (Blake and Wyche, 1983). The main ridge crests are bevelled and have concordant summit levels (Plate 1). The ridges attain a maximum height of almost 600 m above sea level, with local relief commonly less than 150 m. Strike valleys are eroded in the softer recessive units of the Hatches Creek Group and remnant mesas of Cambrian units occur both in these valleys and capping lower hills of Hatches Creek Group rocks.

Relief diminishes to the north and east of HATCHES. Northwestern and northern areas are predominantly sandy and stony plains. Semi-desert, with low broad sand dunes which are aligned subparallel to the prevailing SE trade winds, characterises the SE portion of FREW RIVER. In the NE, there are extensive areas of partially sand-covered stony plain. Small inliers of Cambrian carbonate rocks with negligible relief are dispersed across eastern FREW RIVER.

There is no surface drainage over much of the eastern half of FREW RIVER. In the northeast, aeolian sand cover has largely obliterated drainage. In the west, there is radial drainage away from the main

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* 1:250 000 and 1:100 000 map sheet areas in this report are designated by the use of larger and smaller capital letters, respectively.

† The term 'Hatches Creek Region' incorporates HATCHES and parts of HANLON and EPENARRA 1:100 000 map areas. This work was published as a special 1:100 000 map sheet by the BMR in 1985.

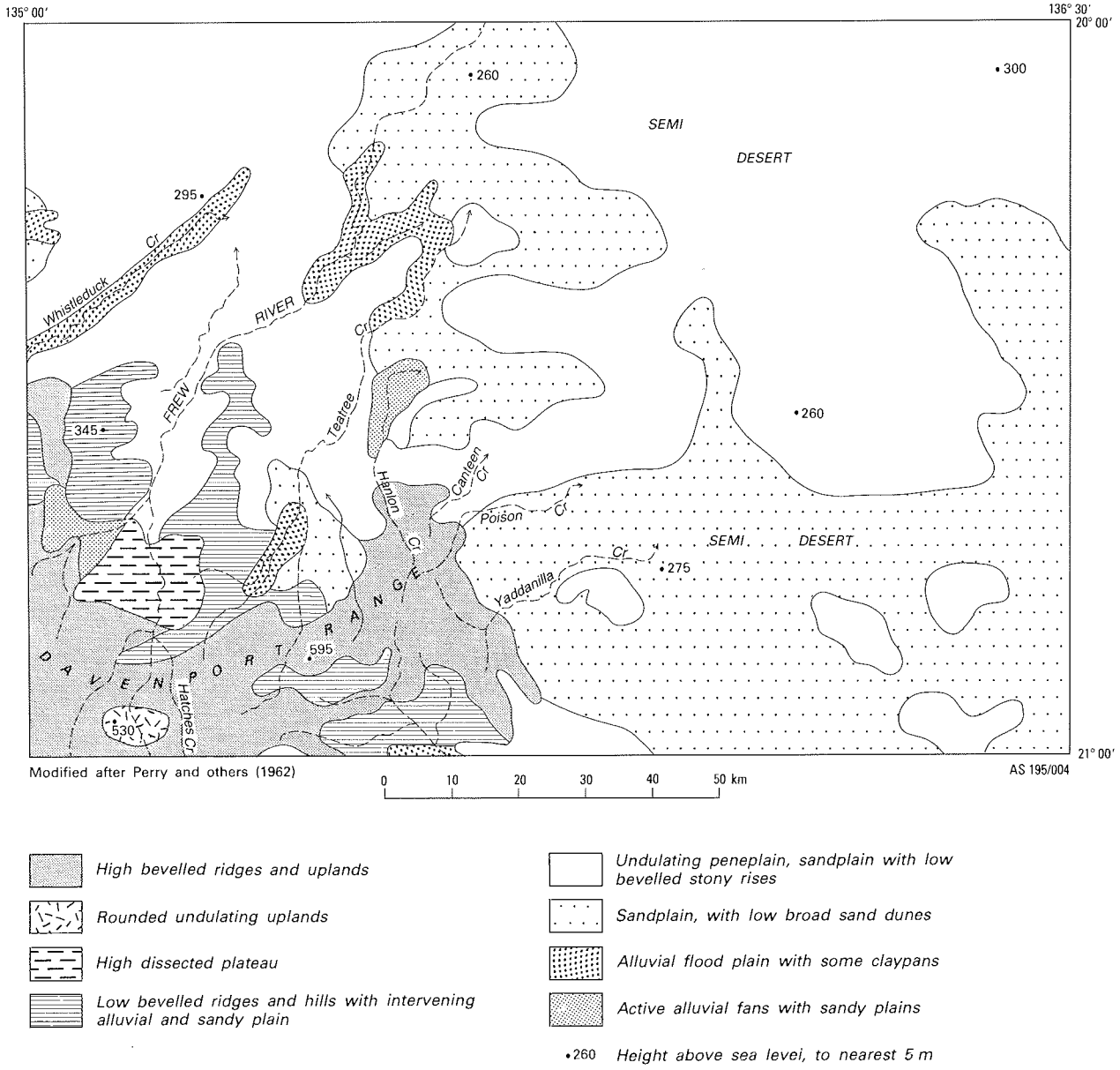


Figure 2 Physiographic divisions.

Davenport Range. Thus, Frew River, Teatree and Hanlon creeks drain to the north, while Poison and Yaddanilla creeks drain to the east and Gastralobium Creek to the south. Frew River formerly flowed into a lake system on the Barkly Tableland (Mabbutt, 1962), but this and other watercourses now terminate in diffuse flood-outs on the plains.

Previous investigations

The earliest recorded exploratory expeditions were led by Brown (1896, 1903), Davidson (1905) and Murray (1907) to the Davenport Range area. The early prospectors were looking for gold and hence wolfram in the Hatches Creek area was not identified until 1913. Mining commenced near Hatches Creek that year (Smith, 1964a).

Oliver (1916) was the first to produce a report on the Hatches Creek Wolfram Field. Between 1937 and 1955 further inspections and reports were made by the Aerial, Geological and Geophysical Survey of Northern Australia (AGGSNA, 1941), Knight (1943), Raggatt (1943), Sullivan (1951, 1953) and Jensen (1955).

Southwestern FREW RIVER was mapped in 1956 during a regional mapping programme by the BMR covering the Davenport-Murchison Range area (Smith and others, 1961). A comprehensive survey of the Hatches Creek Wolfram Field was completed concurrently with the regional project (Ryan, 1961).

An aerial reconnaissance was made over the northern and eastern parts of the sheet area in 1958 (Smith and Condon, 1959) and the mapping of FREW RIVER was completed by Smith and Milligan in 1963, with the aid of helicopter transport to examine outcrops in the desert (Smith, 1964a).

The earliest work on age dating of Proterozoic granites in the Northern Territory, including southwestern FREW RIVER, was by Walpole and Smith (1961) and Hurley and others (1961).

The sheet area was included in the 'Alice Springs area' for the purposes of a land use survey by the Commonwealth Scientific and Industrial Research Organisation (Perry, 1962).

Plate 1 Bevelled ridge crests in the Davenport Range. Low-oblique airphoto showing bevelling on Hatches Creek Group rocks. GR NS0191.

In 1956, the BMR conducted airborne scintillometer and magnetometer surveys over southwestern FREW RIVER, during a survey of the Davenport and Murchison Ranges (Map G, 281-4). A detailed scintillometer survey was carried out south of Hatches Creek (Livingstone, 1957) and a follow-up scintillometer survey was flown over the more promising anomalies (Mulder, 1960). In 1964 the BMR conducted an airborne magnetometer survey over the whole of FREW RIVER, as part of an aeromagnetic survey of the Georgina Basin (Wells and others, 1966; map F53/B1-76). In 1982, more detailed aeromagnetic and radiometric surveys were flown over HATCHES by the BMR, in conjunction with the mapping of the Hatches Creek Region (BMR, 1982a, 1982b). Helicopter gravity surveys by the BMR, at approximately 11 km station spacing, had covered the Georgina Basin, including FREW RIVER, by 1965 (Smith, 1972). BMR gravity data along roads and tracks in the western half of FREW RIVER were later combined with the helicopter data to produce a gravity map covering all of FREW RIVER (Murray and Smilek, 1983a, 1983b).

During 1982, an orientation geochemical stream sediment sampling program was conducted in areas of known mineralisation by the BMR (Hoatson and Cruikshank, 1985).

Company exploration activity in FREW RIVER, which forms the basis of a separate map (Bagas, in preparation), has concentrated on the 'Hatches Creek Region'. Wolframite, scheelite and associated minerals, including those of copper and bismuth, which occur in quartz veins cutting Proterozoic rocks, have been sought and mined. However, mining ceased in 1957 due to lack of demand and low ore prices (Ryan, 1961). Gold, also associated with quartz veins, together with minor alluvial occurrences, was discovered and mined both in the Hatches Creek area (Crystal Mine; Ryan, 1961) and near Kurinelli. The history and prospects of the latter goldfield have been described by Roarty (1977). A resumé of mineralisation in the region was given by Crohn (1976), and mines and prospects in the 'Hatches Creek Region' have been summarised by Blake and Wyche (1983).

No exploration licences were held in eastern FREW RIVER until 1982. Following the discovery of a phosphorite resource in Cambrian units in southeastern ALROY (Perrino, 1969) a Mining Reserve (MR 19) was proclaimed covering that area and the adjacent NE part of FREW RIVER. Areas to the south of this were held under exploration licence between 1982 and 1985 by CRA Exploration Pty Ltd (Harvey, 1985).

Field work for the second edition of FREW RIVER

A detailed reconnaissance survey of the Proterozoic rocks of the 'Hatches Creek Region' was carried out during 1981 by Blake and Wyche (1983). This survey was part of a joint BMR and NTGS project covering the Davenport province, which forms the southern part of the Tennant Creek Block. In addition, Sweet (in preparation) studied sedimentological aspects of the Hatches Creek Group during 1982. The Phanerozoic rocks were not remapped in detail during this survey and the Cambrian units of Smith (1964a) were retained. The 'Hatches Creek Region' 1:100 000 geological special sheet was published by the BMR in 1985.

The remainder of FREW RIVER was mapped by N. Donnellan (NTGS) and A. M. Walley (NTGS) between June and October, 1984. This project included remapping of Phanerozoic units in the 'Hatches Creek Region'. Further field work was undertaken by A. M. Walley in June, 1985.

During the 1984 field season vehicle traverses were made in the NE of FREW RIVER, navigating with the aid of a satellite navigator. Detailed field work by vehicle was accomplished in central western FREW RIVER where there is good road access. A follow-up helicopter survey in October, 1984, enabled visits to be made to remote outcrops in central and SE parts of FREW RIVER, as well as to outcrops in the relatively inaccessible, rugged country of the Davenport Range area.

Map compilation and report preparation

Aerial photography used for mapping of FREW RIVER is indicated in Figure 3. The compilation for the 'Hatches Creek Region' sheet was based on pre-1983 photography. The remainder of FREW RIVER and areas within the 'Hatches Creek Region' previously interpreted from black and white photography were compiled using 1983 colour photography. Compilation sheets are available at 1:50 000 and 1:100 000 scales from the NTGS. A. M. Walley compiled all available data in a preliminary record (Walley, 1985), and wrote the bulk of these explanatory notes. B. A. Simons wrote the Geophysics section.

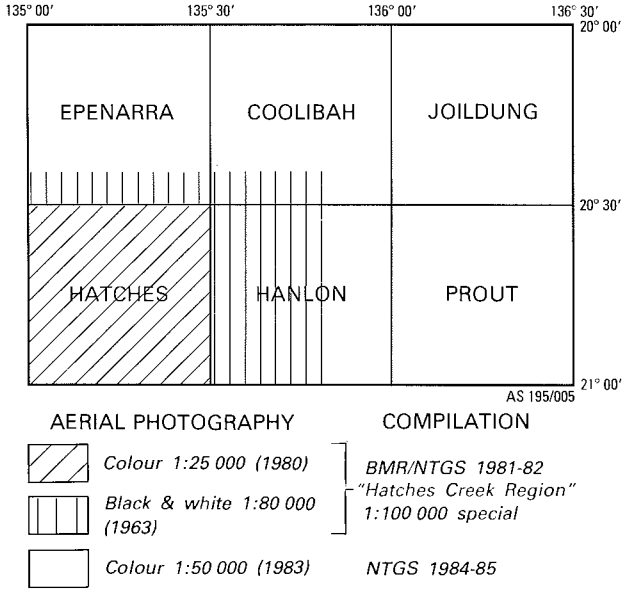


Figure 3 Map compilation data.

Rock nomenclature

Sandstones have been classified after Pettijohn and others (1973) except that in descriptions of Proterozoic rocks, the term 'feldspathic arenite' is used to describe both subarkose and sublitharenite. Conglomerate descriptions are after Pettijohn (1975) and Bates and Jackson (1980), and carbonates according to Dunham (1962), and Folk (1959). The Wentworth scale (Wentworth, 1922), is used to describe grain size.

Blake and Wyche (1983) have classified plutonic igneous rocks in FREW RIVER according to Streckeisen (1973), and metamorphic facies and grades after Turner and Verhoogen (1960). These classifications have been adopted in this report.

Other terms used are as defined in Bates and Jackson (1980).

REGIONAL GEOLOGY

The regional geological setting of FREW RIVER is shown on the accompanying map. Southwestern FREW RIVER forms the SE part of the early Proterozoic Tennant Creek Block, represented by the Warramunga Group, the unconformably overlying Hatches Creek Group, and various intrusions. The southern part of the Tennant Creek Block is also referred to as the Davenport province (Stewart and Blake 1984). Northern and eastern FREW RIVER form part of the western margin of the Georgina Basin, comprising a sequence of sedimentary and minor volcanic rocks of Adelaidean to Devonian age (Shergold and Druce, 1980) which are unconformable on the rocks of the Tennant Creek Block.

The Warramunga Group is a sequence of turbidites and felsic volcanic rocks, deposited at about 1870 Ma (Black, 1984) and subsequently folded at about 1810 Ma (Black, 1981; Blake and Wyche, 1983). The overlying Hatches Creek Group is an intracratonic platform facies of shallow-water sediments and interlayered volcanics. Felsic and mafic intrusives were emplaced prior to the main folding of the Hatches Creek Group, while granite intrusions at about 1640 Ma (Black *in* Blake and Horsfall, 1984) postdate the main folding events (Blake and Wyche, 1983; Blake and others, 1985).

Age dating by the BMR of volcanic units within the Hatches Creek Group is currently in progress (D. H. Blake, personal communication, 1985).

The oldest unit of the Georgina Basin sequence in the sheet area is the Early or earliest Middle Cambrian Andagera Formation, deposited in an alluvial fan setting as a product of erosion of the Hatches Creek Group. It is succeeded with apparent conformity by shallow marine sediments of the Gum Ridge Formation, representing the early Middle Cambrian transgression. In eastern FREW RIVER, carbonate shoals of this transgression comprise a Cambrian dolostone. The Georgina Basin sequence in northern and eastern FREW RIVER is poorly exposed and deeply weathered. Cambrian units are conspicuously jointed, but flat-lying, indicating tectonic stability in the area since the Middle Cambrian.

Ferricrete, silcrete and deeply weathered rock occur throughout the sheet area and developed during the Tertiary Period. Calcrete, overlying Cambrian carbonate in eastern FREW RIVER, formed in the late Tertiary or Quaternary.

Both Tertiary and Quaternary colluvium, the former dissected, flank ridges of the Davenport Range in the southwest. Much of northern and eastern FREW RIVER is covered by Quaternary sand, soil and alluvium.

STRATIGRAPHY

The stratigraphy is summarised in Tables 1 and 2. The Proterozoic geology has been described in detail by Blake and Wyche (1983) and is published in the Map Commentary which accompanies the 'Hatches Creek Region' map sheet (Blake, Wyche and Hone, in press).

PROTEROZOIC

WARRAMUNGA GROUP (Pw)

The Warramunga Group, named by Ivanac (1954), consists of greywacke, siltstone and shale with interbedded porphyritic and vesicular felsic volcanic rocks, which were deposited at about 1870 Ma (Black, 1984). It forms the central part of the Tennant Creek Block (Black, 1977, 1981) and has been correlated with Division 2 of the Arunta Block (Shaw and Stewart, 1976; Stewart and others, 1984).

Mendum and Tonkin (1976) divided the Group into 10 units, but Large (1975) and Le Messurier (1976)

incorporated units earlier described by Crohn and Oldershaw (1965) and Dunnet and Harding (1967) into three main formations. In FREW RIVER, the Group was not differentiated into constituent formations because outcrops are poor, widely separated and deeply weathered. Outcrops occur as low hills in EPENARRA only. Lithologies and relationships are indicated in Table 1.

HATCHES CREEK GROUP (Ph)

Hossfeld (1941) recognised three stratigraphic units in the Hatches Creek area, which he named the 'Bottom Series', 'Hatches Creek Series' and 'Top Series', separated by probable unconformities. He later discarded the upper unconformity and combined the Top Series and Hatches Creek Series into the Hatches Creek Group (Hossfeld, 1954). Smith and others (1961) retained the usage of Hatches Creek Group but extended it to include Hossfeld's Bottom Series. Following detailed remapping of the Group during 1981-82, the usage of Hatches Creek Group by Smith and others (1961) was retained, but the Group was redefined to include formally named subgroups and constituent formations (Blake and others, 1985).

The Group consists of ridge-forming sandstones with recessive sedimentary rocks and volcanics, which form the Davenport Range in southwestern FREW RIVER and adjacent map sheet areas. Arenaceous units also outcrop to the east of the ranges. The maximum thickness in FREW RIVER is at least 13 000 m (Blake and Wyche, 1983).

Quartz arenites, feldspathic, lithic and minor conglomeratic arenites form the ridges and friable sandstone, siltstone, shale, minor carbonate, basaltic and felsic lava and pyroclastics are recessive units. The constituent units in FREW RIVER are described in Table 1.

The Group unconformably overlies the Warramunga Group in the northern Davenport Range and is overlain unconformably by Phanerozoic strata. Dolerite, gabbro, granophyre, feldspar porphyry and granite intrude the lower units of the Group.

Deposition of the Group postdates the folding of the Warramunga Group, which occurred at approximately 1810 Ma (Black, 1981; Blake and Wyche, 1983) and predates the granite intrusions, which in ELKEDRA were emplaced at about 1640 Ma (Black, 1984). An ensialic depositional setting has been suggested (Blake, Stewart and Sweet, in press).

Shaw and Stewart (1976) and Stewart and others (1984) tentatively correlated the Hatches Creek Group with Division 3 of the Arunta Block.

The Hatches Creek Group has been subdivided into the following three subgroups by Blake and others (1985) and descriptions are based on this reference.

Ooradidgee Subgroup

The six formations of the Ooradidgee Subgroup present in FREW RIVER are, in part, lateral equivalents of each other and, in part, interfinger (Table 1). The subgroup is unconformable on the Warramunga Group and is overlain conformably or disconformably by the Unimbra Sandstone of the Wauchope Subgroup and unconformably by flat-lying Cambrian strata. It is intruded by granite, granophyre, dolerite and gabbro.

The Subgroup is more than 5000 m thick and consists of recessive felsic and basaltic volcanics, friable arenite, siltstone, shale and ridge-forming quartz arenite, feldspathic, lithic and pebbly arenite, with minor conglomerate. The lateral relationships contrast with the layer-cake stratigraphy of the overlying Wauchope and Hanlon subgroups. This subgroup contains a greater proportion of volcanic rocks. Moreover, the sedimentary rocks are apparently fluviatile, in contrast to mixed fluviatile-marine (Wauchope Subgroup) or marine (Hanlon Subgroup).

Wauchope Subgroup

The seven formations of the Wauchope Subgroup which occur in FREW RIVER are conformable to locally disconformable on the Ooradidgee Subgroup and overlain conformably by the Hanlon Subgroup and unconformably by Cambrian rocks. The Subgroup is between 3500 m and 4000 m thick and comprises ridge-forming lithic and feldspathic arenite, quartz arenite and pebbly arenite, felsic volcanics, basalt, minor slate, siltstone, limestone and dolostone. Arenites are commonly cross-bedded.

The Unimbra Sandstone, a major ridge-forming unit, marks the base of the Subgroup and the top is marked by an abrupt lithology change from Kudinga Basalt to ridge-forming sandstone of the Hanlon Subgroup. Some formations are intruded by granophyre sills.

The Subgroup is more widespread than the underlying Ooradidgee Subgroup. The stratigraphy is mainly of the layer-cake type and volcanics are less common than in the Ooradidgee Subgroup. The depositional environment was fluviatile to near-shore marine.

Hanlon Subgroup

The six formations of the Hanlon Subgroup which occur in FREW RIVER consist of quartzose, feldspathic, lithic and kaolinitic arenite, siltstone and shale, with minor coarse-grained and pebbly arenite, calcareous beds, and mafic lava. Cross-bedding and wave and current ripple-marks are common. The ridge-forming Errolola Sandstone marks the base of the Subgroup.

Maximum exposed thickness is about 5200 m in western HANLON, but the inclusion of undefined poorly exposed units on eastern HANLON in this Subgroup (Table 1) adds more than 1000 m to the previously recorded thickness. The top is not exposed.

The Subgroup conformably overlies the Wauchope Subgroup and is unconformably overlain by Cambrian units.

There are few volcanic rocks in this Subgroup and the depositional environment appears to have been totally marine.

INTRUSIVE IGNEOUS ROCKS

Rock types include granophyre, microgranite, feldspar porphyry, dolerite, gabbro and granite. They outcrop only in southwestern FREW RIVER, but granite was intersected in the subsurface in the northwest (water bore Epenarra No. 5A). The lithologies are fully described in Blake and Wyche (1983) and summarised in Table 1.

Granophyre, microgranite, feldspar porphyry (Pgy)

These rocks form sills up to several hundred metres thick, minor dykes and irregular bodies. They intrude the Ooradidgee Subgroup and the Unimbra Sandstone

Table 1 Summary of Proterozoic stratigraphy.

ROCK UNIT	MAP SYMBOL	LITHOLOGY	THICK-NESS	TOPOGRAPHIC EXPRESSION	STRATIGRAPHIC RELATIONSHIPS	DEPOSITIONAL ENVIRONMENT	ECONOMIC GEOLOGY
Undivided granite	Pg	Porphyritic and even-grained muscovite-biotite or biotite granite, fine- to coarse-grained, xenolithic in central north outcrops; minor pegmatite, aplite, greisen		Tor-covered, low hummocky terrain, recessive	Intrudes Ooradidgee Subgroup units		W at Hatches Creek related to granite intrusion (Ryan, 1961)
Undivided granophyre and feldspar porphyry	Pgy	Granophyre and feldspar porphyry, very fine to fine-grained, spherulitic, locally vesicular; feldspar porphyry has a microgranitic groundmass	Sills up to 100 m	Undulating terrain; small lateritised mesas	Sills, minor dykes and irregular bodies intrude Ooradidgee and Wauchope subgroups		Disseminated sulphides, mainly pyrite
Undivided dolerite and gabbro	Pd	Dolerite to gabbro, rarely porphyritic, ophitic; epidotic, uralitic and chloritic alteration	Sills up to 100 m	Generally recessive	Sills, dykes and irregular bodies intrude Ooradidgee Subgroup units		Disseminated sulphides; cut by W, Au, Cu-bearing quartz veins
HATCHES CREEK GROUP							Aquifers in fractured quartz arenites and volcanics of Hatches Creek Group
HANLON SUBGROUP							
Yaddanilla Sandstone	Phy	Quartz arenite and feldspathic arenite, medium-grained, medium-bedded, cross-bedded; scattered mudstone pellet casts. Beds tentatively included in this unit in SE of FREW RIVER are thin to medium-bedded with cross-beds and bevelled ripple-marks; grains are fine to medium, well-rounded, well-sorted	Over 1000 m; top concealed	Ridge-forming; recessive concealed interbeds	Conformable on Vaddingilla Formation	Shallow marine shelf	
Vaddingilla Formation	Phv	Siltstone; shale; friable feldspathic and micaceous arenite, cross-bedded, fine to medium-grained	800 m	Recessive	Conformable on Canulgerra Sandstone	Marine	
Canulgerra Sandstone	Phu	Quartz arenite to feldspathic arenite; micaceous siltstone, mudstone	500 m	Ridge-forming; friable recessive interbeds	Conformable on Lennee Creek Formation	Shallow marine shelf, intertidal	
Lennee Creek Formation	Phl	Feldspathic, lithic, kaolinitic and sericitic arenite; siltstone; shale; minor quartz arenite; local calcareous beds; all thin-bedded	Up to 1500 m	Recessive	Conformable on Alinjabon Sandstone	Subtidal	

Alinjabon Sandstone	Phi	Quartz arenite; silicified, lithic, feldspathic arenite; thin to medium-bedded, fine to medium-grained; rare convolute bedding and mudstone pellets: recessive siltstone, sandstone and shale interbeds: amygdaloidal mafic lava near base	450-750 m	Interbedded ridge-forming and recessive units	Conformable on Errolola Sandstone	Shallow marine shelf and deltaic	
Errolola Sandstone	Phe	Quartz arenite; subordinate feldspathic and lithic arenite; medium-bedded, cross-bedded, medium-grained, well-sorted; scattered mudstone pellets; rare pebble beds	100-1200 m	Region-wide, bevelled, ridge-forming unit	Conformable on Kudinga Basalt	Subtidal, intertidal	
WAUCHOPE SUBGROUP							
Kudinga Basalt	Phb	Basalt, amygdaloidal and scoriaceous to massive; epidotic, chloritic alteration; minor interbedded arenite, some feldspathic, fine to coarse-grained, cross-bedded; minor thin-bedded basaltic tuff	400-600 m	Generally recessive, though arenites form low, narrow ridges near base	Conformable on Frew River Formation	Lava flows and shallow marine sediments	Cu minerals in quartz veins in basalt
Frew River Formation	Phf	Kaolinitic arenite, thin-bedded, fine-grained, friable; micaceous siltstone; cherty mudstone; calcareous or dolomitic in upper part: subordinate fine to medium-grained, silicified, feldspathic and quartz arenite: ripple-marks, cross-beds, mudstone pellets, mud-cracks, halite casts, locally stromatolitic	Up to 500 m	Recessive	Conformable on Coulters Sandstone	Very shallow water, intertidal, sabkha	Potential host for stratabound Pb-Zn-Cu
Coulters Sandstone	Phc	Quartz arenite; feldspathic, lithic and kaolinitic arenite; minor granule to pebble conglomerate; thin to thick-bedded, cross-bedded, medium-grained, well-sorted; scattered mudstone pellets; recessive friable feldspathic arenite near top	300-1000 m	Region-wide, bevelled, ridge-forming unit, minor recessive beds	Conformable on Arabulja Volcanics, Newlands Volcanics and Yeeradgi Sandstone	Shallow marine shelf	
Arabulja Volcanics	Phj	Felsic lava, with sparse alkali feldspar phenocrysts, flow-banded with autobrecciated margins, platy jointing	Less than 500 m	Recessive	Conformable on, and locally interfingers with, Yeeradgi Sandstone; equivalent to Newlands Volcanics		
Newlands Volcanics	Pha	Porphyritic, dacitic lava with abundant tabular phenocrysts of sodic plagioclase; minor bedded tuff, ashstone, agglomerate, siltstone, shale and arenite; volcanic rocks commonly cleaved or altered	Less than 500 m	Recessive	Conformable on, and locally interfingers with Yeeradgi Sandstone; lateral equivalent of Arabulja Volcanics	Pyroclastic deposits of subaerial volcanism	

Table 1 (continued)

ROCK UNIT	MAP SYMBOL	LITHOLOGY	THICK-NESS	TOPOGRAPHIC EXPRESSION	STRATIGRAPHIC RELATIONSHIPS	DEPOSITIONAL ENVIRONMENT	ECONOMIC GEOLOGY
Yeeradgi Sandstone	Phd	Feldspathic, lithic, kaolinitic and micaceous arenite, friable to silicified, thin to medium-bedded; fine to medium-grained, cross-bedded; siltstone; mudstone; ashstone; shale; rare calcareous and carbonaceous beds; lenses of thin-bedded micaceous tuff	Up to 800 m	Low strike ridges; in part recessive	Conformable on Unimbra Sandstone, grades laterally into Arabulja and Newlands Volcanics	Fluviatile, during volcanism	
Unimbra Sandstone	Phs	Feldspathic, quartz arenite, medium-bedded, medium to coarse-grained, moderately well sorted, cross-bedded, ripple-marked, mudstone pellets; minor rhyolite and felsic lava lenses; pebble lenses near base	100-1000 m	Major bevelled ridges	Conformable or disconformable on Treasure and Mia Mia Volcanics	Shallow marine and fluviatile	
OORADIDGEE SUBGROUP							
Mia Mia Volcanics	Phm	Felsic tuff, massive, ignimbritic, laminated to thin-bedded; lava, rhyolitic, vesicular, amygdaloidal and porphyritic; also minor feldspathic, volcaniclastic and quartz arenite, medium-bedded, medium to coarse-grained, cross-bedded; rare volcaniclastic conglomerate	Over 2000 m	Recessive but arenite is ridge-forming	Part is laterally equivalent to Treasure Volcanics; intruded by granite and pegmatite	Subaqueous volcanics	
Treasure Volcanics	Pht	Felsic lava, mainly rhyodacite, porphyritic, spherulitic, amygdaloidal and vesicular; subordinate interbeds of feldspathic and quartz arenite, medium-bedded, fine to coarse-grained, locally pebbly, cross-bedded with mudstone pellets and mud-cracks; basaltic lava, amygdaloidal, vesicular, scoriaceous; minor thin-bedded tuff	Ranges from 400 m to over 1700 m	Lava recessive, arenite is ridge-forming	Conformable on and interfingers with Taragan Sandstone; intruded by sills of granophyre, dolerite and and gabbro	Subaerial or shallow water volcanics; shallow marine and fluviatile sediments	W, Bi and Cu minerals in quartz veins in volcanics
Taragan Sandstone	Pho	Feldspathic and quartz arenite, commonly pebbly, medium to thick-bedded, medium to coarse-grained, poorly sorted, cross-bedded; minor conglomerate, siltstone, mudstone, calcareous beds and felsic lava	Probably more than 1000 m	Generally a ridge-forming unit with recessive interbeds	Conformable on Kurinelli Sandstone; part inter-fingers with Treasure Volcanics	Fluviatile	Cut by quartz veins containing W and Cu minerals

Kurinelli Sandstone	Ehk	Feldspathic, lithic and quartz arenite, locally volcaniclastic or tuffaceous, slightly calcareous, possibly evaporitic in parts, thin to thick-bedded, fine to medium-grained, well-sorted, cross-bedded with ripple marks, convolute bedding and mudstone pellets; minor siltstone; rare non-porphyritic andesitic lava	Possibly more than 2000 m	Strike ridges and cuestas separated by depressions; siltstone is recessive	Conformable on and partly interfingers with Rooneys Formation and Epenarra Volcanics; intruded by dolerite, gabbro, granophyre and granite	Shallow marine, deltaic, fluviatile	Cut by quartz veins containing W, Au and Cu minerals
Warnes Sandstone Member	Ehk_w	Feldspathic, lithic arenite, massive to poorly bedded, medium to coarse-grained, poorly sorted, rare cross-beds	0-500 m	Knobbly strike ridges	Conformable lenses within upper Kurinelli Sandstone; intruded by dolerite, gabbro and granophyre		Cut by quartz veins containing W minerals
Endurance Sandstone Member	Ehk_d	Micaceous greywacke and siltstone, thinly interbedded, fine-grained, graded bedding common; minor feldspathic arenite, thin to medium-bedded	0-500m	Recessive	Conformable lens within lower Kurinelli Sandstone; intruded by dolerite and gabbro		Cut by quartz veins containing W minerals
Rooneys Formation	Ehn	Feldspathic and lithic arenite, fine-grained; micaceous siltstone; laminated to thin-bedded with convolute bedding; local well-developed cleavage	Possibly more than 1200m	Generally recessive with low ridges, hills	Conformable on and locally inter-fingers with Epenarra Volcanics; intruded by dolerite, gabbro and granite	Shallow water, deltaic	Cut by Au-bearing quartz veins
Epenarra Volcanics	Ehr	Felsic tuff; lapilli tuff; laminated to thin-bedded: porphyritic lava and agglomerate, cleaved; minor amygdaloidal mafic lava and tuff: volcaniclastic arenite; conglomerate; thin to medium-bedded, cross-bedded, silicified	Possibly more than 3000 m	Generally recessive; arenite forms low ridges	Unconformable on Warramunga Group; intruded by dolerite and granophyre	Subaerial volcanics, shallow water sediments	
WARRAMUNGA GROUP	Ew	Interbedded phyllitic siltstone and fine-grained greywacke, thin to medium-bedded; deep-weathered, vesicular and porphyritic volcanics in NW of FREW RIVER	Not known	Low hills dispersed on plains	Overlain unconformably by Epenarra Volcanics	Deep marine	Cut by quartz-hematite veins containing W minerals

After Blake and Wyche (1983) and Blake and others (1985)

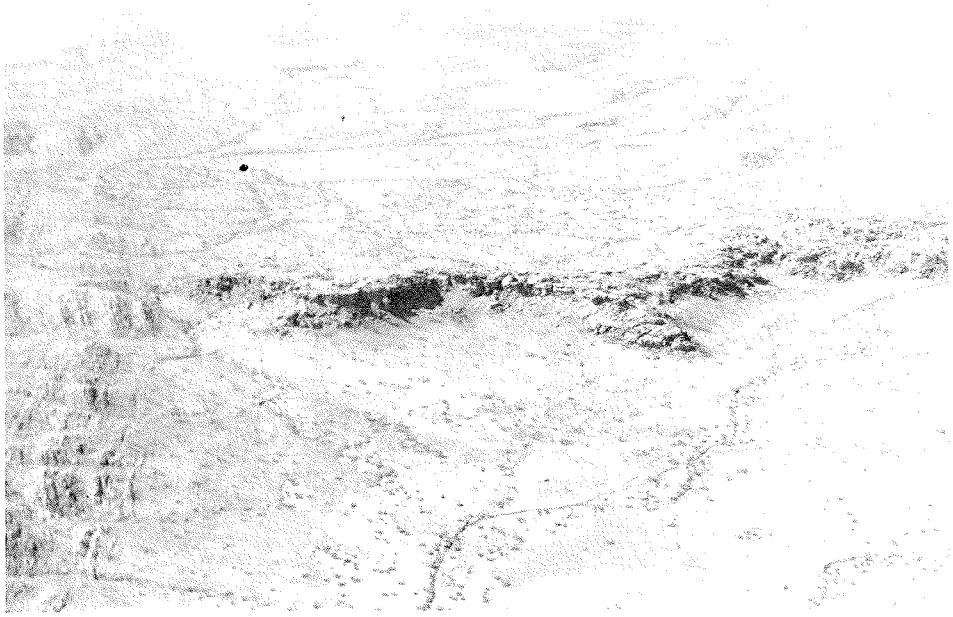


Plate 2 Remnant mesa of Andagera Formation within the Davenport Range. GR NT5204.

and Arabulja Volcanics of the Wauchope Subgroup and are folded and metamorphosed with the country rocks. The relationship to the mafic intrusives is unclear. These intrusions may be comagmatic with felsic volcanics of the Hatches Creek Group and some sills may have been emplaced into unconsolidated sediments (Blake and Wyche, 1983).

Dolerite, gabbro (Pd)
Dolerite and gabbro occur in HATCHES and southwestern EPENARRA as sills up to several hundred metres thick, dykes and irregular bodies and apparently include multiple intrusions. They intrude the Ooradidgee Subgroup and may be comagmatic with basalts of the Hatches Creek Group (Blake and Wyche, 1983). These mafic intrusives are also folded and metamorphosed with the country rocks.

Granite (Pg)
Granite is poorly exposed, commonly as scattered tors. Both porphyritic and even-grained types occur. Intrusions in southern and northeastern HATCHES penetrate the Ooradidgee Subgroup. They appear to be unrelated to the felsic volcanics of the Hatches Creek Group and to postdate the main folding events of the region (Blake and Wyche, 1983). Granite in southwestern EPENARRA, however, may be an extension of an unnamed granite in BONNEY WELL, which is inferred to be overlain by the Epenarra Volcanics and is therefore older than the Hatches Creek Group (Stewart and Blake, 1986). Hurley and others (1961) obtained a K-Ar date of 1480 Ma for granite in the Mia Mia Dome. However, a K-Ar date of 1460 Ma for granite emplacement in ELKEDRA was later revised to 1695 Ma by the Rb-Sr method (Riley, *in* Compston and Arriens, 1968) and was more recently recalculated to 1640 Ma by Black (*in* Blake and Horsfall, 1984). Additional age dating is currently being conducted by the BMR.

PALAEOZOIC

CAMBRIAN

Andagera Formation (Cld)
The Andagera Formation is a newly defined unit (Stidolph and others, in preparation) consisting of sandstone and conglomerate, with clasts up to boulder-size, which was formerly assigned to established formations of various ages. The type locality is in ELKEDRA (Stidolph and others, in preparation), where the unit was mapped as the basal part of the Sandover beds by Smith and Milligan (1966). In western ELKEDRA, however, it was formerly mapped as the Tomahawk beds. The formation also occurs in BARROW CREEK (referred to as the Tomahawk beds, Smith and Milligan, 1964) and BONNEY WELL (Wyche, in preparation) where outcrops were previously regarded as Mesozoic (Smith, 1970). On the first edition of FREW RIVER, the formation was placed within the Gum Ridge Formation (Smith, 1964a).

This horizontally bedded unit occurs as remnant mesas within extant valleys in recessive units of the Hatches Creek Group (Plate 2). The mesas commonly lie slightly below the level of surrounding bevelled Proterozoic ridges. However, in areas where Proterozoic topography has lower relief, mesas of Andagera Formation and ridges of the Hatches Creek Group have concordant summit levels. The Andagera Formation was clearly a more extensive deposit and locally spread across portions of the Proterozoic ridges. Figure 4 shows the present distribution of the unit.

Isolated, very small outcrops of sandstone surrounded by sand plain in southeastern FREW RIVER have been tentatively assigned to the Andagera Formation.

Measured sections through the formation are illustrated in Figure 5 and section locations in Figure 4. Maximum thickness in the sheet area is approximately 45 m (Section 22), but outcrops are commonly less than 15 m thick. Lithologies are lenticular, displaying marked lateral facies variations.

Table 2 Summary of Palaeozoic to Cainozoic stratigraphy.

LITHOLOGY	THICKNESS (m)	STRATIGRAPHIC RELATIONSHIPS	DEPOSITIONAL ENVIRONMENT	FOSSILS
QUATERNARY				
Qa Alluvium, alluvial soil, mainly red; minor aeolian and colluvial material	2-80	Superficial		
Qs Aeolian sands, red, coarse-grained, some clayey; stabilised sheets and dunes	2-50	Superficial		
Qc Colluvium; on slopes of ridges, hills		Superficial		
Qr Red soil, including red earth, with characteristic groves of mulga (*Acacia aneura*)		Superficial		
Qp Claypan, with expansive clayey soil; poorly drained shallow depression		Superficial		
Qas Alluvium-filled depressions with substantial sand cover; relict fluvial systems;		Superficial		
CAINOZOIC, UNDIVIDED				
Czc Cobbles, gravel, sand; dissected alluvial and colluvial fan deposits		Incised by present drainage		
Czk Calcrete		Disconformable on underlying strata	Probably formed in arid/semi-arid environment	Rhizomorphs
Czq Vein quartz rubble				
TERTIARY				
Tf Ferricrete, ferruginised rock	Deep weathering profiles	Disconformable or unconformable on underlying strata	Developed on areas of low relief in warm humid climate	
Ts Silcrete	Up to 8			
Ta Deaply weathered rock, parent rock not identified	50+ in subsurface			
MIDDLE CAMBRIAN		**Disconformity**		
∈mg Gum Ridge Formation				
Chert, ferruginised chert, laminated and concentrically banded; siltstone, laminated and fossiliferous coquinite, ferruginised and silicified; minor sandstone; rare dolostone; limestone and dolostone in subsurface	5-150	Apparent transitional contact with Andagera Formation but may be disconformable; unconformable on Precambrian basement	Very shallow marine–near-shore; subtidal to lagoonal	Trilobites (including *Xystridura* and *Redlichia),* brachiopods, hyoliths
∈d Undifferentiated dolostone				
Dolostone, micritic and crystalline; poor outcrop with characteristic calcrete capping	Not known	Partly underlies and partly interdigitates with Gum Ridge Formation	Very shallow marine–supratidal, carbonate shoals	
EARLY OR EARLY MIDDLE CAMBRIAN				
∈ld Andagera Formation				
Conglomerate, massive to medium-bedded, oligomictic, pebble to boulder P clasts; quartz sandstone with rare pebble to boulder P clasts, thin to thick-bedded, parallel and cross-bedded; siltstone lenses; forms mesas and valley-fill	5-20	Unconformable on Hatches Creek Group	Alluvial fan	

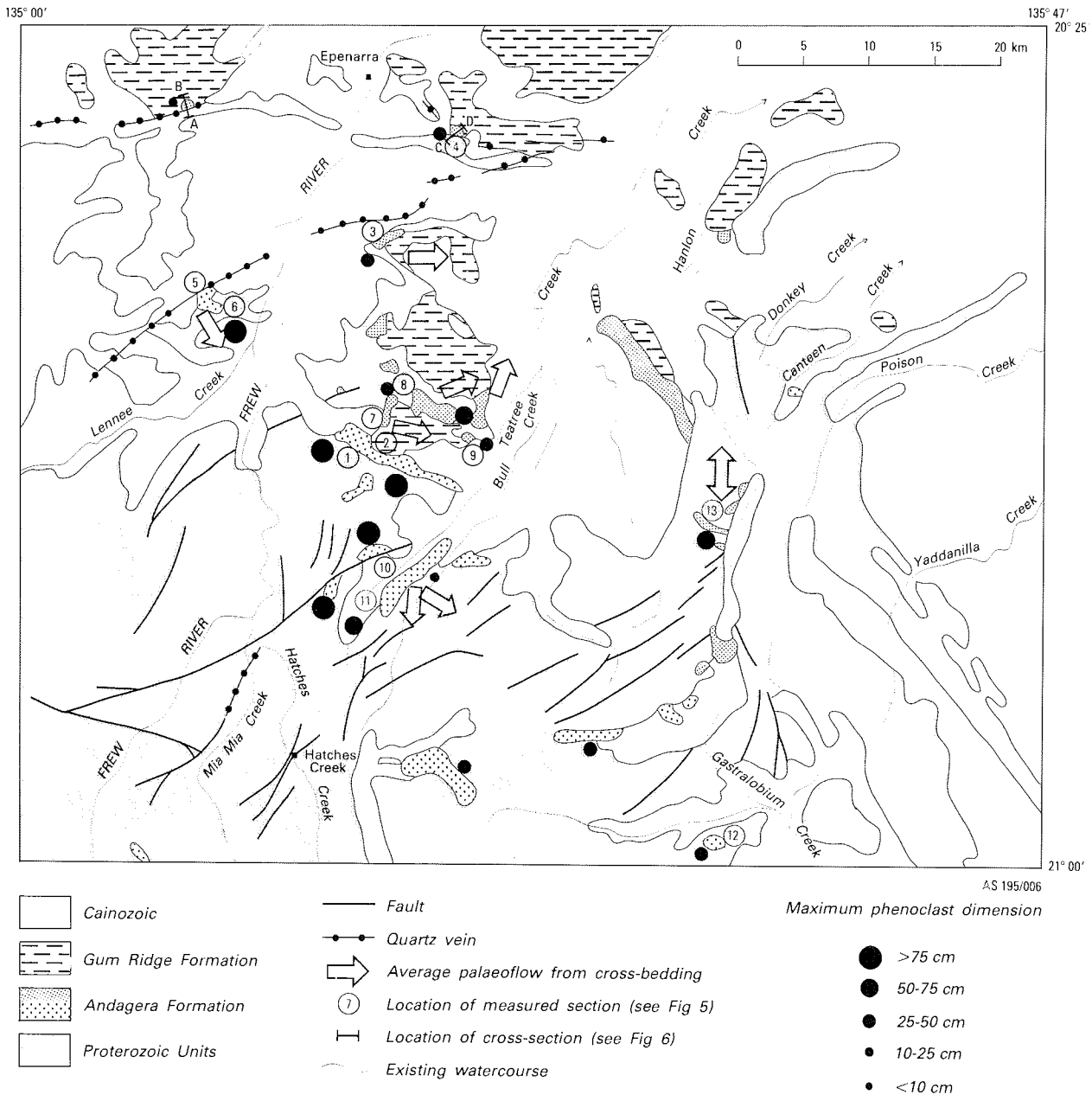


Figure 4 Distribution of the Andagera Formation in the Davenport Range area.

Oligomictic orthoconglomerates predominate with clasts locally derived from ridge-forming sandstones of the Hatches Creek Group, but there are also polymictic deposits which include clasts of both ridge-forming and recessive Proterozoic units. There are two main types of conglomerate. Firstly, there are those which consist of poorly sorted, subangular to subrounded, pebble to boulder clasts in a fine to very coarse-grained sandstone matrix. These are weakly stratified, with crude or pronounced clast imbrication (Plate 3) and display large-scale fining-upward cycles (Section 12) or combined coarsening and fining-upward cycles (Section 5). In the coarsest conglomerates, boulders are rounded and percussion-marked, and little or no matrix is preserved. Secondly, there are unstratified, unsorted conglomerates consisting of angular clasts in a fine-grained matrix (Plate 4, Section 1). The conglomerates are typically medium-bedded to massive and fill channels scoured into the sandstones and into underlying Proterozoic units.

Sandstones are fine to very coarse-grained and granule-bearing, and vary from immature, in association with conglomerates, to mature, in more distal areas. Sandstones are thin to thick-bedded and predominantly planar bedded. Parallel lamination is common, but both small and large-scale planar (Plate 5) and trough cross-stratification are locally well developed and apparently current dominated. Limited palaeocurrent data indicate a bimodal distribution (Figure 4). Other sedimentary structures include small-scale fining-upward cycles, pebble imbrication, asymmetrical, lunate, interference and bevelled ripple marks, mud clast moulds and mudcracks. Petrographically, sandstones are quartz arenites, sublitharenites, quartz wackes and lithic greywackes. The matrix is in part derived from degraded labile grains. Clasts in the sandstones are similar to those in the conglomerates and occur isolated or in lenses. They are commonly angular and include small boulders (top of Section 6, Figure 5).

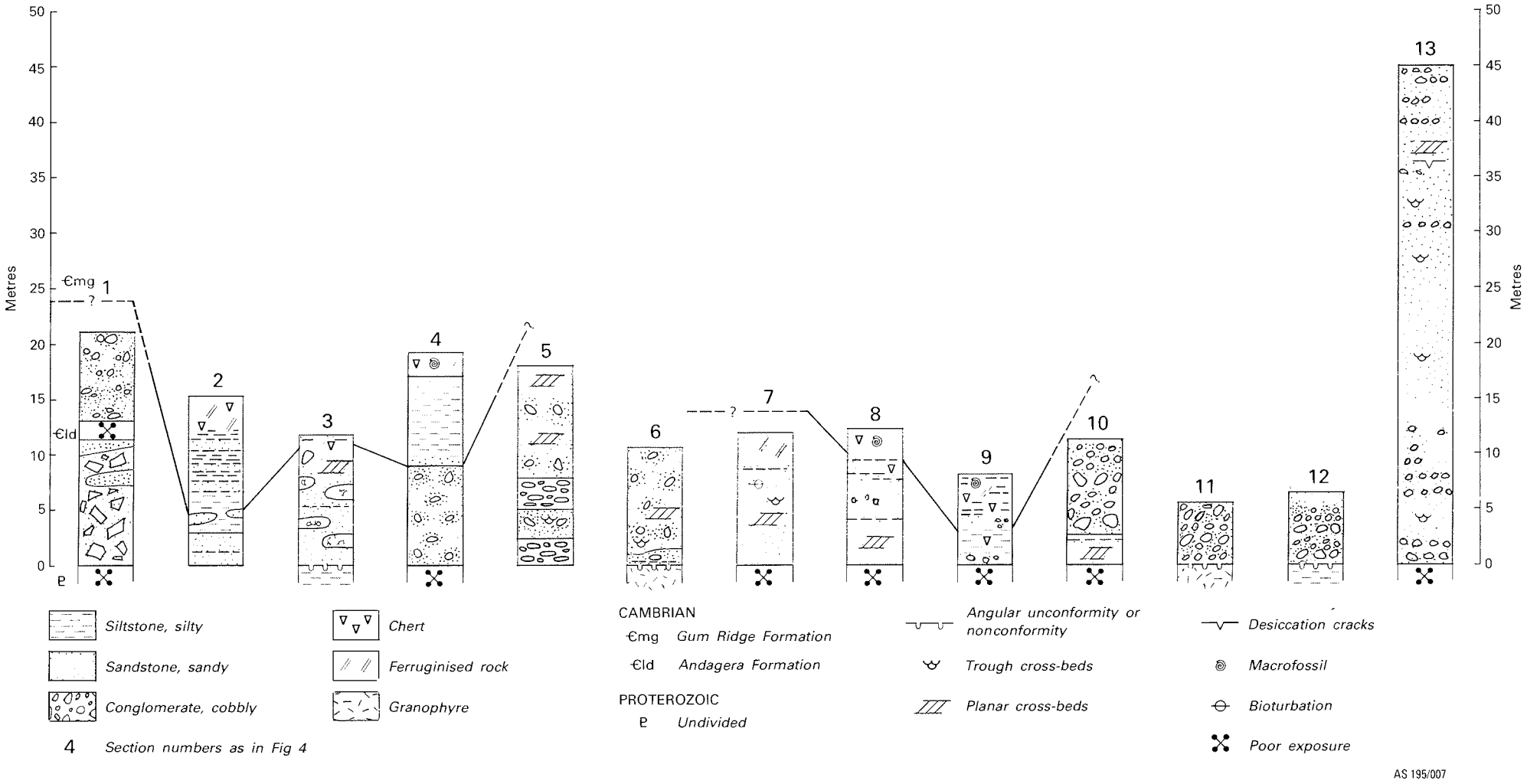


Figure 5 Measured sections in the Andagera and Gum Ridge formations.

Plate 3 Clast imbrication in conglomerate of the Andagera Formation. GR NS2899.

Siltstones occur as lenses in finer-grained, more distal, outcrops of the Andagera Formation. They are parallel laminated to medium-bedded and locally micaceous.

The formation is generally unfossiliferous. However, bioturbated beds and burrows were recorded in sandstone and siltstone at one distal locality (Section 7, Figure 5; Walley, 1985).

The formation unconformably overlies Proterozoic rocks (Plate 4). The unconformity surface is highly irregular and can be subvertical where the Andagera Formation has filled valleys in the steeply dipping Hatches Creek Group (Figure 6). The Andagera Formation appears to be overlain transitionally by siltstones of the Gum Ridge Formation, but a disconformity may be present.

Plate 4 Unsorted, unstratified polymictic conglomerate of the Andagera Formation.
The Andagera Formation unconformably overlies vertically cleaved Proterozoic granophyre at the level of the hammer head.
GR NT2609.

The Andagera Formation is older than the Late(?) Ordian to Templetonian Gum Ridge Formation but any time-break between the two units is believed to be small. In ELKEDRA, the Andagera Formation has been tentatively assigned an Early Cambrian age, whereas in FREW RIVER the formation may extend into the early Middle Cambrian.

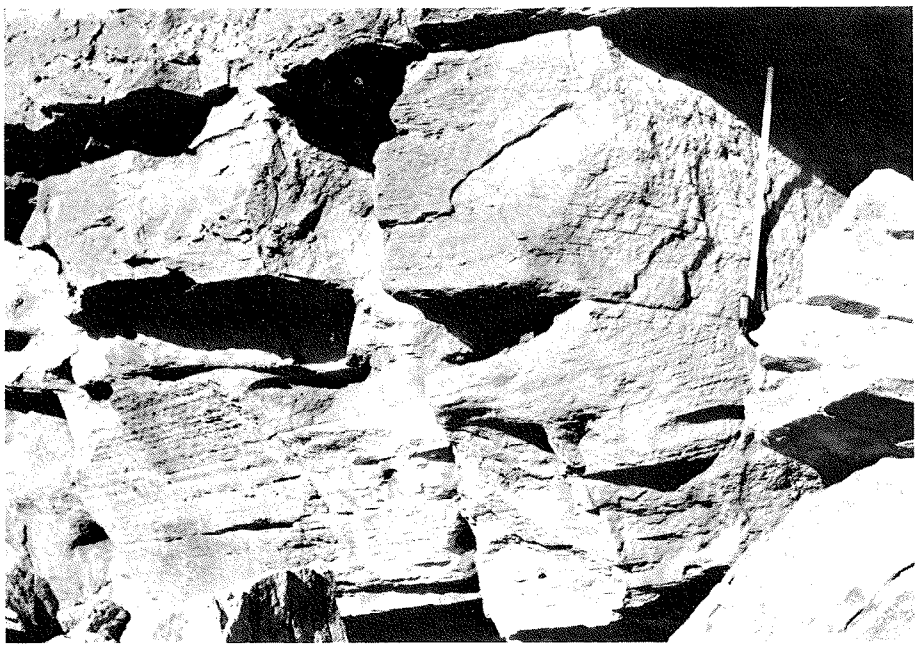


Plate 5 Thick, planar cross-bedding in sandstone of the Andagera Formation.
Scale: tape measure is 0.5 m long.
GR NT2812.

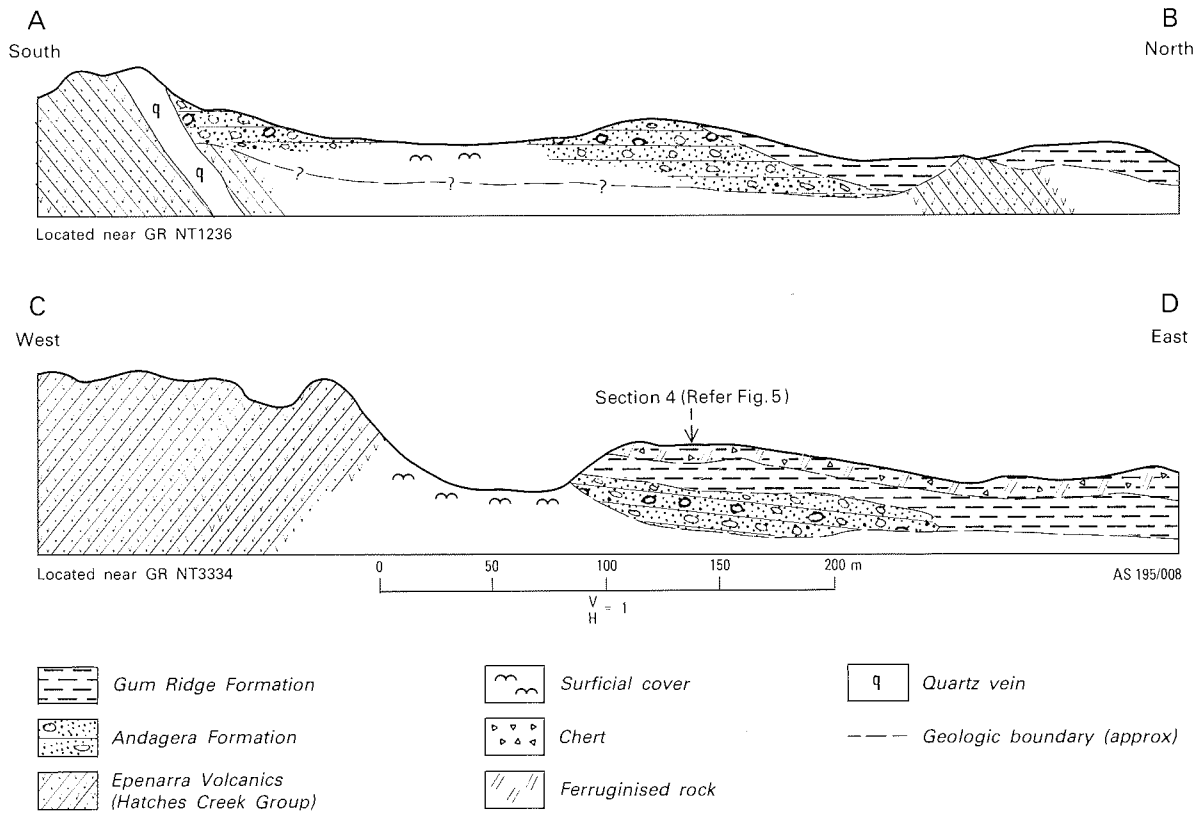


Figure 6 Stratigraphic relationships of the Hatches Creek Group and the Andagera and Gum Ridge formations.

The sedimentary structures outlined above suggest a high energy fluviatile depositional setting and a distal interdigitation with a shoreline environment. Conglomerates are interpreted as deposited by both stream (Plate 3) and debris (Plate 4) flow. An alluvial fan depositional environment was postulated for the formation in ELKEDRA (Donnellan *in* Stidolph and others, 1986) and an alluvial fan-fluvial braidplain environment is also inferred in FREW RIVER (Walley, 1985). There appear to have been a number of local source areas for the unit. At some localities a single fining-upward cycle is present (Section 4, Figure 5), while at other localities there are two episodes of coarse sedimentation (Sections 5, 10-12, for example). Coarsening-fining cycles reflect fan progradation, possibly in response to a tectonic pulse, followed by a return to equilibrium, as described by Rust (1979). The formation fines away from the local proximal source areas and stratification improves distally. Palaeocurrent data support this pattern (Figure 4).

A number of proximal depositional areas are adjacent to major Proterozoic fault zones. Reactivation of major faults could have created local sediment traps and supplied debris to form small alluvial fan deposits. These deposits coalesced distally and interdigitated with the onlapping Gum Ridge Formation. Deposition was probably not synchronous throughout the area and the southwest appears to have been the more tectonically active region. A simplified, hypothesised depositional setting is summarised in Figure 7. The pattern appears to be one of small intermontane alluvial basins as discussed by Miall (1981).

Central Australia was at palaeolatitude 60° N at the start of the earliest Cambrian (Veevers, 1976), but rapid plate motion occurred during the Early Cambrian and deposition in this area in the early Middle Cambrian took place at about 20° N (Jell, 1974; Veevers, 1976; Shergold and Druce, 1980). As the Gum Ridge Formation has been dated as early Middle Cambrian and the time interval between this unit and the Andagera Formation is believed to be small, the Andagera Formation may also have been deposited in a tropical climate. Debris flow deposits are more common in arid region fans (Cherven, 1984) but can reflect fluctuation in precipitation on a humid fan (Rust, 1979). Supporting criteria for an arid climate, such as caliche, palaeosols and evaporite pseudomorphs, do not appear to be present in the Andagera Formation. A tropical humid climate is therefore favoured.

Slight doming of the bevelled Proterozoic rocks (Stewart and others, 1986) and renewed fault movement in the region were probably concurrent with deposition of the Andagera Formation. The Andagera Formation appears to be one of a number of coeval coarse fluviatile sequences deposited as a result of fault movements during a period of tectonic instability and volcanism associated with lithospheric plate divergence in the Early to early Middle Cambrian.

Gum Ridge Formation (Emg)

This formation was named by Öpik, *in* Ivanac (1954). The type locality is Gum Ridge, in TENNANT CREEK. The holostratotype consists of very highly weathered, fossiliferous, sandy limestone and chert, siliceous shale and thinly bedded fine sandstone unconformably overlying the Helen Springs Volcanics (Ivan overlying the Helen Springs Volcanics (Ivanac, 1954).

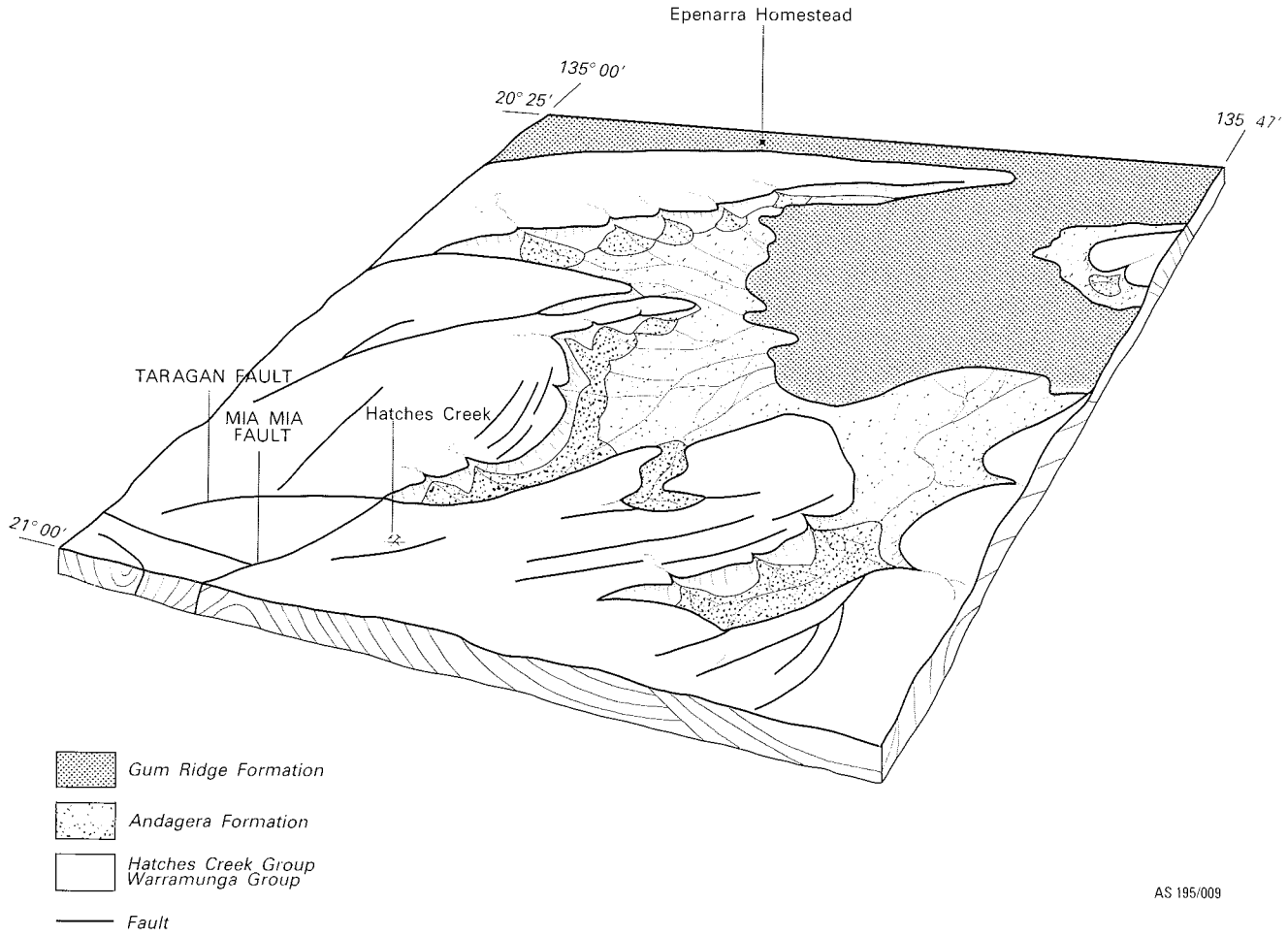


Figure 7 Depositional environment of the Andagera Formation.

In FREW RIVER, sandstone and conglomerate formerly included in the Gum Ridge Formation (Smith, 1964a, 1972) have now been mapped as Andagera Formation. Units in eastern FREW RIVER formerly mapped as Wonarah beds (Smith, 1964a) are included in the Gum Ridge Formation.

The Gum Ridge Formation outcrops as low hills overlying recessive Proterozoic units and Andagera Formation in the Davenport Range (Figure 4) and also forms rises in northern and eastern FREW RIVER.

Lithologies consist of chert, laminated to thin-bedded siltstone and fine-grained sandstone, coquinite and, in the subsurface, dolostone. However, outcrops are deeply weathered and occur as silicified and ferruginised rubble associated with massive silcrete which encloses angular clasts of amorphous and banded chert. The clastic rocks are petrographically lutites, fine-grained quartz wackes and sublithic lutites containing sand-grained rock fragments of vein quartz and quartz arenite. Anhydrite pseudomorphs occur locally in silicified siltstone throughout the outcrop area. Both amorphous and banded chert rubble are common and concentrically banded chert is found in eastern FREW RIVER in areas of abundant anhydrite pseudomorphs.

Rock types intersected in water bores in western FREW RIVER (Appendix) are predominantly fine-grained carbonates, silty carbonates and chert, but weathered silty rock is more common above the water table. From this information, it is apparent that some of the silicified surface rubble represents weathered fine-grained carbonates or silty carbonates. Concentrically banded cherts are thought to be diagenetic siliceous nodules originally in a carbonate sequence and preserved during weathering.

The formation contains trilobites, brachiopods, hyoliths and sponges (Öpik, *in* Ivanac, 1954; Öpik, 1956; Smith, 1972). Coquinite consists predominantly of silicified trilobites and hyoliths. Brachiopods, which are mainly inarticulate species originally with chitino-phosphatic shells, occur in the silicified siltstone. The Ordian trilobite *Redlichia* sp. was found west of Epenarra homestead during the mapping programme for the first edition of FREW RIVER (Smith, 1964b). Fossils found during the 1984 mapping programme were identified by Dr. J. R. Laurie (BMR) and are listed in Table 3.

The unit is from less than 5 m to approximately 15 m thick in outcrop, but up to 150 m thick in the subsurface near Epenarra (Appendix, bore 5A), although part of this subsurface carbonate may be an older unit. The formation is probably a veneer overlying the Hatches Creek Group in southeastern FREW RIVER and, by comparison with known subsurface geology in ALROY (Howard and Perrino, 1976), could be a thin sequence over volcanic basement in the NE of FREW RIVER. Elsewhere the thickness is unknown.

The fauna (Table 3; Öpik, 1956, 1967, 1970, 1975 and 1979) indicates an early Middle Cambrian, late(?) Ordian to late(?) Templetonian, age. The Gum Ridge Formation correlates with part of the Arthur Creek Formation in ELKEDRA (Stidolph and others, in preparation) and there is an overlap with the Wonarah beds (Öpik, 1956; Smith, 1972) during the Temple-

Table 3 Fossils collected from the Gum Ridge Formation, FREW RIVER.

NTGS LOCALITY	GRID REFERENCE	FOSSILS	AGE
FR17	PT2484	Obolid brachiopod, indeterminate articulate brachiopod, hyoliths	
FR18	PT2684	*Xystridura* sp. and indeterminate pagetiid (eodiscine) trilobite	Ordian to Templetonian
FR40	PT0982	Indeterminate ptychopariine trilobite	
FR97	NT4837	Obolid brachiopod, hyoliths	
FR118	NT1537	?*Lingulella* sp. and indeterminate ptychopariine trilobite	Middle Cambrian
FR299	NT3337	Lingulide or acrotretide brachiopod	
FR328	NT3334	*Redlichia ?idonea* Whitehouse 1939 (Öpik, 1970)	Late Ordian
FR339	NT3933	*Lingulella* sp., hyoliths	
FR340	NT3933	Obolid brachiopod	

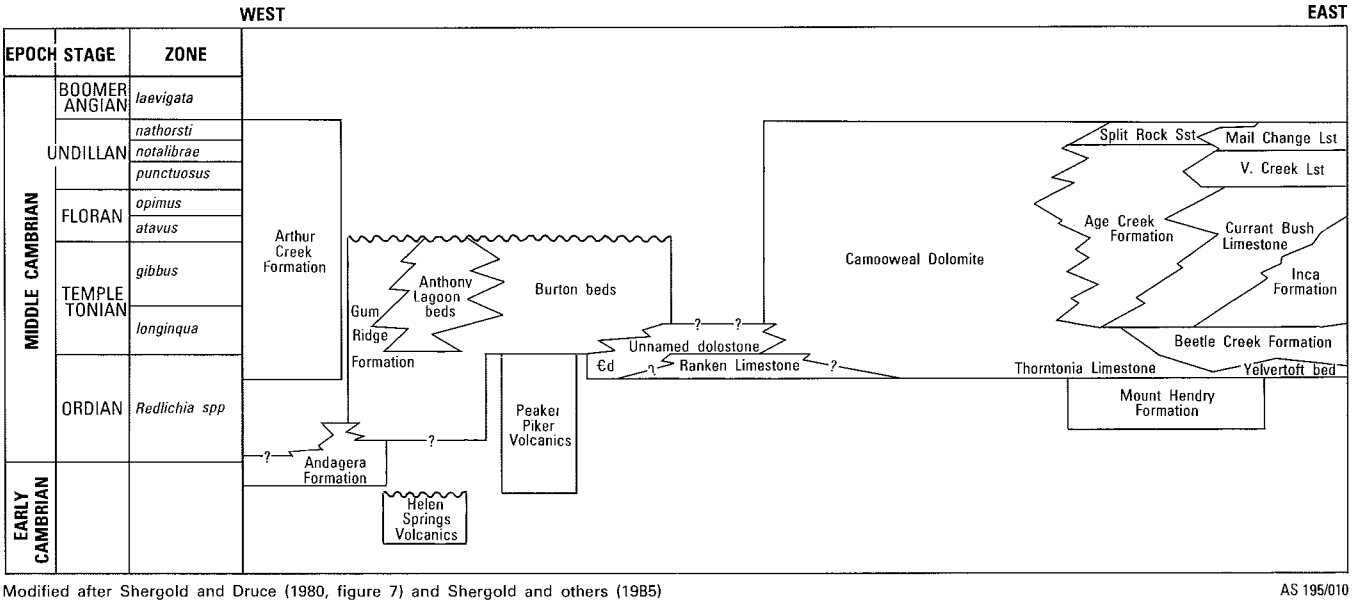
All fossils poorly preserved or fragmentary. Identifications by Dr. J. R. Laurie, BMR

tonian. The Wonarah beds outcrops are now mapped as part of the Gum Ridge Formation. The formation may interdigitate with Cambrian dolostone ϵ_d in eastern FREW RIVER. The Beetle Creek Formation, which overlies and interdigitates with the Thorntonia Limestone in Queensland (Howard and Perrino, 1976), is correlated with and is lithologically similar to the Gum Ridge Formation (Figure 8).

The Gum Ridge Formation overlies the Andagera Formation with an apparently transitional contact in FREW RIVER, but in ELKEDRA the contact is, in part, disconformable (Stidolph and others, in preparation). Where sandstones of Andagera type grade upwards into siltstones, the base of the Gum Ridge Formation has been tentatively placed at the top of the sandstone. The Gum Ridge Formation onlaps the Andagera Formation and diachronous deposition is suggested. Stratigraphic relationships are summarised in Figure 6.

There are no younger Cambrian units preserved in FREW RIVER. The only strata overlying the Gum Ridge Formation are surficial Cainozoic sands and clays (Appendix).

From faunal evidence, the environment of deposition was very shallow marine. Small pelagic Eodiscid trilobites (Öpik, 1979) and minute inarticulate brachiopods, generally found in shaly beds deposited in poorly oxygenated waters (Moore and others, 1952), signify periodically euxinic conditions. A restricted, intermittently subaerial environment is further indicated by evaporite pseudomorphs. A marginal subtidal, lagoonal and estuarine depositional environment is in accord with that proposed for the Beetle Creek Formation by de Keyser and Cook (1972), with comparable restricted sea water circulation and high salinity (Russell and Trueman, 1971). Coquina probably accumulated on offshore banks during periods of high wave energy. In common with the Beetle Creek



Modified after Shergold and Druce (1980, figure 7) and Shergold and others (1985) AS 195/010

Figure 8 Inferred spatial and temporal relationships of formations on an E-W parallel of the Georgina Basin at approximate latitude 20°S.

Formation, the Gum Ridge Formation is prospective for phosphorite. This is discussed under 'Economic Geology'.

The Gum Ridge Formation marks the beginning of the early Middle Cambrian transgression on the western margin of the Georgina Basin.

Unnamed Cambrian dolostone (ϵ_d).
In JOILDUNG and PROUT there are poor outcrops of a dolostone unit which has an extensive calcrete cover. The outcrop area occupies up to 1300 km^2, but the subsurface extent of the unit is not known. Some of the carbonate intersected in water bores on Epenarra station may be a lateral continuation of the same sequence.

The unit consists of flat-lying thin to medium-bedded micritic to coarsely crystalline pale buff-grey dolostone. The coarse dolostones include recrystallised peloidal grainstones with abundant stylolites, vugs and a pitted frothy texture on weathered surfaces. Outcrops are generally less than 1 m thick.

The dolostone is unfossiliferous. It is locally overlain by rubble of concentrically banded chert and silicified siltstone with anhydrite pseudomorphs, the latter representing a residuum of units within the Gum Ridge Formation. This carbonate unit may both underlie and interdigitate with the Gum Ridge Formation and be a westerly extension of the Camooweal Dolomite in AVON DOWNS, as inferred in Figure 8. The unnamed Cambrian dolostone has been retained (following Smith, 1964a) as a separate unit because the lithology differs from thinly laminated siltstone and silty carbonates of the Gum Ridge Formation. Alternatively, the dolostones are unweathered units within that formation. The inferred age of the unnamed dolostone is Middle Cambrian. Stratigraphic drilling is required to resolve the unit.

There is no basal contact exposed and the unit is overlain disconformably by laminated pisolitic and nodular Cainozoic calcrete.

The dolostones are interpreted as forming offshore shoals and probably comprised part of the extensive carbonate banks marking the early Middle Cambrian transgression (Shergold and Druce, 1980).

CAINOZOIC

TERTIARY

Ferricrete (Tf), **silcrete** (Ts), **deeply weathered rock** (Ta)
Ferruginous and siliceous duricrusts occur throughout FREW RIVER, capping mesas and hills of both Proterozoic and Cambrian rocks at various topographic levels. They are best developed on outcrops of Gum Ridge Formation and are locally underlain by several metres of leached and ferruginised deeply weathered rock.

The duricrusts consist of thin to massive caps of highly silicified or ferruginised rock, or both, in which the nature of the parent rock influences the type of cap. Silcretes developed on Hatches Creek Group arenites north of the Clough Range have a silicified quartz sandstone texture. Silcretes on the Gum Ridge Formation typically contain subrounded to angular clasts of amorphous and banded chert. Where ferruginisation of silcrete has occurred, structures resembling solution pipes (Jennings, 1971, p.50) have developed in the ferricrete. Where the duricrusts are several metres thick, induration increases upward. Locally, in thick duricrusts developed on Gum Ridge Formation overlying Hatches Creek Group, there are clasts of both units in the silicified matrix. A complete laterite profile (Noakes and Travers, 1949) is rarely developed.

Duricrust formation postdated the summit bevelling of the Davenport Range, which was considered by Hays (1971), Mabbutt (1971) and Twidale (1980) to be an early Cretaceous planation. However, the bevelled surface, the Ashburton Surface, (Hays, 1971) is now believed to be an exhumed landscape of at least Cambrian age (Stewart and others, 1986). In Queensland, Idnurm and Senior (1978) palaeomagnetically dated two weathered profiles as Maastrichtian to Early Eocene and Late Oligocene. Rock weathering and duricrust development in FREW RIVER thus probably occurred over a considerable period of time during the Cretaceous and Tertiary periods. A number of phases of silcrete and ferricrete development are indicated both by the presence of clasts of silicified rock in the duricrust matrix and by the ferruginisation of silcrete.

TERTIARY TO QUATERNARY

Dissected colluvial deposits (Czc)
Alluvial and colluvial sediments formed fans which are being incised by active watercourses along the flanks of Hatches Creek Group sandstone ridges throughout the Davenport Range. The deposits are poorly consolidated to unconsolidated.

Vein quartz rubble (Czq)
Colluvial and residual deposits of quartz rubble flank ridge-forming quartz veins in the southwestern of FREW RIVER and are thought to be partly Tertiary and partly Quaternary in age (Blake and Wyche, 1983).

Calcrete (Czk)
Calcrete occurs mainly in COOLIBAH, JOILDUNG and PROUT. It forms a thin cover over part of the Gum Ridge Formation and unnamed dolostone outcrop areas and includes areas formerly mapped as travertine (Smith, 1964a).

The calcrete hardpan is usually less than a metre thick and is laminated to medium-bedded. It comprises both laminated and glaebular fabric. The latter consists of irregular pebble to cobble-sized glaebules of pale buff-grey micritic carbonate in a sandy calcareous matrix. The glaebules commonly have concentrically laminated micritic rims. Interstitial matrix is a mixture of micrite with quartz silt to fine sand and irregular fine carbonate peloids. Alveolar texture, representing rootlet penetration of sediment (Esteban and Klappa, 1983), is present in the matrix.

Calcrete is disconformable on all underlying units. In southern JOILDUNG it contains cobbles of ferruginised and silicified Gum Ridge Formation and thus postdates the Tertiary deep weathering phases. However, calcrete in northern JOILDUNG is locally partly silicified and could therefore be of Tertiary age.

Airphoto patterns in JOILDUNG and PROUT indicate the calcrete in that area represents a soil development on a karst surface which formed on the underlying carbonates (Walley, 1985). Calcrete formation has been assigned to an arid or semi-arid climate (Esteban and Klappa, 1983; Warren, 1983) and the karst represents a preceding wetter period.

QUATERNARY

Sand, soil and alluvium

Qa is predominantly water-course and floodplain alluvium and alluvial soil. It includes minor aeolian and colluvial material. There is a varied vegetation cover of grasses, shrubs and trees on alluvial plains.

Qas represents relict fluvial systems and comprises former water courses now covered partly or totally by sand.

Qs represents red aeolian sands. These form sand plains and stabilised dune fields in northern and eastern FREW RIVER. Areas of sand, incised by present drainage, also occur in the southwest. Both red clayey sands and red dune sands are found in the region (Perry 1962). Dunes are longitudinal, low broad features, generally less than 2 m high. They are continuous for many kilometres parallel to the prevalent southeasterly winds. Dune surfaces are fixed by vegetation, which is mainly spinifex, with scattered low trees and sparsely to thickly distributed shrubs.

Qc consists of fans of colluvial material flanking ridges and hills in the Davenport Range. Whilst not dissected, the fans are weakly incised by active water courses.

Qr comprises red earth soils on lowlands and alluvial plains. These soils may be developed on both stabilised alluvium and deeply weathered rock (Litchfield, 1962). Monospecific stands or groves of mulga (*Acacia aneura*) over short grasses are characteristic.

Qp represents claypans and poorly-drained depressions in water courses, on floodplains and in interdune corridors. Both flat pans of sun-baked sediment with sparse vegetation and areas of lush vegetation favouring waterlogged conditions are included. These areas retain water after rain.

STRUCTURE

The main structural elements of FREW RIVER, shown in Figure 9, were developed during the Proterozoic. In the following description, the structures and tectonic history of southwestern FREW RIVER are based on work by Blake and Wyche (1983), Blake, Wyche and Hone (in press), and Stewart and Blake (1984). In addition, Stewart (in preparation) is producing a paper on the structural history of the Davenport province.

There are four major Proterozoic structural units in FREW RIVER, comprising portions of three fault blocks and a Fold and Thrust Belt. These units were defined in southwestern FREW RIVER and their easterly extent (Figure 9) is drawn largely from interpretation of geophysical information. In HATCHES, the Taragan Fault separates the Taragan Fault Block from the Fold and Thrust Belt. The three fault blocks are distinguished from the Fold and Thrust Belt by structural trends and folding style. They are each bounded by major faults or shear zones and each fault block has a unique structure.

The *Ooradidgee Fault Block* is the northernmost structural unit and contains the Warramunga Group, characterised by tight, small-scale folding, and outcrops of eastern granite. The limits of the fault block are unclear whereas to the west the fault block extends into BONNEY WELL where it also contains part of the Epenarra Volcanics (Stewart and Blake, 1984). The volcanics, and the unconformably underlying Warramunga Group, were probably affected by the same deformation in this area and both are north of a shear zone, with abundant quartz veins, which marks the southern margin of the Ooradidgee Fault Block (Stewart and Blake, 1984). In contrast, aeromagnetic trends in eastern FREW RIVER indicate that the Epenarra Volcanics have the same fold pattern as that of the Fold and Thrust Belt, and therefore are not part of the Ooradidgee Fault Block.

The *Edmirringee Fault Block* consists mainly of Ooradidgee Subgroup units of the Hatches Creek Group, forming broad NE trending folds. Its SE margin is a dextral strike-slip fault, in contact with the Taragan Fault Block.

The *Taragan Fault Block* also consists of Ooradidgee Subgroup units which, except in the SW corner of the fault block, are relatively flat-lying. The Taragan Fault forms the SE margin of the Taragan Fault Block. The NE extension of this fault is ill-defined, but on geophysical evidence it appear to cut across and offset poorly exposed granite and continue to the north. Stewart and Blake (1984) inferred a sinistral strike-slip movement of 1-2 km, based on interpretation of magnetic trends of a dolerite unit. However a different interpretation of the geophysical evidence can be made, indicating a dextral or even a purely vertical north-side-down movement. The fault block may have behaved as an 'immobile buttress' during deformation.

The *Fold and Thrust Belt* contains predominantly NW-trending folds, as in BONNEY WELL. The major folds are upright and concentric in style, with arcuate trends. In eastern FREW RIVER the Hatches Creek Group has been folded into a large structural basin (Figure 9). In the southwest of HATCHES, there are tight, east- to north-trending folds with axial-plane cleavage. Trend variation in folds may reflect a wrapping around relatively competent nuclei such as the Mia Mia Volcanics, in the Mia Mia Dome, during deformation (Blake and Wyche, 1983; Stewart, in preparation). Many faults in the Fold and Thrust Belt are probably thrusts, which would account for anomalous local thickness of some formations. Ryan (1961) suggested that most of the NE-trending faults in the Hatches Creek Wolfram Field are wrench-faults. There is dextral displacement of 1-2 km along the Mia Mia Fault, a splay of the Taragan Fault.

Stewart and Blake (1984) recognise two main folding and faulting events in the Davenport province, both of which postdated tight folding of the Warramunga Group. They cite evidence that the NW-oriented structures formed first, in response to NE-SW compression.

Faults trending NE developed during the second phase of deformation. The principal compression during this episode was oriented at a high angle to that in the first phase of deformation (Stewart and Blake, 1984) as indicated by the dome and basin, superimposed fold pattern in the region, which is clearly delineated on landsat imagery. Anticlines oriented NE-SW, probably related to lateral movement on faults bounding the Taragan Fault Block, are apparently second-phase structures. Superimposed folding in the Davenport province is discussed by Stewart (in preparation).

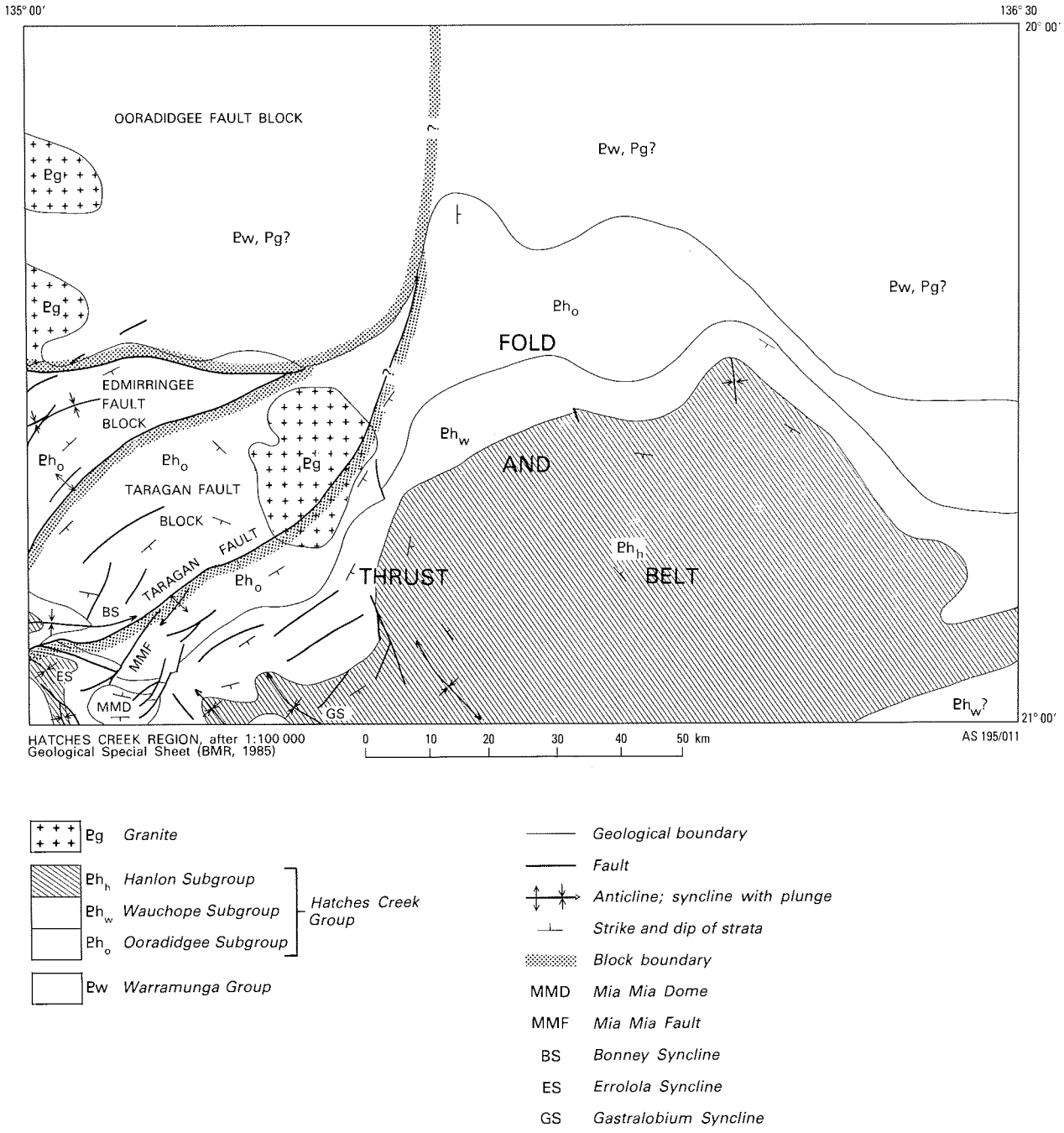


Figure 9 Proterozoic geology and structure.

Reactivation of Proterozoic faults in the region is suggested during the Early or early Middle Cambrian, initiating alluvial fan sedimentation of the Andagera Formation.

With the exception of a very minor NE-trending fault, flat-lying Cambrian and Cainozoic units appear to be largely undisturbed by post-Cambrian tectonism which affected ELKEDRA. Joint sets in Cambrian carbonate units are prominent on air photos.

METAMORPHISM

Very low-grade regional metamorphism has affected all Proterozoic rocks in the sheet area. This is described in Blake and Wyche (1983) and Blake, Wyche and Hone (in press) and summarised below from these reports.

Warramunga Group greywacke and siltstone have well-preserved original textures and have not been significantly recrystallised. However, they have probably been regionally metamorphosed to prehnite-pumpellyite facies or to lower greenschist facies.

Most of the Hatches Creek Group rocks have been regionally metamorphosed to greenschist facies. The effects of this metamorphism are most obvious in the volcanic units. Original textures are well preserved in both sedimentary and volcanic rocks. Quartz sandstones display diagenetic changes, but the only metamorphic minerals present are white mica and biotite. Felsic volcanics also contain metamorphic white mica or biotite or both. Secondary actinolitic amphibole occurs in mafic lavas and primary pyroxene is partly or completely replaced by secondary green amphibole in dolerite and gabbro intrusions. Locally, regional metamorphism may have reached upper greenschist or lower amphibolite facies. This is indicated by the presence of possible metamorphic

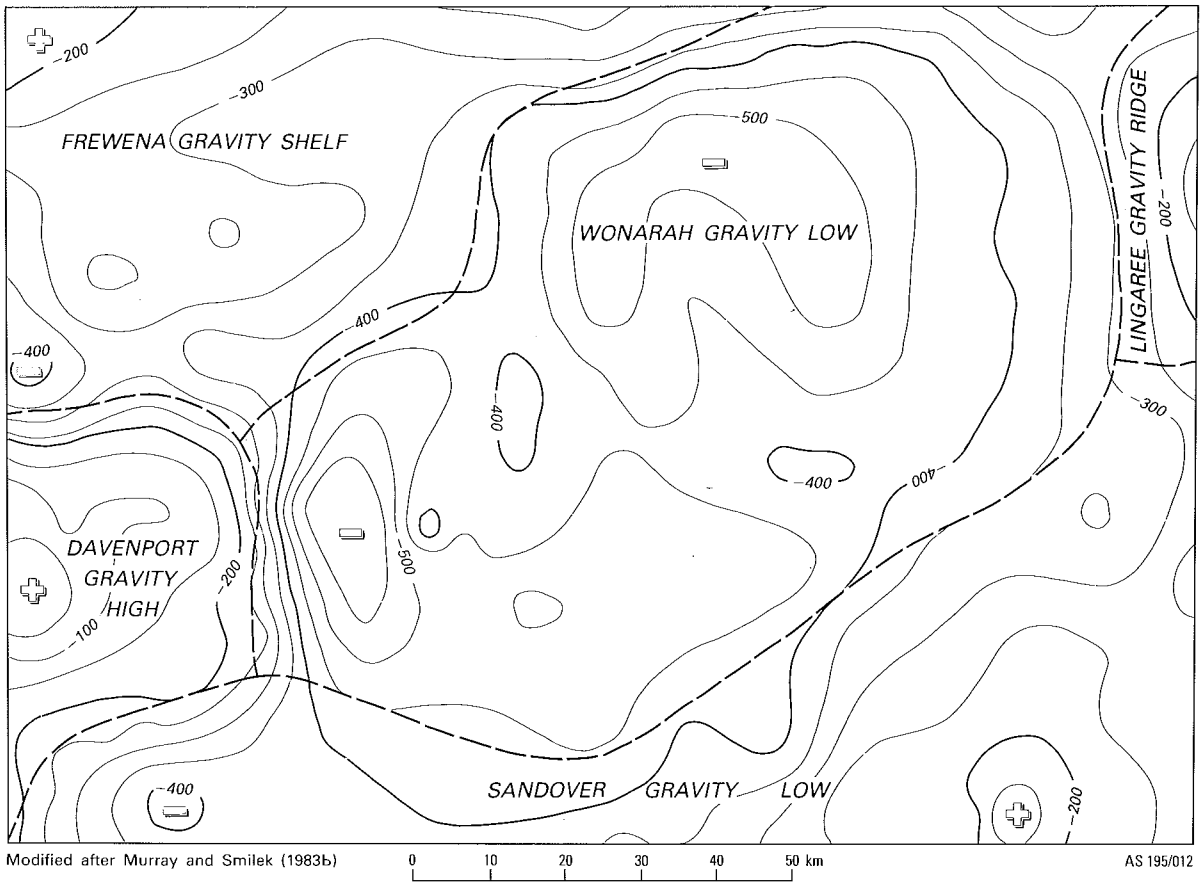


Figure 10 Bouguer anomaly contours.

hornblende in the Newlands Volcanics near Hatches Creek.

Granophyre, dolerite, gabbro and granite intrusions commonly have contact metamorphic aureoles from less than one metre to more than 100 m in width.

The low-grade regional metamorphism of the Hatches Creek Group, and possibly also the Warramunga Group, accompanied folding and faulting of the Hatches Creek Group.

Phanerozoic rocks have not been metamorphosed.

GEOPHYSICS (by B. A. Simons)

GRAVITY

FREW RIVER is covered by BMR gravity data at an 11 km station spacing with additional traverses along roads and tracks in the western half of the sheet area. The data have been processed by the BMR and released as Bouguer anomaly contour maps (Figure 10; Murray and Smilek, 1983a, 1983b). The station spacing is inadequate for detailed interpretation but can be used for broad regional correlations. A number of density measurements have also been made on rock samples from within the Davenport province (Hone and others, in press) and a summary of this data is shown in Table 4.

FREW RIVER lies wholly within the Georgina Regional Gravity Shelf Province (Fraser and others, 1977) which is subdivided into five units: Frewena Gravity Shelf; Wonarah Gravity Low; Lingaree Gravity Ridge; Sandover Gravity Low; and Ooratippra Gravity High. The Sandover Gravity Low is here considered to cover the southern portion of the sheet and the gravity high in the SW corner is renamed the Davenport Gravity High (Figure 10). Both these areas were previously considered to be part of the Ooratippra Gravity High (Fraser and others, 1977).

The Frewena Gravity Shelf occupies the NW corner of FREW RIVER and coincides with the Ooradidgee Fault Block. It is characterised by gentle gravity gradients with Bouguer anomaly values ranging from -400 to -150 $\mu m/s^2$. Individual gravity features generally trend NE and are probably due to density variations within the underlying Warramunga Group. Density measurements taken on samples from elsewhere in the Davenport province indicate that granites are generally less dense than rocks of the Warramunga Group (Table 4). The gravity low in the south of the unit coincides with granite outcrop.

The Wonarah Gravity Low is an elongate NE-trending gravity trough occupying the central part of FREW RIVER and extending NE into RANKEN. The Bouguer anomaly values range from -600 to -300 $\mu m/s^2$ and are attributed to mass deficiencies within the pre-Hatches Creek Group basement. A gravity low at the western end of this unit coincides with outcropping granite, indicating that these mass deficiencies could be due to granites intruding this basement. A slight gravity ridge cutting across the

Table 4 Summary of density measurements.

UNIT	NO. OF SAMPLES	DENSITY (t/m³) RANGE	MEAN	MEDIAN
Granites	15	2.63 – 2.74	2.69	2.70
Mafic Volcanics				
Mafic Sills*	23	2.80 – 3.12	2.98	2.96
In Alinjabon Sandstone*	12	2.64 – 3.33	3.03	2.97
Kudinga Basalt*	30	2.80 – 3.17	2.92	2.92
Treasure Volcanics*	8	2.75 – 3.02	2.93	2.93
Edmirringee Volcanics	6	2.78 – 3.09	2.88	2.84
Felsic Volcanics				
Granophyre*	6	2.65 – 2.70	2.69	2.69
Arabulja Volcanics*	16	2.63 – 2.81	2.76	2.78
Treasure Volcanics*	12	2.50 – 2.77	2.66	2.67
Mia Mia Volcanics*	3	2.65 – 2.74	2.68	2.66
Epenarra Volcanics*	9	2.58 – 2.82	2.67	2.68
Sandstone*	32	2.34 – 2.89	2.64	2.63
Warramunga Group*	14	2.71 – 2.89	2.79	2.78
'Basement'	14	2.53 – 4.51	2.89	2.74

*Outcropping in FREW RIVER
After Hone and others, in press

Wonarah Gravity Low in the central part of FREW RIVER is probably due to subcropping Hatches Creek Group rocks.

The Lingaree Gravity Ridge extends into FREW RIVER east of the Wonarah Gravity Low. This ridge trends NE and has a range of Bouguer anomaly values from −250 to −100 μm/s². Fraser and others (1977) suggest that the Lingaree Gravity Ridge corresponds to a zone of early Proterozoic basement which is shallower than that of the Sandover Gravity Low and correlates approximately with the NW margin of an inferred downwarp within the Adelaidean sequence underlying the Cambrian sediments. However, since there is little evidence for a thick sequence of Adelaidean sediments within the Sandover Gravity Low (Stidolph and others, in preparation), the Lingaree Gravity Ridge and Wonarah Gravity Low are probably due to density variations within the underlying Precambrian rocks.

The Sandover Gravity Low is a broad NE-trending gravity depression with Bouguer anomaly values ranging from −150 to −400 μm/s². Previously the southern part of FREW RIVER and NW part of ELKEDRA were considered to be part of the Ooratippra Gravity High (Fraser and others, 1977). However the Sandover Gravity Low is now interpreted as extending across ELKEDRA (Stidolph and others, in preparation) and the southern part of FREW RIVER (Figure 10). As the unit extends over outcropping Hatches Creek Group rocks in ELKEDRA the low Bouguer anomaly values are thought to be mainly due to the thick clastic sequence of the Hanlon Subgroup which contains virtually no volcanic rocks. A gravity low occurs in the SW corner of FREW RIVER to the east of the Mia Mia Dome. This low is probably caused by the presence of a subcropping granite body.

North of the Sandover Gravity Low in western FREW RIVER is the Davenport Gravity High which is distinguished by relatively high Bouguer anomaly values ranging from −250 to 50 μm/s². As noted above, this unit was previously considered to be part of the Ooratippra Gravity High. The Bouguer anomaly values are highlighted by the occurrence of granite to the north, east and south, producing low Bouguer anomaly values.

The gravity pattern over the Davenport Gravity High is similar to that over the Ooratippra Gravity High in ELKEDRA, which has been interpreted as being caused by basement density variations. The Davenport Gravity High coincides with the Edmirringee and Taragan fault blocks which contain Ooradidgee Subgroup rocks consisting of a large proportion of relatively dense volcanic rocks (Table 4). In addition, the Edmirringee and Taragan fault blocks contain extensive relatively dense mafic sills. The high Bouguer anomaly values of the Davenport Gravity High are therefore more likely to be due to dense, near-surface rocks rather than pre-Hatches Creek Group rocks (Hone, 1983).

MAGNETICS

The BMR has flown an airborne magnetic survey over FREW RIVER as part of the Georgina Basin survey at an altitude of 600 m above sea level and a line spacing of 3 km (Figure 11; BMR, 1967). Additional semi-detailed surveys have been flown over HATCHES (BMR, 1982a) and part of JOILDUNG (Harvey, 1984).

Laboratory measurements of magnetic susceptibility and remanence have been made on representative samples of rock units from within the Davenport province (Table 5; Hone and others, in press). The susceptibility measurements indicate that the sandstones and granites are relatively nonmagnetic, whereas the volcanic units display a wide range of susceptibilities with some units proving very magnetic. Moderate strength magnetic anomalies arise from sources within the Kudinga Basalt and Mia Mia and Treasure Volcanics, although magnetic susceptibility measurements on these units are low (Table 5). This may relate to the difficulty of adequately sampling the volcanic units due to preferential weathering of the

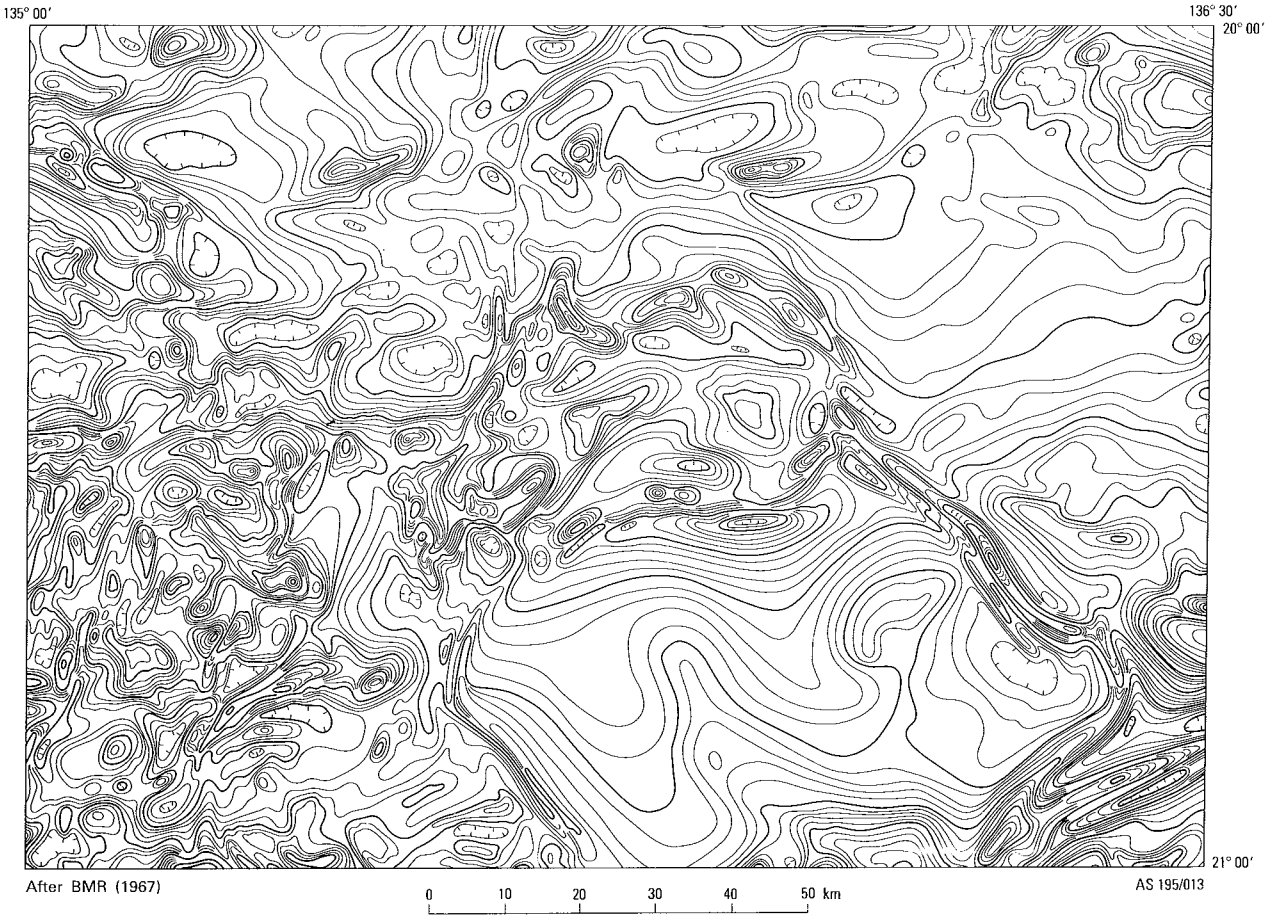


Figure 11 Total magnetic intensity contours.

Table 5 Summary of laboratory magnetic measurements.

UNIT	No of Samples	SUSCEPTIBILITY (10^{-6}SI)		REMANENCE (mA/m)	
		Range	Median	Range	Median
Granites	15	65–9400	300	1–150	10
Mafic Volcanics					
Mafic Sills*	30	460–84160	1690	1–300000	850
In Alinjabon Sandstone*	12	20–49420	2810	2–10000	125
Kudinga Basalt*	30	140–29100	810	1–2400	3
Treasure Volcanics*	8	390–8230	1380	1–2200	65
Edmirringee Volcanics	6	6580–129730	67280	3100–65000	10750
Felsic Volcanics					
Granophyre*	12	2570–25930	4400	35–7000	2400
Arabulja Volcanics*	19	10–47490	6000	20–4500	150
Treasure Volcanics*	19	10–22000	380	1–57500	50
Mia Mia Volcanics*	3	50–235	80	1–4	3
Epenarra Volcanics*	9	140–4750	360	1–1200	30
Sandstone*	32	0–1300	40	0–550	3
Warramunga Group*	14	20–149110	15030	1–11200	400
'Basement'	14	0–7830	250	1–900	5

*Outcropping in FREW RIVER
After Hone and others, in press

more magnetic horizons. The strong remanent magnetic component present in many of the samples may vary sufficiently from the earth's present magnetic field to produce errors in dip determinations.

Within rocks of the Hatches Creek Group the susceptibility contrast between the nonmagnetic sandstones and granites and the magnetic volcanic units produces a simple relationship between magnetic anomalies and trends and mapped geology. This relationship can be readily seen in the results from semi-detailed airborne magnetic surveys (BMR, 1982a).

At 1:250 000 scale the relationship is less clear with a complex magnetic contour pattern associated with outcropping Hatches Creek Group (Figure 11). The magnetic contours do, however, outline the northern boundary of the Edmirringee Fault Block and the eastern extent of subcropping Hatches Creek Group rocks. A NW-trending linear feature in the western part of HANLON coincides with outcropping mafic lava of the Alinjabon Sandstone. Further north this feature follows east-trending outcrops of the Hatches Creek Group then swings to the southeast at GR PT0935. In the SE corner of FREW RIVER the magnetic trends are northeasterly and extend into AVON DOWNS to the east and ELKEDRA to the south.

This magnetic feature delimits the subcropping extent of the volcanic unit of the Alinjabon Sandstone and defines a large basin structure within the Hatches Creek Group. Within this region the smooth magnetic contour pattern indicates a substantial thickness of overlying nonmagnetic sediments. Depth determinations made on the few anomalies present suggest that the magnetic basement could be more than 2500 m below the surface (Wells and others, 1966). Outcropping sandstone, probably Yaddanilla Sandstone, within this region indicates that the nonmagnetic sediments within this basin are Proterozoic Hatches Creek Group sediments. This is consistent with the estimated thickness of sandstone units above the Alinjabon Sandstone (Blake and Wyche, 1983).

The magnetic contour pattern in northeastern HATCHES (GR NT4919) is quiet and clearly outlines the extent of the poorly exposed granite. A slightly higher total magnetic intensity over the western part of the granite suggests that a compositional change occurs within the granite. This change coincides with the northern extension of the Taragan Fault and may relate to faulting within the granite.

The northern half of FREW RIVER is characterised by broad magnetic patterns with isolated contour closures. This suggests that the underlying rocks consist of interspersed magnetic and nonmagnetic material. The area is therefore most likely to be underlain by magnetic Warramunga Group rocks and nonmagnetic granite. The Warramunga Group appears to predominate in the northwest, with only isolated areas of shallow magnetic material occurring to the east. Depth determinations within this area suggest that magnetic basement is relatively shallow with less than 500 m of overlying Phanerozoic sediments. In the east the southern extent of the Warramunga Group rocks is defined by the linear magnetic feature of the Fold and Thrust Belt corresponding to subcropping Epenarra Volcanics.

A detailed airborne survey over the NE corner of FREW RIVER indicated that magnetic units occur at depths of 20-30 m (Harvey, 1984) overlying a magnetic basement at a depth of approximately 500 m. This probably corresponds to shallow Cambrian Peaker Piker Volcanics overlying Proterozoic basement.

RADIOMETRICS

Airborne scintillometer surveys carried out by the BMR in 1956 (Livingstone, 1957) and 1957 (Mulder, 1960) over the Davenport Range area failed to locate any prospective radiometric anomalies in FREW RIVER. In 1982 a semi-detailed radiometric survey was flown by the BMR in conjunction with the airborne magnetic survey. The results of this survey have been released as radiometric total count contours covering HATCHES (BMR, 1982b).

The total count contours indicate that the most strongly radioactive units are the felsic sills and volcanics. In southern Hatches the contours clearly outline the Treasure, Mia Mia and Arabulja volcanics and the granophyres. Preliminary investigations indicate that the radioactivity arises mainly from potassium and thorium sources (Hone and others, in press). Scattered radiometric anomalies over sandstone units, in particular the Yeeradgi Sandstone, are probably caused by minerals derived from local occurrences of felsic volcanic material.

High radiometric values occur over areas of outcropping granite in northeastern HATCHES. However the interpreted subcrop of this granite has a generally low total count. This low count is probably caused by the masking effect of the Quaternary cover.

GEOLOGICAL HISTORY

The oldest rocks in FREW RIVER, the Warramunga Group, were deposited as deep-water turbidites and volcanics at about 1870 Ma (Black, 1981, 1984; Blake and Wyche, 1983). Folding, metamorphism and uplift of this Group occurred at approximately 1810 Ma (Black, 1977, 1981) during the Strangways Event in the Arunta and Tennant Creek blocks (Shaw and others, 1984).

Gradual regional subsidence occurred and the Hatches Creek Group accumulated in shallow-marine to fluvial and locally subaerial environments (Sweet, in preparation; Blake and Wyche, 1983). Sedimentation was accompanied by felsic and basaltic volcanism, with volcanic products being interbedded and interfingering with, or overlapped by, sediments.

The Hatches Creek Group was deformed, metamorphosed to greenschist facies and intruded by granite at about 1640 Ma (Black, *in* Blake and Horsfall, 1984). There was accompanying copper-tungsten mineralisation (Blake and Wyche, 1983). This episode of deformation has been assigned to the Aileron Event, which affected both the Arunta Block and the Davenport province (Shaw and others, 1984).

The deformed and uplifted Hatches Creek Group was subjected to subaerial erosion and gradually worn down to a mature landscape of low relief (Blake and Wyche, 1983), the Ashburton Surface (Hays, 1971; Stewart and others, 1986). This peneplanation occurred prior to or during the Early Cambrian. During the later part of the Early Cambrian or early Middle Cambrian a phase of mild tectonism occurred in the area (Shergold and Druce, 1980). During this event there was basaltic volcanism in the NE of FREW RIVER and adjacent

sheet areas (Peaker Piker and Helen Springs Volcanics). At about the same time, coarse clastic sediments (Andagera Formation) accumulated in alluvial fans at the foot of contemporaneously faulted, uplifted and eroded Hatches Creek Group rocks in the SW of FREW RIVER.

Relief of the Hatches Creek region was gradually reduced and a shallow epeiric sea transgressed the area during the Ordian to Templetonian. Carbonate shoals developed in very shallow-water (supratidal to intertidal), intermittently hypersaline conditions. In subtidal channels (Shergold and Druce, 1980) or lagoonal to estuarine areas between and fringing these banks, calcareous or dolomitic and probably organic-rich siltstones of the Gum Ridge Formation accumulated. Sea water circulation appears to have been restricted and the area was apparently one of relatively high salinity.

The sea probably retreated from the area in the late Templetonian, as no post-Templetonian rocks are present, but it is possible that subsequent erosion has removed part of the sequence. FREW RIVER was apparently a stable area of non-deposition during the remainder of the Palaeozoic and Mesozoic, although, again, it is possible that some later deposits have been removed by erosion. Minor warping of Cambrian units and development of joint sets may have occurred during movements which gently folded and faulted Cambrian to Devonian units further south in ELKEDRA. These events are correlated with the Carboniferous Alice Springs Orogeny, which was most intense in the Alice Springs region.

There is no known evidence of Cretaceous events in FREW RIVER. During warm and humid periods in the Tertiary, deep weathering occurred, forming deeply weathered profiles with ferruginous and siliceous cappings. A karst erosion surface may also have developed on Cambrian carbonates in the east of FREW RIVER in the same period. Minor uptilting of the Davenport Range area in the late Tertiary (Mabbutt, 1962) caused renewed stream incision and some re-organisation of drainage patterns, together with further erosion and dissection of weathered peneplaned areas.

The climate at the end of the Tertiary and during the Quaternary became cooler and drier (Bowler, 1976). Calcrete formed in previously alluvial areas, and sand dunes and sand plain developed over much of northern and eastern FREW RIVER. During a later period of increased rainfall, dunes were stabilised and there was renewed drainage incision. Interdune corridors became sites of clay accumulation, the clay probably derived from weathering within the dunes and washed into the corridors during episodic rainfall (Hallsworth and others, 1982). The latter processes are continuing at the present day.

ECONOMIC GEOLOGY

All the known metalliferous deposits (tungsten, gold, copper, bismuth) occur in Proterozoic rocks in southwestern FREW RIVER, and most production has come from the Hatches Creek Wolfram Field.

Ryan (1961) has described the Hatches Creek Wolfram Field in detail and Roarty (1977) has discussed the Kurundi goldfield. The mines, mineral resources and economic potential of the Hatches Creek Region are summarised by Blake and Wyche (1983) and Blake, Wyche and Hone (in press). Smith (1964a) also outlined the economic geology of the sheet area.

The mineral resources and potential are summarised below under commodity subheadings.

Tungsten

Lodes near Hatches Creek are steeply dipping quartz veins in shear zones which cut both folded sedimentary and volcanic rocks of the Hatches Creek Group and dolerite and gabbro. The veins are thought to be related to an underlying granite (Blake and Wyche, 1983). Three types of mineralisation have been recognised (Ryan, 1961): wolframite-scheelite confined to lodes within gabbro; cupriferous wolframite in lodes within acid porphyritic volcanic rocks; and wolframite in lodes mainly in sedimentary and volcanic rocks.

Bismuth, copper, iron, molybdenum and tin minerals are associated with the tungsten lodes, but only bismuth and copper have been worked economically (Smith, 1964a). The main gangue minerals are quartz and muscovite.

Mines on the Hatches Creek Wolfram Field were worked sporadically between 1913 and 1957. The total recorded production to 1958 was 2840.85 t of wolframite and scheelite concentrate (Ryan, 1961). Available data on individual mines are summarised in Table 6.

Wolframite also occurs in quartz veins cutting Warramunga Group greywackes and siltstones at the small Woodenjerrie Mine near Epenarra Homestead.

In view of the prominent nature of the quartz vein outcrops and the fact that they have been extensively prospected, Blake and Wyche (1983) considered it unlikely that any significant new tungsten deposits remain to be found in the area. A report by Amdel (Moskovits, 1966) on the separation of tungsten concentrate suggested improved methods which could be employed if production resumed in the future.

Bismuth

Bismuth is a common accessory mineral in the wolframite-scheelite lodes and is present in minor amounts in the cupriferous wolframite and wolframite orebodies. About 6 t of bismuth concentrate were extracted from the Hatches Creek Wolfram Field between 1943 and 1958 (Ryan, 1961).

Copper

Copper minerals are present in virtually all tungsten lodes in the Hatches Creek Wolfram Field and copper ore has been mined in that area, mostly from the oxidised zone. The recorded production was 70 t of concentrate assaying 30%-45% Cu, mined between 1950 and 1958 (Ryan, 1961). There is also a small abandoned copper mine at GR NS3787 but production figures are not known. Traces of copper minerals occur in the Treasure Volcanics and dolerite and gabbro bodies. In the wolfram field, only two mines reached the primary zone. However, large copper deposits are not likely to be found in the tungsten lodes (Blake and Wyche, 1983).

Gold

Most of the gold produced from within the sheet area has come from small mines near Kurinelli (Roarty, 1977). In addition, traces of gold have been obtained from the Pioneer Mine and a small amount of gold from

the Crystal Mine at Hatches Creek (Ryan, 1961). Gold in both areas occurs in quartz veins cutting gabbro and associated xenoliths of Hatches Creek Group rocks within gabbro. There are no production details for the Crystal Mine but the quartz reefs are short, exposed intermittently over about 400 m and range from 0.3 to 6 m in width. Most of the reefs contain only traces of gold; better values, up to 34 g/t, are confined to short narrow sections (Ryan, 1961). The total recorded production from the Kurinelli area is about 13.6 kg gold (Blake and Wyche, 1983) extracted between 1926 and 1975. Additional auriferous quartz veins may exist, but due to the irregular distribution and overall low grade of the reefs adequate testing is likely to prove too costly (Roarty, 1977).

Lead-zinc

Blake and Wyche (1983) considered the Frew River Formation of the Wauchope Subgroup (Hatches Creek Group) to be a prospective target for base-metal deposits. The formation consists of very shallow-marine or sabkha carbonate rocks similar to those associated with the McArthur River lead-zinc deposit. The potential for stratiform lead-zinc mineralisation in Cambrian carbonate sequences in the north and east of FREW RIVER has not been assessed.

Uranium

Radioactive anomalies were detected during an airborne radiometric survey over the Mia Mia Dome south of Hatches Creek (Livingstone, 1957) and were later re-examined by Mulder (1960) and by Project Mining Corporation (1979) but no significant uranium was found. Recent work indicates that radioactivity in southern HATCHES has potassium and thorium sources (Hone and others, in press). CRA Exploration Pty Ltd (Snelling, 1979) found small uranium anomalies in acid volcanic units of the Hatches Creek Group but discovered the uranium to be leached and of no economic importance.

Petroleum

There is insufficient subsurface information in FREW RIVER for assessment of petroleum potential. No trace of hydrocarbons has been found in water bores on Epenarra and Kurundi Stations although only one of the deeper boreholes penetrated the full Cambrian sequence to reach granite basement (No 5A). Areas of perhaps thicker Cambrian sequences, for example in the central east of FREW RIVER, have not been tested. Potential source beds may exist at depth, as Middle Cambrian formations elsewhere in the Georgina Basin (Freeman, 1986) have good source rock potential. However, the Middle Cambrian sequences in FREW RIVER are apparently at shallow depth throughout and lack suitable cover rocks. As they are largely unaffected by later tectonic events it is unlikely that suitable stratigraphic or structural traps are present. As concluded by Smith, (1964a), therefore, based on present knowledge, the petroleum potential of FREW RIVER appears to be low.

Phosphate

A large, low-grade resource of phosphate, of the order of 900 Mt at 15-20% P_2O_5, was discovered near Wonarah in ALROY by IMC Development Corporation (Perrino, 1969). The phosphorite occurs in the Gum Ridge Formation (formerly the Wonarah beds)

Table 6 Tungsten mines in FREW RIVER: summary of available data (after Blake and Wyche, 1983).

MINE (with index no. on map face)	MINERALISATION, MAJOR (Minor)	HOST FORMATION	REEF WIDTH (cm)	DEPTH OF WORKINGS (m)	PERIOD WORKED	PRODUCTION (t)
Black Diamond (16)	Wf(Sch,Bi,Cu)	Ehk	–	60	1939-58	87
Bonanza (17)	Wf(Sch,Cu,Bi)	Ehk	45	30	1938-54	57
BXB (28)	Wf(Sch,Cu,Bi)	Eht	40	18	?-57	19
Copper Show (33)	Wf,Sch,Cu	Eht	60	27	1938-56	22
					1950-55	44 (Cu)
Endurance (14)	Sch,Wf,Bi,Cu	gabbro,Ehk	35	12	1952-58	7
Euro (29)	Wf	Eho	–	–	1948-57	1
Frenchmens Point (19)	Wf	Eho	15	–	1942-44	6
Green Diamond Group (18)	Wf,Sch,Cu,Bi	Ehk	45	41	1937-58	58
					1969	Cu?
Hen & Chickens (26)	Wf(Sch,Cu,Bi)	Eht	–	25	pre-1940-58	468
Hit or Miss group, (31)	Wf(Mo,Cu)	Eht	–	62	?-58	over 400
Kangaroo group (30)	Wf(Mo,Cu)	Eht,Eho	100	41	?	over 100
Masters Gully (25)	Wf(Cu,Bi,Mo)	Eht,Eho	–	46	1937-58	95
Pioneer (13)	Wf,Sch,Bi,Cu, (Mo) (av. grade 2.2% WO_3)	gabbro, Ehk	100	63	1935-58	442
Ricketty Kate (15)	Wf(Cu,Bi)	Ehk	30	3	?-52	9
Silver Granite (32)	Wf,Cu,Mo,Bi	Ehk	–	28	1938-57	19
Treasure group (22-24)	Wf(Cu,Bi,Pb)	Ehk	30	55	?	?
White Diamond (27)	Wf(Cu,Mo)	Ehk	40	15	1942-58	345+
Woodenjerrie (1)	Wf	Ew	–	–	1952-53	minor

Minerals: Wf = wolframite; Sch = scheelite (±tungstite, cuprotungstite);
Cu = malachite, azurite, chalcocite, bornite, chalcopyrite, cuprite, native Cu, covellite, tetrahedrite, brochantite, atacamite;
Mo = molybdenite;
Bi = bismutite, bismuthinite, native bismuth, bismuth carbonates.

Host formations: Ew = Warramunga Group; Ehk = Kurinelli Sandstone; Eht = Treasure Volcanics; Eho = Taragan Sandstone.

and is distributed around the margins of a volcanic basement high which extends into the NE of FREW RIVER. The Wonarah phosphorite is a collophane mudstone with only rare pelletal phosphorite (Howard and Perrino, 1976). CRA Exploration Pty. Ltd. held an exploration licence to the south of the Wonarah deposits in eastern FREW RIVER from 1982 to 1985. Aeromagnetic data obtained over the area indicated potential for phosphorite at 20-30 m depth but planned drilling did not proceed (Harvey, 1985).

Other basement highs of probable Hatches Creek Group rocks occur in southeastern FREW RIVER where onlapping Gum Ridge Formation may also contain coevally deposited phosphorite.

Potential for phosphorite occurrence therefore exists in the Gum Ridge Formation, particularly in northeastern FREW RIVER, but distance from markets make any possible deposits uneconomic at present, and there could be benefication problems due to fine grain size. Deleterious constituents, such as iron, organic matter and carbonate, need to be assessed.

Construction materials

Both ferricretes and ridge-forming units of the Hatches Creek Group provide suitable supplies of gravel and have been used for unsealed roads in the area.

Water

There are semi-permanent waterholes in the main watercourses in the Davenport Range. As noted by Smith (1964a), they are generally adequate for pastoral use in the hilly areas where there is little suitable grazing pasture.

In lowland areas north and east of the Davenport Range, surface water supplies are augmented by bore water. Surface water in the east is ephemeral and confined to claypans which hold water for short periods after rain. No water bores have been drilled east of longitude 135° 40'E. All available water bore data are summarised in the Appendix.

Aquifers in the Proterozoic basement are in fracture and fault zones and in porous rocks. Yields are variable and aquifers are generally intersected at shallower depths than those in Cambrian rocks. Aquifers in Cambrian units include fractured zones, solution cavities in carbonate rocks, and porous sandstone horizons.

Assuming subsurface lithologies in eastern FREW RIVER to be similar to those in the NW of FREW RIVER and the SE of ALROY, water bores in this area would probably be successful.

Water is also obtained from Cainozoic aquifers, for example near Epenarra homestead (Appendix).

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APPENDIX
WATER BORE DATA

STATION OR LOCATION	BORE NAME	REG. NO. OF BORE	GRID REF.	DEPTH (m)	YIELD (L/s)	STANDING WATER LEVEL (m)	STRATA (m) From unchecked drillers' logs unless otherwise indicated	REMARKS*
EPENARRA	No. 1	1934	NT3656	148	No data	No data	0-5, soil; 5-23, sand, clay; 23-117, 'rock'; 117-148, shale, clay	Bore abandoned; 23-148m: Є?
EPENARRA	No. 2	1935	NT3546	107	No data	No data	0-6, soil; 6-12, river gravel; 12-108, 'stones' and clay	Bore abandoned
EPENARRA	No. 3 (Beantree)	1677	NT5154	107	2.5	No data	No data	
EPENARRA	No.4	1936	NT5344	86	0.2	52	0-15, sandy loam; 15-16, quartz; 16-17 sand; 17-42, clay; 42-86, diorite boulders + clay	'Diorite' may be G or porphyritic Phr
EPENARRA	No.5 (Bloodwood)	1937	NT3060	108	2.9	101	0-2, red soil; 2-15, white clay and gravel; 15-37, red clay; 37-55, yellow clay; 55-77, boulders and clay	
EPENARRA	No.5A (Yellowhole)		NT2757	200	0.4	105	0-15, red sand; 15-80, clay with dolostone chips; 80-89, sandy clay with dolostone chips; 89-104, dolostone; 104-131, dolostone and cherty dolostone; 131-155, cherty dolostone; 155-200, granite	G.Log.* Top of Cambrian at 15m; top of granite at 155m
EPENARRA	No.6	2906	NT1448	49	No data	No data	Various coloured clays; black clay at 49	
EPENARRA	No.7	1939	NT5754	74	No data	No data	At 54, white crystalline limestone	Bore abandoned
EPENARRA	No.7A	2908	NT5849	52	No data	No data	Cave at 51-52, limestone	Bore abandoned
EPENARRA	No.8 (Bluff)	1940	NT1742	46	No data	No data	0-38, sandy clay; 38-45, sandy clay and quartz porphyry fragments; 45-46, quartz porphyry	G.sample descriptions (PJC); bore abandoned
EPENARRA	No.9 (Salt)	2907	NT0835	54	0.4	20	0-42, sand and clay; 42-51, quartzite of Hatches Creek Group	G.Log. (DW) 42-51m: Vein quartz intruding Phr?
EPENARRA	Mulga	2322	NT1651	89?	No data	No data	0-76, soil, sand, clay, gravel; 76-89, dolostone, dolomitic limestone, chert nodules	G.Log. Aquifer in Єmg?
EPENARRA	Walkabout	2510	NT4966	111	2.3	88	0-46, sand; 46-63, clay; 63-74, chert and sandstone; 74-80, dolomite; 80-100, limestone and chert; 100-101, sandstone (aquifer); 101-111, limestone	G.Log. 63-111 m: Єmg?
EPENARRA	Homestead	3832	NT2739	30	0.3	18	0-3, red soil; 3-17, sand and clay; 17-28, conglomerate and red clay; 28-30, yellow sandstone	Cz?
EPENARRA	Whitewood	5035	NT2846	118	No data	110	No data	Bore abandoned
EPENARRA	Homestead	10388	NT2739	34	No data	18	No data	

APPENDIX (continued)

STATION OR LOCATION	BORE NAME	REG. NO. OF BORE	GRID REF.	DEPTH (m)	YIELD (L/s)	STANDING WATER LEVEL (m)	STRATA (m) From unchecked drillers' logs unless otherwise indicated	REMARKS*
EPENARRA	A129/1	10448	NT2738	68	soakage	25	0-46, clay, silt, sand, gravel; 46-61, deeply weathered siltstone gravel; 61-68, very fine-grained dolostone	G. Log. (AMW) No water supply. Єmg
EPENARRA	80/1	12694	NT2739	23	1.0	15	0-15, sand, clay; 15-20, sand, gravel; 20-23, clay	Aquifer in Cz
EPENARRA	80/2	12695	NT2739	35	0.2	15	0-21, sand, clay; 21-24, sand, gravel; 24-35, clay	Aquifer in Cz
EPENARRA	80/3	12696	NT2739	21	1.0	15	0-18, sandy clay; 18-21, coarse gravel	Aquifer in Cz
EPENARRA		12948	NT4538	13	No data	No data	0-4, clay; 4-5, clay, grit; 5-13, rock	5-13m: Єmg?
EPENARRA	Epenarra 4	12949	NT4842	2	Nil	Nil	0-2; sand; 2-?, rock	2m+: Єmg?
EPENARRA	Epenarra 5	12950	NT4936	38	1.9	14	0-14, clay; 14-26, stone; 26-35, soft grey stone; 35-38, stone	Aquifer in Єmg?
EPENARRA	Whistleduck I	12951	NT0745	54?	No data	No data	0-15, clay; 15-16, gravel; 16-20, clay; 20-50, clay, grit; 50-54, clay, sandstone, compacted gravel, ribbon stone	Bore dry; Єmg?
EPENARRA		12986	NT2241	21	Nil	Nil	0-9, clay, silt, sand, gravel; 9-15, dolostone; 15-21, deeply weathered siltstone	G.Log. (AMW), Єmg?
EPENARRA		13496	NT2757	100	Nil	Nil	0-36, sandy clay, gravel; 36-48, weathered siltstone; 48-87, very fine dolostone, siltstone, chert; 87-100m, lost circulation	G.Log. (AMW), Єmg?
EPENARRA	A129/4	14075	NT6356	97	1.9	73	0-9, red soil, gravel; 9-51, clay, weathered siltstone gravel; 51-81, blue-grey silty dolostone and chert; 81-96, pale grey dolostone and banded chert	G.Log. (AMW) Aquifer in Єmg
EPENARRA		14163	NT3153	128	Nil	Nil	0-6, sandy clay; 6-48, gravel of weathered siltstone+fine-grained sandstone; 48-60, dolostone, chert; 60-81, brown siltstone, chert, silicified dolostone; 81-128, lost circulation	G.Log. (AMW) Єmg
KURUNDI	Bull Creek	2441	NT3306	39	No data	28?	No data	Saline water
KURUNDI	Kurinelli	2443	NT0419	42	No data	No data	No data	Aquifer probably fractured gabbro (Smith, 1964a)
KURUNDI	Fat Bullock	2575	NT3920	19	1.9	12	0-12, sand, gravel; 12-19, silicified siltstone	G.Log, Єmg
KURUNDI		2613	NT3108	38	0.1	25	Silicified siltstone and sandstone of Hatches Creek Group	G. interpretation
KURUNDI		11509	NT3224	40	Nil	Nil	0-1, red sandy loam; 1-6, clay; 6-15, coloured shale; 15-30, weathered granite; 30-40, blue granite	
KURUNDI		11510	NT5217	40	0.1	?	0-5, soil, gravel; 5-7, clay, boulders; 7-19, limestone; 19-30, sandstone; 30-40, granite or quartzite	
KURUNDI	Dempsey's Well	13138	NT3901	?	No data	No data	No data	

Vacant Crown Land 1/76 — for Canteen Creek Settlement		11452	NT6520	59	2.0	40	0-3, sand, gravel; 3-48, weathered siltstone, friable sandstone; 48-57, weathered sandstone; 57-59, fine sandstone	G.Log. (AMW)
		11453	NT6520	64	2.0	No data	0-12 clay, sand, gravel; 12-30, weathered siltstone, sandstone; 30-54 siltstone, chert, sandstone gravel; 54-64, sandstone	Aquifer in Coulters Sandstone?
Police Station Hatches Creek	No.1 Try	1958	NT2285	31	No data	6	0-9, sand, gravel; 9-23, quartzite; 23-31, diorite	
	No.2 Try	1959	NT2285	27	0.4	15	0-2, soil; 2-3, siltstone; 3-11, sand; 11-16, sand and quartzite; 16-20, sandstone; 20-27, silicified quartz sandstone and quartzite	G.Log. (TQ), aquifer in Phs?
Near Wolfram Hill		1021	NS1891	10	No data	No data	No data	Bore dry
		1027	NS1791	38	No data	No data	No data	Bore successful
		1068	NS1891	49	No data	No data	No data	Bore successful
		2854	NS1891	53	No data	No data	0-53, clay, silt, sand, gravel	Cz
		3251	NS1791	?	No data	No data	No data	
	Old Battery Well	3894	NS2186	?	No data	No data	No data	
		3982	NS1891	?	No data	No data	No data	
NT Minerals Mining Lease	No.2, Pioneer Mine	7541	NS1792	71	2.5	15	0-6, sand, gravel; 6-26, sandy clay; 26-31, clay, sandstone; 31-55, clay; 55-62, sandstone; 62-71, quartzite.	Aquifer in Kurinelli Sandstone?
	No.1	7542	NS1792	31	0.4	15	0-5, sand, gravel; 5-23, clay; 23-31, 'blue mineral rock'(quartzite)	
	No.4	7543	NS2188	24	0.8	12	0-6, sand, gravel; 6-24, hard quartzite	Kurinelli Sandstone?

* G. Log : Geologist's log; PJC = P. J. COOK, TQ = T. QUINLAN, AMW = A. M. WALLEY, DW = D. WOOLLEY
Cz = Cainozoic sediment; $\in$ = Cambrian rocks; $\in$mg = Gum Ridge Formation; Phs = Unimbra Sandstone; Phr = Epenarra Volcanics; G = granite
Note: Data derived from Smith, 1964a (Table 2) and water bore data held at Water Resources Division, Department of Mines and Energy, Alice Springs.

Appendix 4:

The following reports downloaded from the NT Government NRM website contains information on environmental aspects of the Exploration Licence site and surrounding region. This information was drawn on to identify environmental and other risks.

EL27821 Environs

Territory Natural Resource Management

Northern Territory Government

CHARLES DARWIN UNIVERSITY

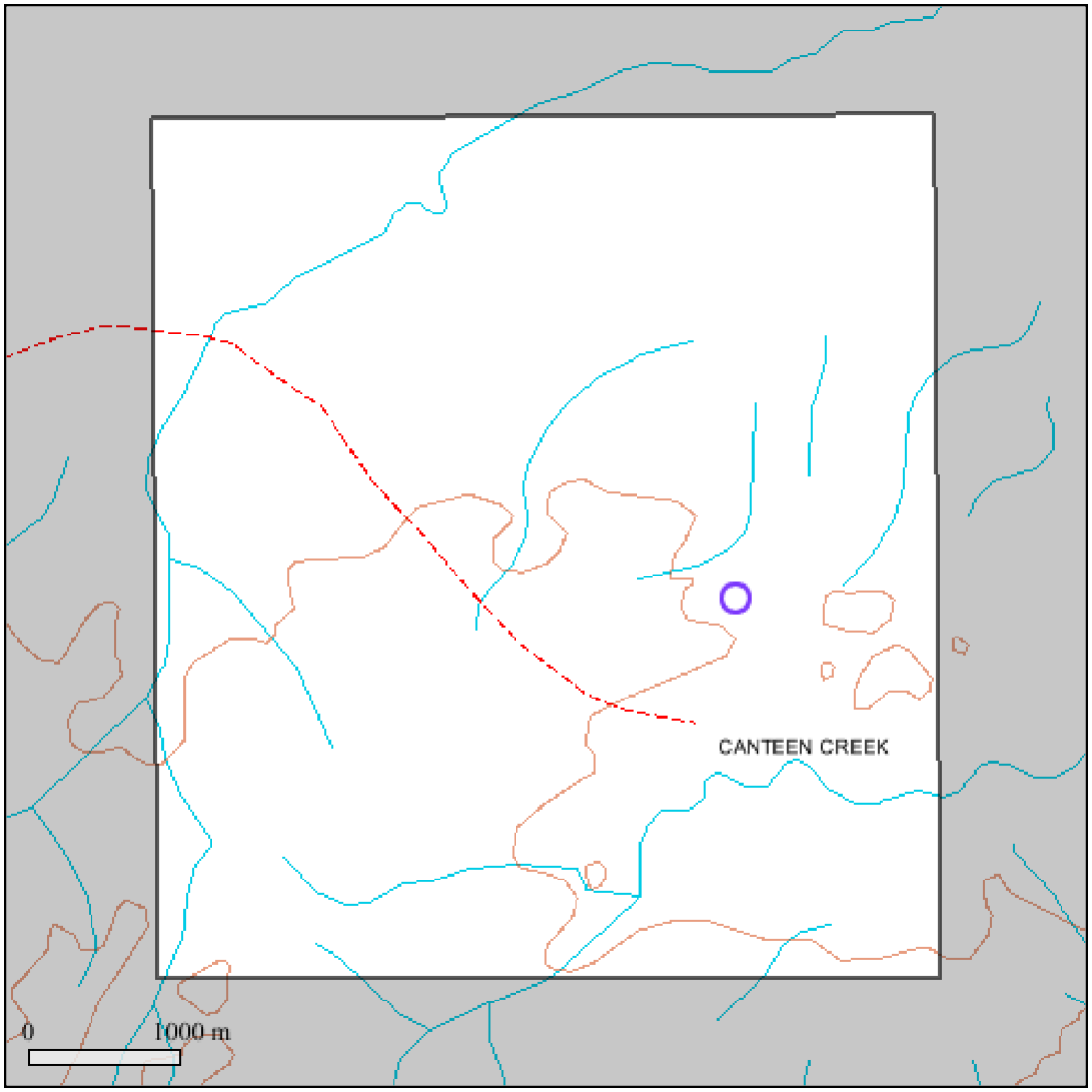
NT NRM Report

EL27821 Environs

EL27821 Environs encompasses an area of 26.49 sq km extending from 20 deg 36.0 min to 20 deg 39.0 min S and 135 deg 33.0 min to 135 deg 35.0 min E.

EL27821 Environs is located in the Davenport Murchison Ranges, bioregion(s)

Location of EL27821 Environs

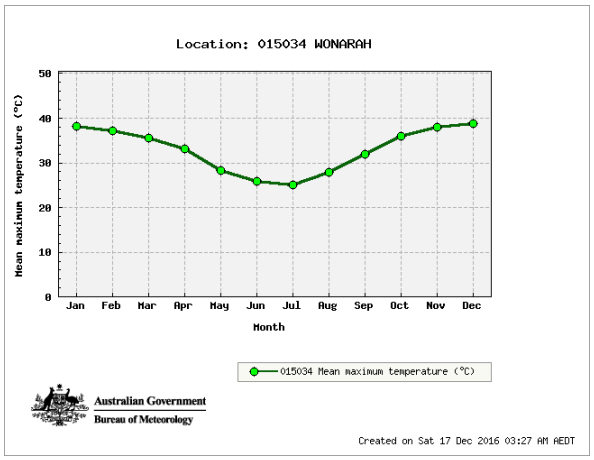


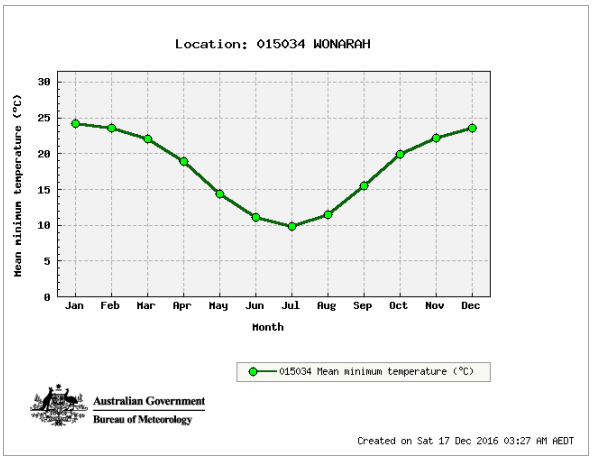
EL27821 Environs Climate

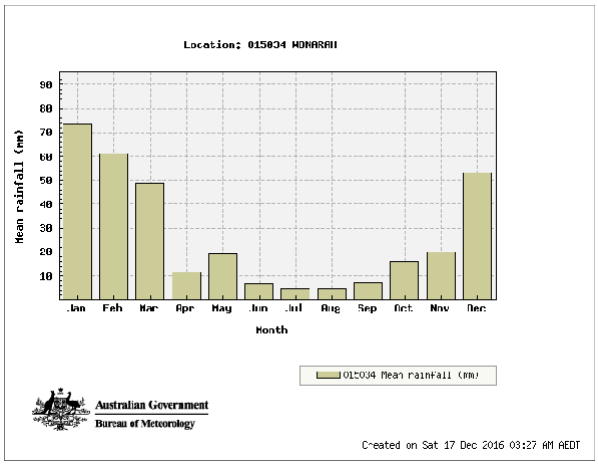
The closest long-term weather station is WONARAH (19 deg 53.0 min S, 136.3358E) 113 km NE of the center of selected area

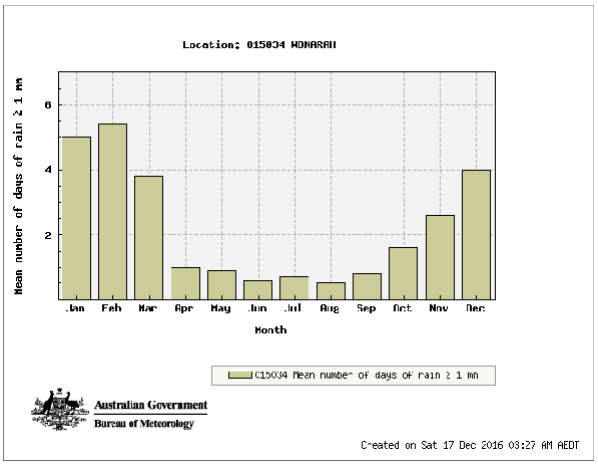
Statistics	Annual Values	Years of record
Mean max temp (deg C)	32.9	23
Mean min temp (deg C)	18.1	23
Average rainfall (mm)	316.2	27
Average days of rain	26.9	28

Climate summaries from Bureau of Meteorology (www.bom.gov.au)







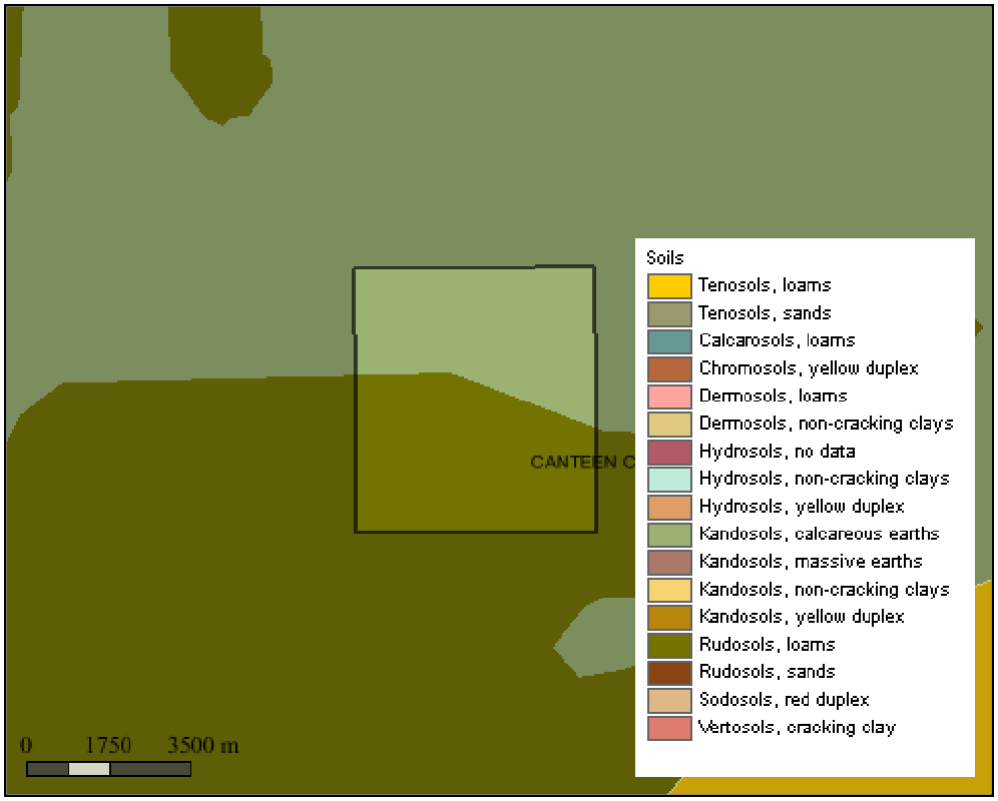


EL27821 Environs Soils

Soil Types	Area of soil types (Northcote Factual Key)

Selected area is too small to produce reliable statistics

Soil Types

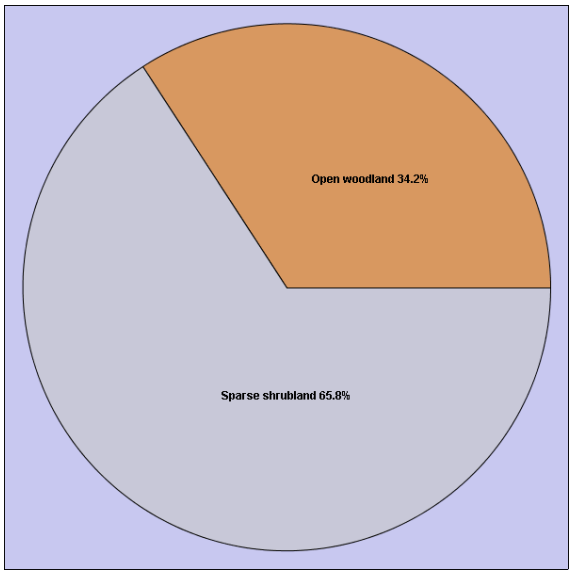


Soils 1:2M Layer is a copy of the NT portion (1:2,000,000 scale dataset) of the CSIRO Atlas of Australian Soils - K.H. Northcote et al. Data scale: 1:2,000,000 ANZLIC Identifier: 2DBCB771205D06B6E040CD9B0F274EFE

More details: Go to www.lrm.nt.gov.au/nrmapsnt/ and enter the ANZLIC identifier in the Spatial Data Search

EL27821 Environs Vegetation

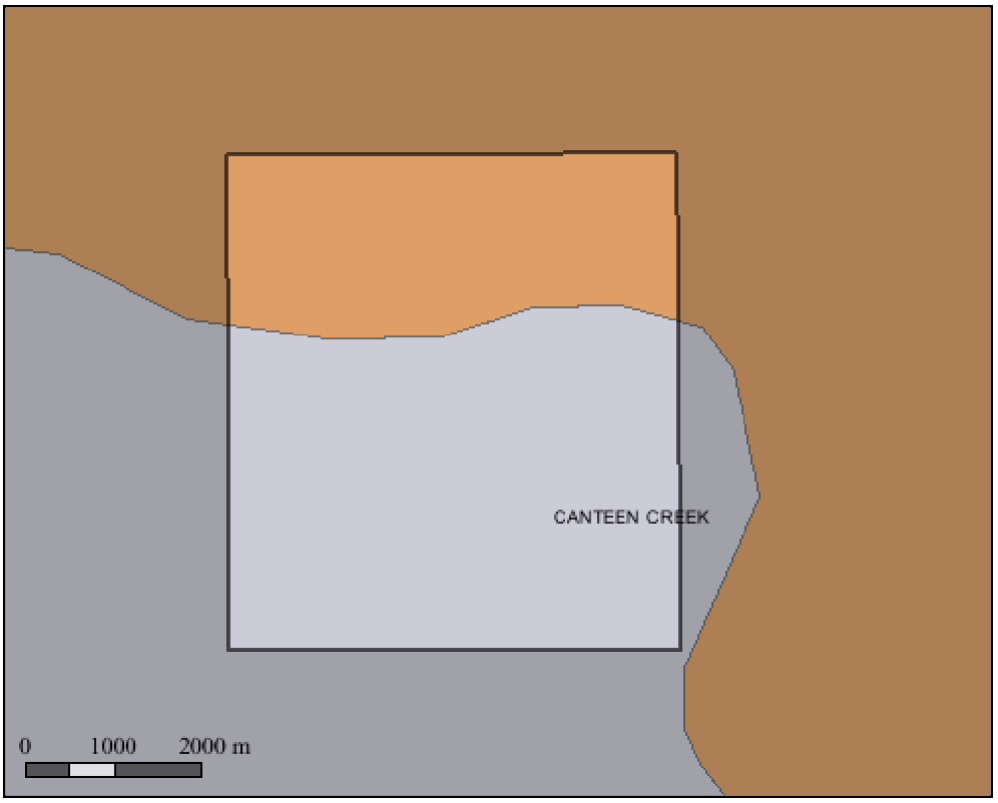
Vegetation Communities



Area of vegetation communities

Category	Area sq km	Area%
Sparse shrubland	17.44	65.85
Open woodland	9.05	34.15

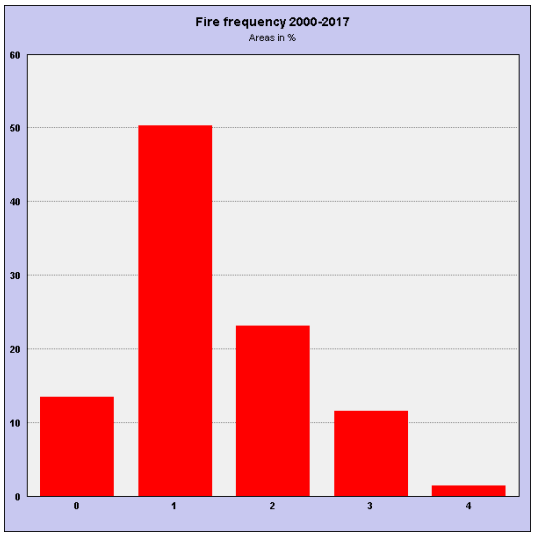
Vegetation Communities



The NVIS 2005 Layer is compiled from a number of vegetation and land unit survey maps that were recoded and re-attributed for the National Vegetation Information ***System (NVIS)***
Data scale variable depending on location. ANZLIC Identifier:2DBCB771207006B6E040CD9B0F274EFE More details:Go to www.lrm.nt.gov.au/nrmapsnt/ and enter the ANZLIC identifier in the Spatial Data Search

EL27821 Environs Fire History

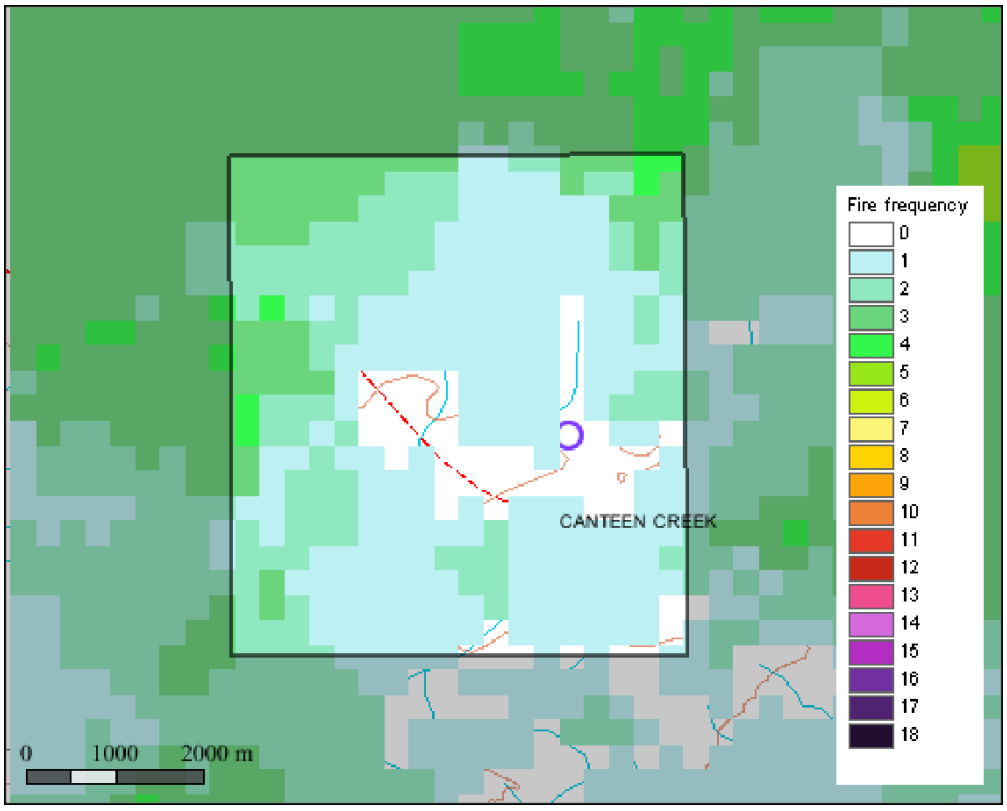
Fire frequency 2000-2017



area burnt for each fire frequency category 2000-2017

Category	Area sq km	Area%
0	3.57	13.49
1	13.33	50.31
2	6.13	23.15
3	3.07	11.60
4	.38	1.45

Fire frequency 2000-2017



The fire frequency(250m) Layer is derived from satellite imagery sourced from the Moderate Resolution Imaging Spectroradiometer (MODIS) on the NASA Terra satellite Spatial Resolution: 250m x 250m pixels (at Nadir).

EL27821 Environs Threatened Species

EX = Extinct

EW = Extinct in the Wild ER = Extinct in the NT EN = Endangered

EN/VU = One Endangered subspecies/One Vulnerable subspecies VU=Vulnerable

VU/- = One or more subspecies vulnerable EN/- = One or more subspecies endangered

Survey = this category refers to data collected using systematic survey methodology

Specimen = this category refers to museum or other records where a specimen has been collected and lodged

Observation = this category refers to all other incidental recordings where systematic methodology may not have been used consistently.

More species info: Go to www.landmanager.org.au/view/index.aspx?id=#### where #### is the ID number from the tables above for the species of interest.

EL27821 Environs Threatened Species Grid

Threatened species recorded in the grid cell(s) in which EL27821 Environs occurs (Records Updated: Sept 2013)

Group	Family Name	Scientific Name	Common Name	NT Status	National Status	#Observations	Latest Observation Date	#Specimens	Latest Specimen Date	#Surveys	Latest Survey Record
Mammals	Thylacomyidae	*Macrotis lagotis*	Greater Bilby	VU	VU	10	1980	2	1955	0	Unknown
Mammals	Phalangeridae	*Trichosurus vulpecula vulpecula*	Common Brushtail Possum (southern)	EN		5	1969	0	Unknown	0	Unknown
Mammals	Macropodidae	*Petrogale lateralis*	Black-footed Rock-wallaby		VU	4	Unknown	0	Unknown	0	Unknown

EX = Extinct

EW = Extinct in the Wild ER = Extinct in the NT EN = Endangered

EN/VU = One Endangered subspecies/One Vulnerable subspecies VU=Vulnerable

VU/- = One or more subspecies vulnerable EN/- = One or more subspecies endangered

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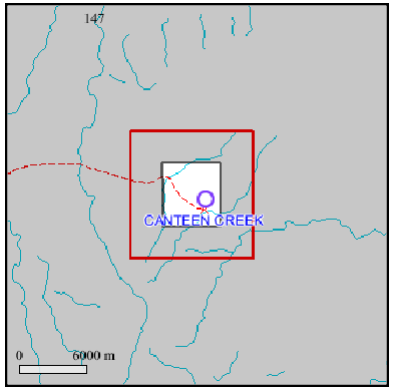
More species info: Go to www.landmanager.org.au/view/index.aspx?id=#### where #### is the ID number from the tables above for the species of interest.

Species listed in the table above were recorded from all the grid cells shown below (red/blue line) that overlap EL27821 Environs



EL27821 Environs Weeds and Potential Weeds

 Introduced plants recorded in the grid cell(s) in which EL27821 Environs occurs and that have been identified as problem weeds in one or more locations in northern Australia. Occurrence based on Northern Territory Government databases.

Family Name	Scientific Name	Common Name	NT Status	National Status	Other Status	#Surveys	Latest Record
Asteraceae	*Acanthospermum hispidum*	Starburr	*B C*			2	2001
Apocynaceae	*Calotropis procera*	Rubber Bush	*B C (S of 16 5 deg S)*		*WA1 WA2 G&M*	0	Unknown
Poaceae	*Cenchrus biflorus*	Gallon`s Curse			*NSW*	2	2001
Poaceae	*Cenchrus ciliaris*	Buffel Grass			*MP Gr G&M DEU*	0	Unknown
Poaceae	*Chloris virgata*	Feathertop Rhodes Grass			*DEU*	0	Unknown
Cucurbitaceae	*Citrullus lanatus*	Camel Melon			*G&M*	0	Unknown
Poaceae	*Echinochloa colona*	Awnless Barnyard Grass			*DEU*	4	2001
Amaranthaceae	*Gomphrena celosioides*	Gomphrena Weed			*DEU*	0	Unknown
Malvaceae	*Malvastrum americanum*	Spiked Malvastrum			*DEU*	2	2003
Fabaceae	*Parkinsonia aculeata*	Parkinsonia	*B C*	*WONS*	*MP K2 WA1 WA4 Q2 G&M CYP DEU NSW SA*	1	2001
Fabaceae	*Senna occidentalis*	Coffee Senna	*B C*		*G&M DEU*	1	2001
Fabaceae	*Stylosanthes humilis*	Townsville Lucerne			*DEU*	1	2003
Zygophyllaceae	*Tribulus terrestris*	Caltrop	*B C*		*CYP SA*	0	Unknown

Status Codes:

NATIONAL STATUS CODES

Alert, Alert List for Environmental Weeds (Please call Exotic Plant Pest Hotline 1800 084 881 if you think you have seen this weed) Sleeper, National Sleeper Weed

Target,Targeted for eradication. (www.landmanager.com.au/view/index.aspx?id=449837) WONS, Weeds of National Significance

NT STATUS CODES

A, NT Class A Weed (to be eradicated)

B, NT Class B Weed (growth & spread to be controlled)

C, NT Class C Weed (not to be introduced) (www.landmanager.com.au/view/index.aspx?id=449869)

OTHER STATUS CODES

C&E, Csurhes, S. & Edwards, R. (1998) Potential Environmental Weeds in Australia. Candidate Species for Preventative Control. Environment Australia, Canberra (www.landmanager.com.au/view/index.aspx?id=394504) CYP, Draft Cape York Peninsula Pest Management Plan 2006-2011 (www.landmanager.com.au/view/index.aspx?id=371200)

DEU, Plants listed as environmental weeds by the Desert Uplands Strategic Land Resource Assessment (www.landmanager.com.au/view/index.aspx?id=332123)

G&M, Grice AC, Martin TG. 2005. The Management of Weeds and Their Impact on Biodiversity in the Rangelands. Cooperative Research Centre (CRC) for Australian Weed Management and CSIRO Sustainable Ecosystems. Commonwealth Australia

(www.landmanager.com.au/view/ index.aspx?id=163572)

Gr, Groves et al. 2003. Weed categories for natural and agricultural ecosystem management. Bureau of Rural Sciences (www.landmanager.com.au/view/index.aspx?id=388018)

K0, High Priority Weeds not yet established in the Katherine region

K1, High Priority Weeds posing environmental threats in the Katherine region

K2, High Priority Weeds posing existing threats in the Katherine region, as described in the Katherine Regional Weed Management Strategy 2005-2010 (www.landmanager.com.au/view/index.aspx?id=130286) MP, Northern Territory Parks & Conservation Masterplan (www.landmanager.com.au/view/index.aspx?id=144141)

NAQS, North Australian Quarantine Strategy Target List (www.landmanager.com.au/view/index.aspx?id=449416) NSW, Declared Noxious Weed in NSW (www.landmanager.com.au/view/index.aspx?id=449983)

Q1, QLD Class 1 Weed (not to be introduced, kept or supplied-

Q2, Class 2 Weed (eradicate where possible, not to be introduced, kept or supplied)

Q3, Qld Class 3 Weed (to be controlled near environmentally sensitive areas- not to be supplied/sold without a permit) (www.landmanager.com.au/view/index.aspx?id=190714) SA, Declared Plant in South Australia (www.landmanager.com.au/view/index.aspx?id=449996)

WeedsAus, Listed as a significant weed by Weeds Australia (www.landmanager.com.au/view/index.aspx?id=14576) WA1, WA Weed Class P1 (movement prohibited)

Survey = this category refers to data collected using systematic survey methodology

Specimen = this category refers to museum or other records where a specimen has been collected and lodged

Observation = this category refers to all other incidental recordings where systematic methodology may not have been used consistently.

Plants listed in the table above were recorded from all the grid cells shown below (red/blue line) that overlap EL27821 Environs

EL27821 Environs Pest and Potential Pest Animals

Animals with pest potential recorded in the grid cell(s) in which EL27821 Environs occurs. Occurrence based on Northern Territory Government databases.

Common Name	Scientific Name	NT Status	National Status	ID	#Observations (Latest)	#Specimens (Latest)	#Surveys (Latest)
House Mouse	*Mus musculus*	P	.	187720	6 (1992)	9 (1992)	0 (Unknown)
Dingo / Wild dog	*Canis lupus*	N	.	183280	1 (1988)	12 (1970)	6 (2004)
Fox	*Vulpes vulpes*	P	.	183294	0 (Unknown)	0 (Unknown)	1 (2011)
Cat	*Felis catus*	P	.	183259	1 (1988)	0 (Unknown)	0 (Unknown)
Donkey	*Equus asinus*	P	.	183287	8 (1992)	0 (Unknown)	2 (2004)
Cattle	*Bos taurus*	P	.	183266	0 (Unknown)	0 (Unknown)	3 (2011)

NT STATUS CODES:

Int, Introduced species (all non-prohibited vertebrates, and all other exotic species (www.landmanager.com.au/view/index.aspx?id=280771) N, Native species with pest potential.

P, Prohibited species (all exotic vertebrates except those listed as non-prohibited (www.landmanager.com.au/view/index.aspx?id=450509)

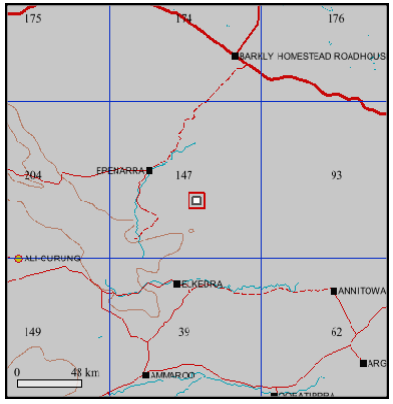
Survey = this category refers to data collected using systematic survey methodology

Specimen = this category refers to museum or other records where a specimen has been collected and lodged

Observation = this category refers to all other incidental recordings where systematic methodology may not have been used consistently.

More species info: Go to www.landmanager.org.au/view/index.aspx?id=#### where #### is the ID number from the tables above for the species of interest.

Potential pest animals listed in the table above were recorded from all the grid cells shown below (red/blue line) that overlap EL27821 Environs



Commercial in confidence

Canteen Creek Project EL27821 – Exploration Operations Mining Management Plan

Generated from NT Infonet (http://www.infonet.org.au) Tue May 29 12:02:10 CST 2018

Soils and vegetation graphs and tables refer to area of soils and vegetation only. Fire graphs and tables refer to entire selected area including sea if present. Calculations are derived from map images or vector data, and should be taken as a guide only. Accuracy cannot be guaranteed. For small areas, figures should be rounded to the nearest whole number.

Fire map layers used in these reports have been updated in 2018 so their pixels are aligned to the same grid.

App4.2 Barkly Region Weed Management Plan

Northern Territory Government

DEPARTMENT OF LAND RESOURCE MANAGEMENT

Barkly Regional Weed Management Plan

2015-2020

Image 1: Prickly acacia (*Acacia nilotica*)

For further information about this Plan contact the Department of Land Resource Management, Weed Management Branch, Tennant Creek District Weeds Officer on 08 89624314

Weed Management Branch

Department of Land Resource Management

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Palmerston

Northern Territory 0831

The Plan was compiled by Dan Steel, Meg Humphrys and Kirby Doak.

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Location

The Barkly Region encompasses the Mitchell Grass Downs and Davenport Murchison Ranges bioregions, the Northern Territory section of the Mount Isa Inlier and parts of the Tanami, Gulf Fall and Uplands and Sturt Plateau. Its largest towns are Tennant Creek and Elliott. The Barkly region covers an area of 283,648 km^2.

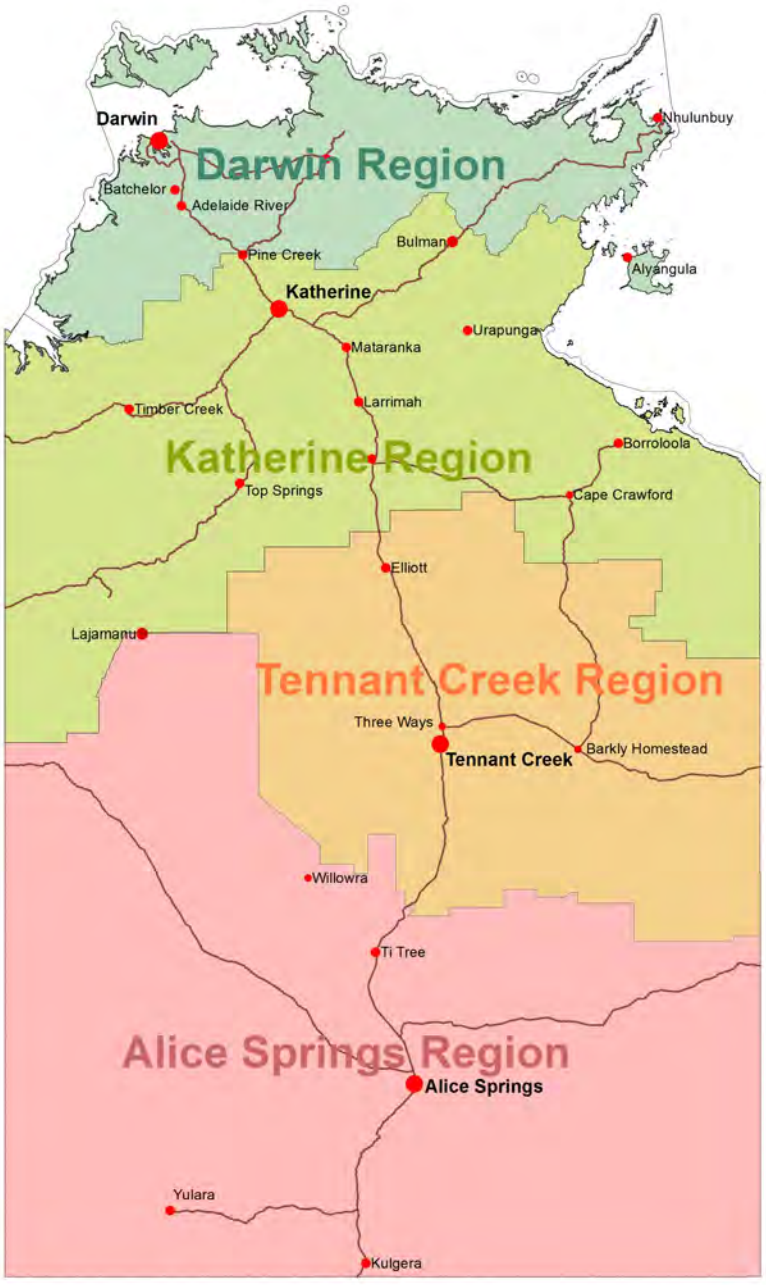


Figure 1: Northern Territory weed management regions

Purpose and Development of the Plan

Weeds remain an increasing threat to the Barkly region's natural assets. This threat is not new and considerable time and effort has already been invested in weed management across the region.

The Barkly Regional Weed Management Plan (the Plan) represents the Northern Territory Government's Weed Management Branch and key stakeholders' ongoing effort to reduce the impact of the regions priority weeds[1].

The Plan has been developed in line with the Department of Land Resource Management, Strategic Plan 2013 – 2018. It is intended to support local weed management priorities. Subsequently, direct consultation with key stakeholders has occurred throughout the development of the Plan.

The Plan also supports the implementation of individual statutory Weed Management Plans and provides a direction for managing weed threats through:

- Identifying priority weeds, landscape areas and pathways of weed spread;
- Providing a platform for the regional weed working group to operate;
- Guiding funding and resource investment; and
- Ensuring the Department of Land Resource Management, Weed Management Branch is transparent in its business planning.

The scale and range of weed management issues which already exist across the region highlight the importance of a coordinated and collaborative approach to the reduction of weed impacts. Therefore, the Plan encourages a 'working together' approach.

[1] The Northern Territory (NT) Government uses the NT Weed Risk Management System to identify and assess the weed risk of plants to the N.T.

Image 2: Rubber Bush (***Calotropis procera***) can invade pastoral country if not managed.

The core set of questions used to develop the Plan included:

1. What are our priority weeds? Where did the weeds come from? Where can they end up?
2. What are our objectives for regional weed management and do we have the time and money to succeed?
3. What actions are most appropriate to achieve our objectives?

Key Stakeholders

The following key stakeholders were consulted during the development of the plan and will support implementation of actions identified in the objectives of the plan.

Table 1: Key stakeholders

Weed Management Branch (WMB)
Barkly Regional Weed Working Group (BRWWG)
Central Land Council (CLC)
Northern Land Council (NLC)
NT Cattlemen's Association – Barkly Branch
Bushfires NT
Barkly Shire Council
Department of Primary Industry and Fisheries (DPIF)
Territory Natural Resource Management (TNRM)
Department of Infrastructure (DoI)
Department of Mines and Energy (DME)
Parks and Wildlife Commission of the Northern Territory (PWCNT)
Barkly Landcare and Conservation Association (BLCA)
Julalikari Council Aboriginal Corporation

Aim

To protect the Barkly region's economy, community and environment from the adverse impacts of weeds by:

- providing clear regional priorities; and
- providing clear, achievable and measurable regional management actions.

Legal Requirements of Landholders

All landholders must take all reasonable measures to prevent their land being infested with a declared weed and prevent a declared weed on their land spreading to other land.

All landholders must meet the management requirements outlined in statutory Weed Management Plans in order to secure compliance with the ***Weeds Management Act*** (the Act). The purpose of the Act, as defined in section 3, is:

1. To prevent the spread of weeds in, into and out of the Territory and to ensure that the management of weeds is an integral component of land management in accordance with the Northern Territory Weeds Management Strategy 1996 – 2005 or any other strategy adopted to control weeds in the Territory;
2. To ensure there is community consultation in the creation of weed management plans; and
3. To ensure that there is community responsibility in implementing weed management plans.

The Barkly Regional Weed Management Plan supports landholders in their obligations to manage weeds on their land.

Principles of Weed Management

The Plan incorporates the Northern Territory Weeds Management Strategy principles. These include:

1. Landholders and land users are responsible for weed management.
2. Weed management is an integral part of all land management.
3. Preventing initial introduction and spread is the most effective form of weed management.
4. When introduction does occur, early detection followed by swift action is the essence of successful weed management.
5. Weed management requires a continuous, long term commitment.
6. The integration of control methods including physical, chemical, ecological and biological can achieve the best weed management outcomes.
7. Cooperative weed management amongst landholders and land users on a catchment basis is recommended and supported.
8. Coordination between government agencies and landholders is necessary to establish the research, educational and legislative framework required for successful weed management.

Essential Supportive Documents

This Plan must be viewed in association with the following documents. Additional information resources are listed in Appendix 1.

NT Statutory Weed Management Plans

A Weed Risk Assessment informs the Minister for Land Resource Management of the risk of a weed and where potential exists for successful management. On the basis of this assessment and in consultation with the minister responsible for the administration of the ***Territory Parks and Wildlife Conservation Act*** he can declare a weed species under the ***Weeds Management Act*** (the Act) as:

Class A: To be eradicated,

Class B: Growth and spread to be controlled; and

Class C: Not to be introduced into the NT (all Class A and B weeds are also Class C).

Once a plant species is declared, the Minister can develop a statutory weed management plan, which identifies a strategic approach to managing the weed species in the NT.

A statutory weed management plan establishes the objectives, management requirements and management actions to be achieved by land managers. The following plans apply to the Barkly region.

Weed Management Plan for Mesquite (***Prosopis*** spp.)

Weed Management Plan for Prickly Acacia (***Acacia nilotica***)

Weed Management Plan for Bellyache Bush (***Jatropha gossypiifolia)***

Weed Management Plan for Neem (***Azadirachta indica)***

The weed management plans detail the legislated obligations of all land owners, land managers and land users in the NT to eradicate or manage and avoid further spread of the weed species. Conducting land management practices in accordance with the weed management plans will secure compliance with the requirements of the Act.

NT Weed Management Handbook

The Northern Territory Weed Management Handbook provides detailed information about weed control in the Northern Territory. Weed control option tables are available for most of the priority weeds in the region which detail herbicide recommendations and optimum treatment times. Other control methods have also been described.

Regional Priorities

In order to effectively utilise the limited resources available to the region to manage weeds, the Plan has been guided by three regional priorities: These are:

1. Priority weeds;
2. Priority landscape areas; and
3. Priority pathways of spread.

The Barkly Regional Weed Working Group, as an expert knowledge base, agreed on the final priority lists of weed species, landscape areas and pathways of weed spread. However, it is acknowledged by this group that other stakeholders may have different priorities at an individual catchment or property scale. ***Figure 2*** gives an indication of the distribution of Priority weeds in the region.

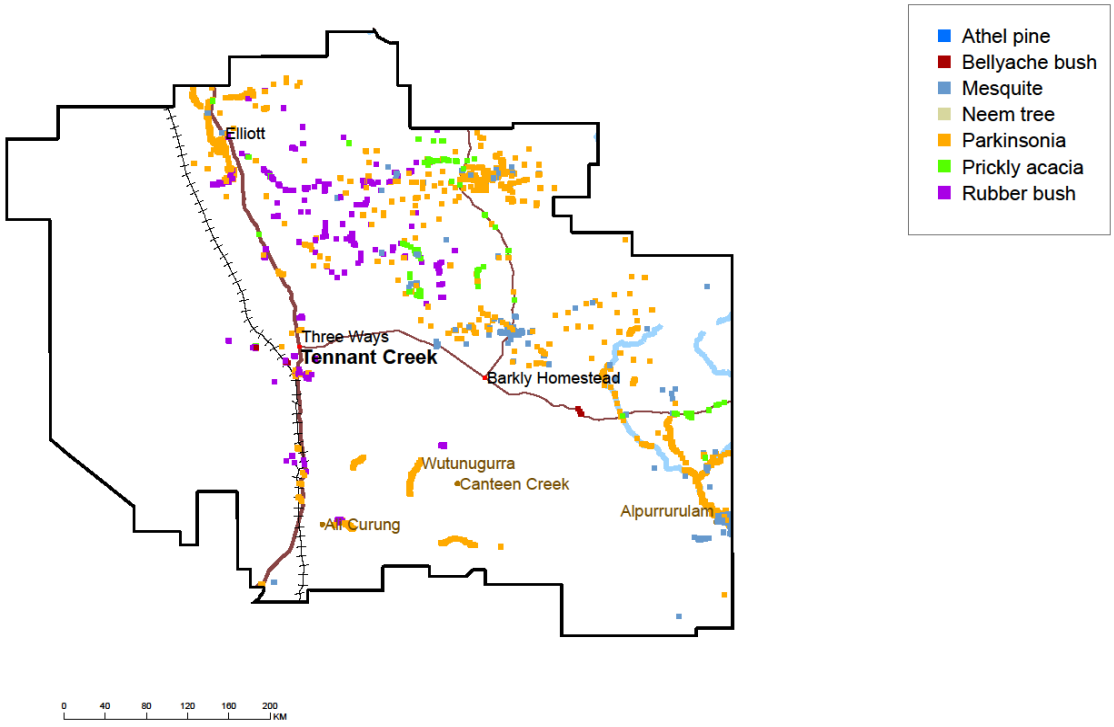


Figure 2: Indicative distribution of priority weed species and neem in the Barkly Region

Priority Weeds

Weed species that attracted priority management attention within the region were determined using one or more of the following criteria: (refer Table 2)

a. rigorous weed risk assessment identified the species to be a very high risk to the Northern Territory and there is potential for successful management***;***

b. identified as a Weed of National Significance (WoNS);

c. local knowledge confirmed control attention within the region was a priority to ensure isolated or core infestations are eradicated or managed; and

d. an Alert weed that may be present in the region.

Table 2: Priority weed species

Common name	Botanical name	NT Class	Weed of National Significance
Bellyache bush*	***Jatropha gossypiifolia***	A	WoNS
Mesquite*	***Prosopis*** spp***.***	A	WoNS
Prickly acacia*	***Acacia nilotica***	A	WoNS
Parkinsonia	***Parkinsonia aculeata***	B	WoNS
Rubber bush	***Calotropis procera***	B	
Athel pine	***Tamarix aphylla***	A	WoNS

* Species must be eradicated as directed by statutory Weed Management Plans.

This priority list does not replace an individual landholder's own priority species for control, but the above mentioned should be incorporated into their management plan. This priority list does not relinquish a landholder of their legislative responsibilities for other declared weeds not listed above.

Opportunistic Weeds

Landholders should also prioritise management of opportunistic weeds such as those listed below, that commonly appear after control of priority species (refer Table 3).

Table 3: Opportunistic weed species

Common name	Botanical name	NT Class	Weed of National Significance
Cacti	***Opuntia*** and ***Cylindropuntia***	B/not declared	WoNS
Neem*	***Azadirachta indica***	B	
Noogoora burr	***Xanthium strumarium***	B	
Mossman River grass	***Cenchrus echinatus***	B	
Grader grass	***Themeda quadrivalvis***	B	

* Species must be eradicated as directed by statutory Weed Management Plans.

Alert Weeds

An alert weed is a species not yet naturalised in the region, that has the potential to have a high level of impact to the region should it become established, and the likelihood of the species naturalising and spreading in the region is perceived to be high. The species identified for the Barkly region are in Table 4.

Table 4: Alert weed species

Common name	Botanical name	NT Class	Weed of National Significance
Fountain grass	***Cenchrus setaceum***	B	
Parthenium[2]	***Parthenium hysterophorus***	A	WoNS
Rubber vine[2]	***Cryptostegia grandiflora***	A	WoNS

[2] Landholders are urged not to attempt to control or dispose of parthenium or rubber vine. If found, please immediately contact the Weed Management Branch in Tennant Creek or Alice Springs for identification and disposal

Image 3: Bellyache bush is only found in closely monitored, isolated infestations in the Barkly region. It poses a considerable threat to the region.

Significant threat

Buffel grass (***Cenchrus ciliaris***) is not a declared weed in the Northern Territory. Buffel grass is the common name for a complex group of cultivars that were introduced successfully to central Australia for improved pasture production, soil stabilisation and dust suppression. These cultivars of varied palatability and suitability to the country appear to have hybridised and spread well beyond areas where they were planted and into places once thought unsuited to their survival. Buffel grass is contentious because it is prized by many pastoralists but is also highly invasive in central Australia. It can impact directly on biodiversity values, for example through competition, and indirectly through increasing the frequency and intensity of fires. These hotter fires can also increase the risk of damage to infrastructure and cultural sites.

Due to its extensive distribution in central Australia, value to pastoralists and the fact it is not a declared weed, buffel grass cannot readily be managed in the same way as the introduced plants in Table 2.

Resources need to be targeted to areas of greatest need and/or where potential for successful management is highest. Where containment is not feasible, resources may need to be focused on asset protection.

Priority Landscape Areas

Landscape areas that attracted priority management attention within the region were determined using one or more of the following criteria (refer Table 5):

a. very high visitation areas;

b. low incursions of weeds;

c. site of significance for biodiversity conservation in the NT[3];

d. significant commercial values;

e. significant cultural and heritage values;

f. susceptibility to invasion; and

g. weed source areas including top of streams and up-wind areas.

Table 5: Priority landscapes areas

Landscape area	Examples
Sites of high community value	Karlu Karlu (The Devils Marbles), Mary Ann Dam, Longreach Water Hole, Tennant Creek Telegraph Station
Sites of significance for biodiversity conservation in the NT	Lake Woods, Lake Sylvester, Lake Tarrabool, Eva Downs Swamp, Connells Lagoon, the Davenport and Murchison Ranges, Elkedra River floodout swamps, Frew River floodout swamps.
Pastoral Properties / Barkly Rangelands	Alexandria Station, Brunette Downs Station

Many of the priority landscape areas in the Barkly are associated with waterways such as rivers and lakes, due to the biodiversity these areas attract as well as the recreational and aesthetic values (refer Figure 3).

[3] Sites considered of high conservation significance because they support important wetland values, large aggregations of wildlife, concentrations of threatened species or endemic species, or are considered botanical hot-spots.

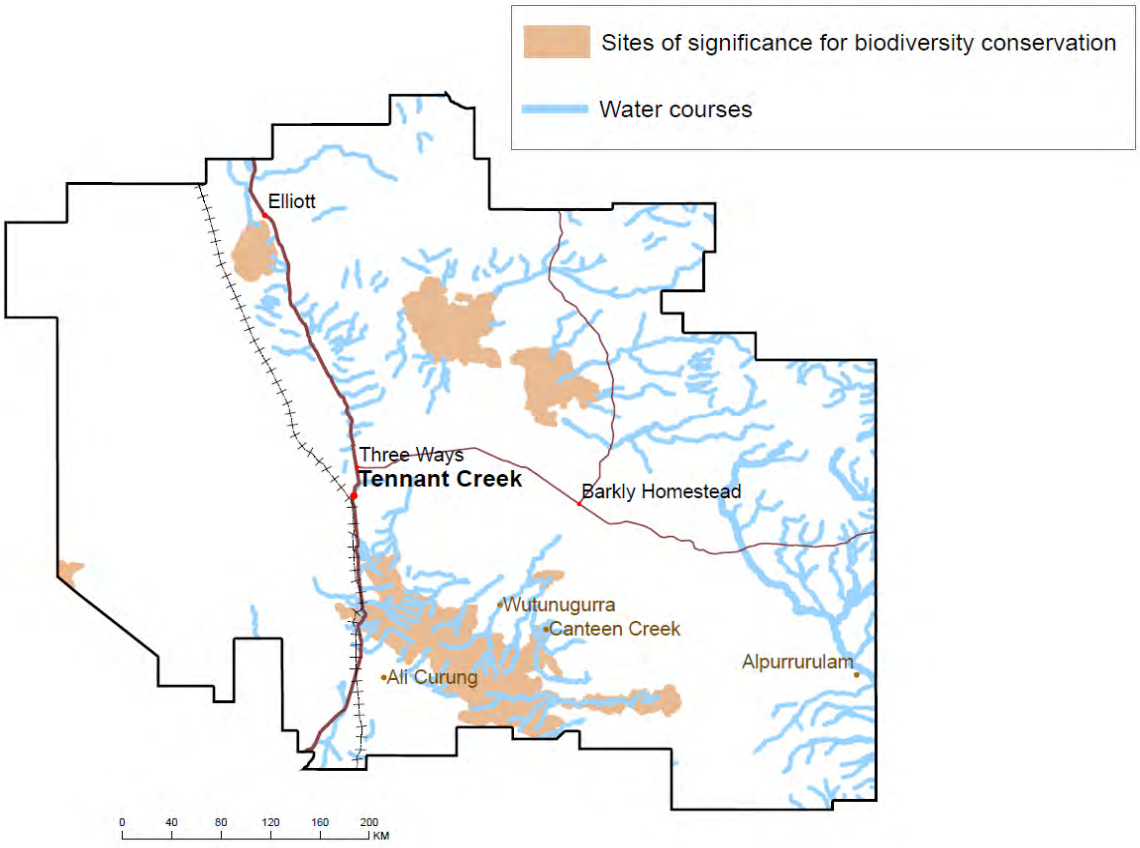


Figure 3: Priority landscape areas in the Barkly region

Image 4: Lake Woods is significant to the Barkly region for its productive pastures, biodiversity and recreation opportunities

Image 5: The highly productive Barkly Tablelands provide an abundance of valuable fodder in the perennial Mitchell grasses.

Priority Pathways of Spread

Pathways of spread (refer Table 6) that attracted priority management attention in the Barkly Region were determined using one or more of the following criteria:

a. the physical characteristics of weeds to be transported;

b. human activities most likely to spread weeds; and

c. likely physical corridor for weed spread.

Table 6: Priority pathways of spread

Pathway of Spread	Examples
River corridors	Livestock, feral and native animal movements, wind, water, and recreation activities.
Mining & Gas exploration	Exploration, construction and maintenance activities.
Rail corridors	Construction and maintenance activities.
Pastoral properties	Roads, tracks, bores, cattle and hay movement of vehicles and equipment.
Roads and Stock routes	Construction and maintenance, such as slashing and grading, 4WD tourism, wind, livestock, feral and native animal movements.

Image 6: The ‘Darwin-Red’ variety of bellyache bush growing in a creek flood out area in the Barkly region.

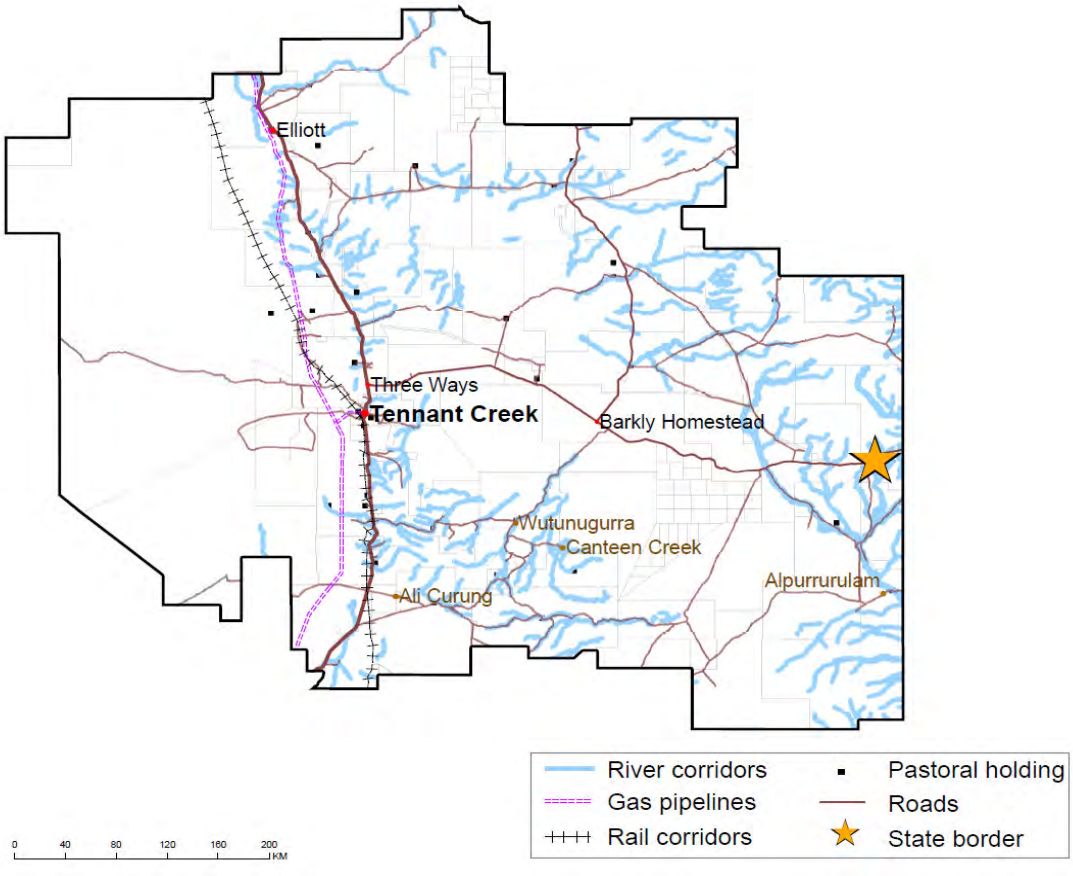


Figure 4: Priority pathways of spread

Objectives and Actions

The following four objectives of the Plan represent a realistic result of what the Plan can achieve in its five year timeframe. However, to achieve the objectives, the management requirements that support the objectives will require significant investment in time and resources over the five year timeframe.

Objective 1: To prevent the introduction and spread of the region's priority weeds

Objective 2: To improve adaptive weed management

Objective 3: To ensure landholders act responsibly and support a 'working together' approach to weed management

Objective 4: To increase the region's awareness of its priorities and capacity to manage weed impacts.

Objective 1: To prevent the introduction and spread of the region's priority weeds

Action		Primary Responsibility	Indicator and Timeframe
1.1.	Prioritise rapid response operations to detected outbreaks of 'Alert' Weeds	WMB	ongoing
1.2.	Support the implementation of the NT Weed Spread Prevention Strategy	WMB	ongoing
1.3.	Implement regional activities to increase awareness and adoption of weed spread prevention procedures such as quarantining livestock and cleaning machinery	WMB & TNRM	2 rural shows annually
1.4.	Develop and/or adopt a code of practice for Weed Spread Prevention	All	All completed 2016
1.5.	Conduct up-skilling of ground level working groups to identify and report priority weeds	WMB & All	1 regional workshop annually
1.6.	Monitor priority pathways for new and spreading weeds	WMB & All	annually
1.7.	Inform landholders of their responsibility as directed by the statutory species Weed Management Plans and the ***Weed Management Act***	WMB and TNRM	presentation annually
1.8.	Identify and implement activities that increase awareness of weed spread prevention to encourage adoption of best practice management	All and WMB	new initiative annually

Management Requirement: Eradicate where possible, implement early detection, and implement weed spread prevention programs.

Objective 2: To improve adaptive weed management

Action	Primary Responsibility	Indicator and Timeframe
2.1. Share the results of weed control success and failings with the BRWWG	All	topical presentations at BRWWG meetings
2.2. Share landscape rehabilitation learnings	All	presentations at BRWWG meeting annually
2.3. Provide weed datasets to the Regional Weed Officer	All & WMB	No. of partners providing datasets
2.4. Continue to regulate and support property holders with a permit to use a declared weed	WMB	Inspect permit holders annually
2.5. Identify and support the trial of new weed management equipment	All	1 new tool tested regionally, annually
2.6. Maintain links with relevant research institutes and continue to support a partnership approach to regional priority weed research	BRWWG	research institutes represented on BRWWG
2.7. Identify and record where there are gaps in knowledge for future investigations	BRWWG & TNRM	Recorded in minutes of BRWWG annually
2.8. Map distribution of priority weeds	WMB & all	WMB present 2 species maps annually

Management Requirement: Monitor progress, utilise appropriate weed management methods and understand what makes resilient landscapes.

Objective 3: To ensure landholders act responsibly and support a 'working together' approach to weed management

Action	Primary Responsibility	Indicator and Timeframe
3.1. Develop and maintain regional partnership programs with industry	WMB	2 programs conducted annually
3.2. Identify priority programs for funding prior to funding announcements	BRWWG & All	2 priority programs identified annually
3.3. Create awareness of landholders' legal responsibility	WMB	Present to landholder group annually
3.4. Participate in Regional Weed Working Group meetings and regional weed forum	All	2 RWWG meetings & 1 forum annually
3.5. Barkly Region Weeds Working Group to have representation on the NT Weed Advisory Committee	BRWWG through Anthony Cox the NTCA representative.	Attend 2 meetings annually
3.6. Coordinate planning activities on a catchment scale	TNRM & WMB	1 plan annually
3.7. Maintain cross border partnerships in support of national programs	WMB & TRNM	Participation in programs annually
3.8. Develop priority species management plans (an example of a management plan for bellyache bush is located as Appendix 2)	WMB	2 plans drafted annually

Management Requirement: Maintain coordination and sharing of resources.

Objective 4: To increase the region's awareness of its priorities and capacity to manage weed impacts

Action		Primary Responsibility	Indicator and Timeframe
4.1.	Promote regional priorities to land managers through key partners	BRWWG & All	All land holders can identify priority weeds by 2016
4.2.	Provide inductions and regular training to identify priority and alert weeds to volunteers and staff	WMB & All	1 official training session annually
4.3.	Support land managers to develop and improve weed management capacity through on ground demonstrations & incentive programs	WMB & All	2 on ground demonstrations annually
4.4.	Continue to develop regional and targeted communication materials	WMB, TNRM, NTCA & CLC	2 new products annually
4.5.	Expose community members to the impact of alert weeds in neighboring states	WMB & TRNM & BRWWG	1 person travelling interstate to see impacts
4.6.	Promote a 'working together' role in detection, management and prevention of spread of weeds	WMB	Develop a 'working together' brand for weed spread prevention by 2016

Management Requirement: Implement targeted communications and motivate landholder actions.

Monitoring and Evaluation of the Regional Plan

Objective	Performance indicator	Monitoring activity
1	Is there better management in eradication of weeds and weed spread prevention?	• number of days spent on species eradication • number of new outbreaks recorded
2	Is there an increase in information distribution and adaptive management?	• number of stakeholders providing weed location data • number of monitoring programs developed and implemented
3	Is there improved partnered investment in the region?	• number of partner investment programs • number of regional meetings and number of people to attend regional forum
4	Is there an increased awareness of regional issues, management priorities and responsibilities?	• number of major awareness raising events held and number of attendees • survey key land managers about their knowledge of regional priorities

Data collection

Datasets that assist with ongoing decision making and ensure accountability are essential. The Regional Weed Working Group, as a part of its core business annually, should consider the available data, presented by the Regional Weeds Officer and discuss progress towards the Plan objectives.

Evaluation

A review of the plan objectives, priorities and actions will be conducted every five years. The review should be undertaken by the Regional Weeds Officer in consultation with key stakeholders, and amendments made to the Plan, if required.

Acknowledgements

The Barkly Regional Weed Working Group and Weed Management Branch would like to acknowledge the contributions made by the BRWWG members, industry groups, community groups and land managers in the development of the Plan.

Appendix 1: Additional information resources

All resources identified below are able to download from www.lrm.nt.gov.au/weeds or you can contact the Weed Management Branch on 8999 4567 to obtain free copies.

Weed Management Handbook

This resource provides information on integrated weed control methods. Specific information is provided on herbicides registered for use in the NT. The handbook also indicates optimum treatment times for specific weeds.

Northern Territory Weed Data Collection Manual

This resource provides information on what and how to collect weed data, how to use it or how to submit this information to the Weed Management Branch.

Management Guides

The Management Guide for Bellyache bush provides information on best practice management of this species.

Weed ID Sheets

This resource provides information on how to identify weed species via use of photos and descriptions of various parts of the plant.

Weed Notes

This resource provides substantially more information on a weed species than the Weed ID Sheets and includes information on control methods for that species

Preventing Weed Spread is Everybody's Business

This industry-focused document highlights the roles and responsibilities of the Department and land managers, in context to weed risk, sustainable economic development and legislated requirements.

Appendix 2: Example of a weed management plan for bellyache bush

Katherine Region - BELLYACHE BUSH									
Goals	**Objectives**	**Actions**	**Milestones**	**Yr1**	**Yr2**	**Yr3**	**Yr4**	**Yr5**
To facilitate strategic management	Prevent spread	Develop cross tenure, co-ordinated management programs	All land managers understand their legal obligations to manage bellyache bush in accordance with the ***Weeds Management Act 2001 (the Act)*** , by complying with the Weed Management Plan for Bellyache Bush (***Jatropha gossypiifolia***).	✓	✓	✓	✓	✓
			Property Management Plans which are consistent with the requirements of the Weed Management Plan for Bellyache Bush (***Jatropha gossypiifolia***) (PMPs) are developed for affected B/C zoned properties and lands	✓				
			PMPs implemented on affected B/C zoned properties and lands	✓	✓	✓	✓	✓
			PMPs developed for affected A/C zoned properties and lands	✓	✓			
			PMPs implemented on affected A/C zoned properties and lands		✓	✓	✓	✓
	Prevent new incursions	Information relating to bellyache bush identification, control, data collection and legislative requirements is promoted and made available to all land holders	All land managers are able to identify bellyache bush and survey their land at intervals commensurate with risk of infestation	✓	✓	✓	✓	✓
			When bellyache bush is identified in areas it has not been found previously, land managers/user have accurately recorded the infestation, reported it to the Weeds Management Branch and are aware of their obligation to manage it in accordance with the Act by developing and implementing an adequate property management plan.	✓	✓	✓	✓	✓
	Reduce impact of established infestations	Contain existing infestations in the B/C Zone using appropriate control methods, including biological control.	PMPs developed and implemented on affected B/C zoned properties and lands	✓	✓	✓	✓	✓
To build capacity	Increase awareness education and skills	Awareness relating to identification and potential impacts of bellyache bush increased in all catchments and in urban settings	Community recognises and accesses services and products provided by the Weed Management Branch. As bellyache bush has been traded as an ornamental, emphasis should be placed on growers and the nursery industry	✓	✓	✓	✓	✓
		All landholders to be provided with levels of support necessary to develop and implement PMPs consistent with the requirements of Weed Management Plan for Bellyache Bush (***Jatropha gossypiifolia***)	PMPs developed and implemented on affected properties and lands	✓	✓	✓	✓	✓
		Continue to work with indigenous ranger groups to increase capacity	Plans developed for affected lands	✓	✓			
			Plans implemented for affected lands		✓	✓	✓	✓
			Capacity to undertake contract work on other areas increased		✓	✓	✓	✓
		Motivate land managers to manage weeds strategically and consistently	Land managers undertaking weed management which is consistent with Weed Management Plan for Bellyache Bush		✓	✓	✓	✓
					✓	✓	✓	✓
	Increase coordination across land uses/tenures	Promote regional/catchment approaches to weed management which are consistent with the Weed Management Plan for Bellyache Bush (*Jatropha* ***gossypiifolia***)	Control activities are occurring as indicated in the Weed Management Plan for Bellyache Bush.	✓	✓	✓	✓	✓
	Increase information available for decision making	To support research efforts regarding control techniques	Establish optimal aerial application techniques		✓			
			Work with APVMA to utilise successful trial outcomes			✓		
		To support research efforts regarding biological control	Support Queensland research efforts	✓	✓			
		To facilitate the collection of appropriate and consistent data	Land managers are supplying data as per the draft Weed Data Collection Guidelines NT	✓	✓	✓	✓	✓
		To collate all data received and make it publicly available in an appropriate format	Distribution maps are available for all priority weed species	✓				
			Distribution maps are for priority weed species are updated as new data becomes available		✓	✓	✓	✓
To identify emerging threats	Identify emerging threats	Not applicable						

Weed Management Branch Contacts

For more information or advice in relation to the identification, management or monitoring of weeds please contact the Weed Management Branch:

Phone: (08) 8962 4314 or if the office is unattended (08) 8999 4567 (Darwin Branch)

Email: weedinfo@nt.gov.au

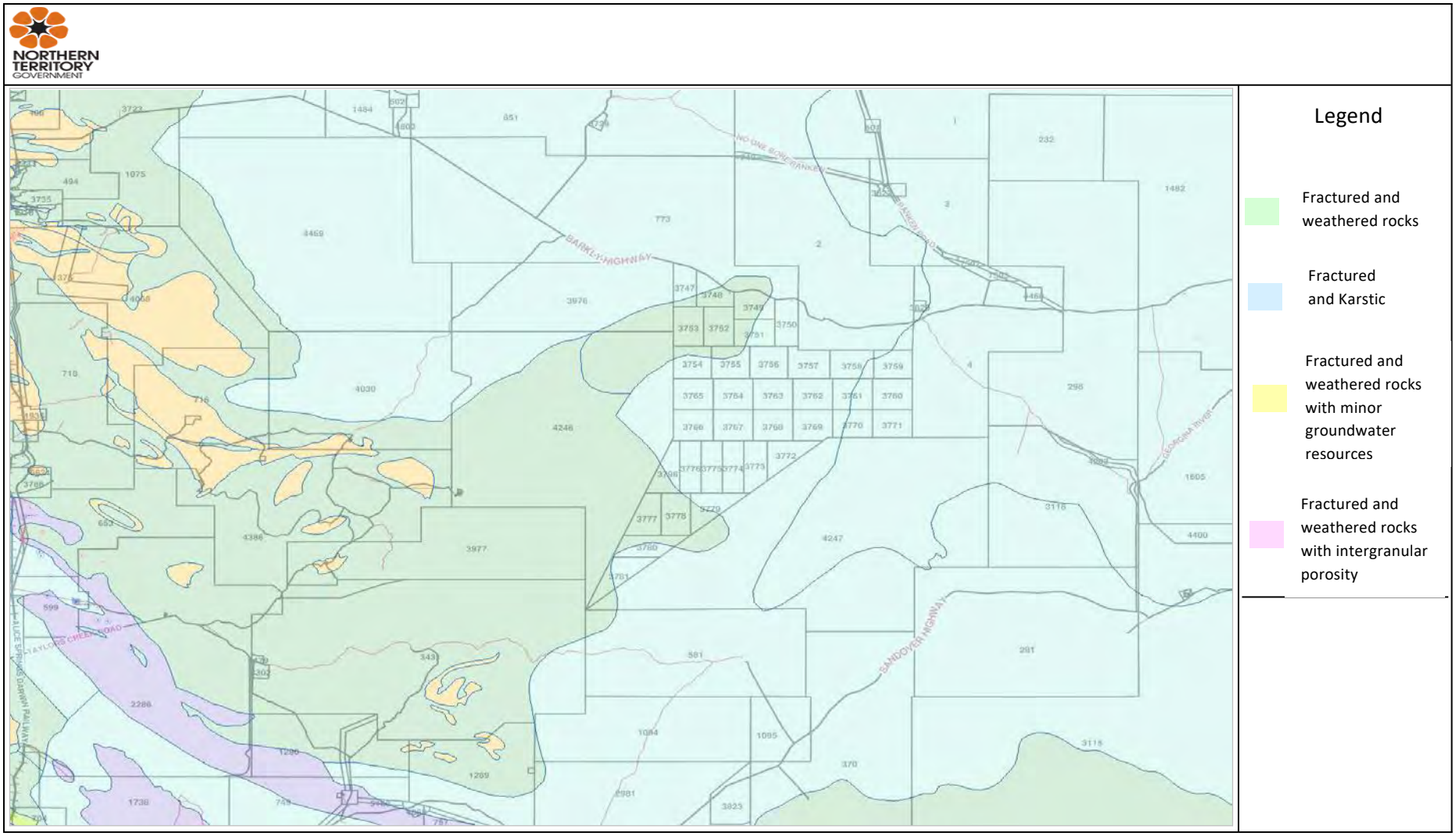
Website: www.lrm.nt.gov.au/weeds

The NT Herbarium can also provide plant identification advice:

Phone: 08 8999 4516

Appendix 6: Groundwater report

This report has been used to inform aspects of the Plan relevant to considerations of groundwater.



Appendix 7: Threatened fauna species in the general region

Threatened species identified in the general region (as per map below downloaded from the NT Government website). This information has been drawn on to assess environmental risks for the proposed exploration.

Scientific Name	Common Name	Latitude	Longitude	Location Description	Date	Observer Notes	Original Data source
Dasycercus blythi	Brush-tailed Mulgara	-20.1819	136.0345		1993-05-10	Miscellaneous Fauna Data	Brs
Macrotis lagotis	Greater Bilby	-20.4209	136.1758	The Granites, 184km NW	1994-07-19	Miscellaneous Fauna	Bilby Database
Dasycercus blythi	Brush-tailed Mulgara	-20.1819	136.0345		1993-05-10	Miscellaneous Fauna Data	DLRM - Flora and Fauna

NR MAPS

EL27821 Threatened Fauna