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PEPR

PROGRAM FOR ENVIRONMENTAL PROTECTION AND REHABILITATION

ML 733, 734 & 665

"Mining Program of the Morgan Gypsum Deposit"

Section 77 and part sects in the Hundred of Stuart
18 km North East of Morgan

OPERATOR & TENEMENT HOLDER CONTACT

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SEPTEMBER 2014

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Introduction

This PEPR (Program for Environment Protection and Rehabilitation) is a review of the mining activities at the Morgan gypsum deposit under Mills Freightlines Pty Ltd. The mining program is made in accordance with the Minerals Regulatory Guidelines MG6, Version 2.0 April 2012 (DSD) and the MD005: Ministerial Determination 12 July 2012. It is noted that this application commenced under previous guidelines and has been updated where necessary.

Tenement holder contact and details:

Mills Freightlines Pty Ltd of PO Box 60, Main Street, Brinkworth, SA 5464.
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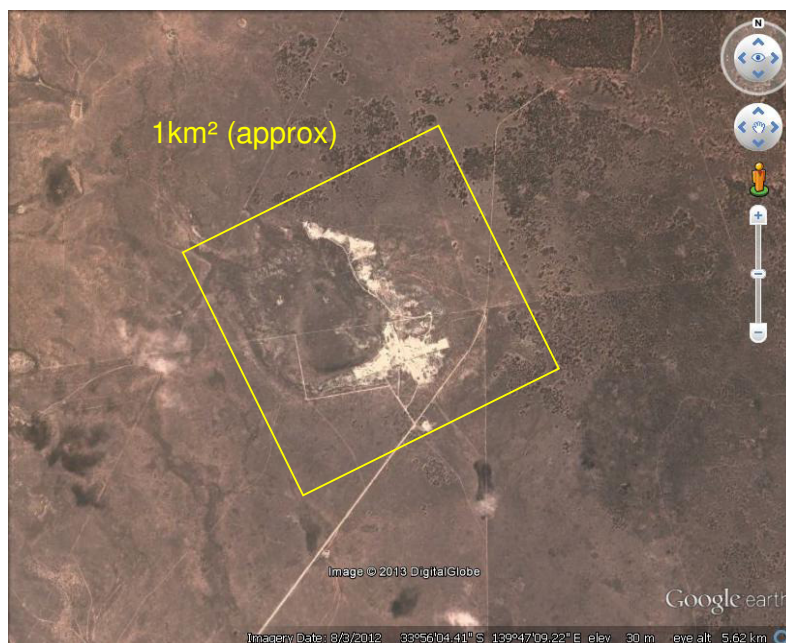
Mineral Lease (ML) tenement details in the Hundred of Stuart:

Number	Start	Expiry	Area	Comments
ML 733	1/6/75	11/7/16	13ha	These leases were transferred to current holder in the late 1990's from T. O. Marshall.
ML 734	1/6/75	11/7/16	13ha	
ML 665	1/4/81	1/7/16	(57ha)	

See list of surrounding leases and holders in attachments.

Location:

The gypsum deposit is located approximately 10 km north east of the Murray rive town of Morgan, north west of Waikerie in the Riverland of South Australia. The site is remote, in bluebush country and under grazing.



1. Company Senior Executive Declaration

I, the Applicant and operator confirm that in accordance with Regulation 65(8) I have taken reasonable steps to review the information in this document and to ensure its accuracy.

Applicant:Date.....

Gavin Mills

Mills Freightlines Pty Ltd
Tenement Holder/Operator

Operator Capacity

The operators Mills Freightlines have been mining the gypsum for many years and have the capacity and experience to work the area in an environmentally sensible manner. Since occupying the site the operators have initiated a new plan and have commenced the rehabilitation of older worked out areas (from previous operators). The operators have operated mine machinery and have links to transport materials and products throughout South Australia and beyond.

Operations will be conducted by experienced contractors who have the capacity to mine the area in a safe and orderly manner in accordance with legislative requirements and as approved in the PEPR.

Lease Conditions

ML 733 (13ha): None

ML 734 (13ha): None

ML 665 (57ha): as follows and includes 'partial surrender' N0. 18907
(approximately 50% of the lease area)

1. "to take due care to preserve and protect any item of Aboriginal or European heritage discovered in the course of mining operations and shall cause such item to be reported to the Relics or Cultural Heritage Units of the Department for the Environment and shall allow reasonable time for its inspection and documentation."

Refer to Operator Compliance Monitoring Plan section on Heritage.

2. "not to conduct mining operations on the said land which interfere or are likely to interfere with the natural drainage of the said land without written approval of an inspector."

Refer to PEPR Operator Compliance Monitoring Plan sections on Soil and Mine rehabilitation, also 3.4.2. Sequence of mining and rehabilitation operations, 3.6.1. description of mine site at completion and 3.10.7 Silt control and drainage.

3. "not to conduct mining operations on the said land which are likely to cause undue or excessive soil erosion."

Refer to Operator Compliance Monitoring Plan section on Soil.

4. "to comply with any directions of the Chief Inspector of Mines with respect to the rehabilitation of the said land in accordance with the approved 'Programme of Works'".

Refer to PEPR.

5. "not to conduct mining operations on the said land which are likely to cause or contribute to pollution to any river, dam, billabong, watercourse or any other part thereof located on or adjacent to the said land nor to permit any waste to come into contact directly or indirectly with the said river, dam, billabong or watercourse".

Refer to PEPR.

6. "not to conduct mining operations on the said land which are likely to interfere with, damage or destroy any protected wildflower or protected native plant".

Refer to PEPR Attachment 1.

7. "to prepare a 'Programme of Works' comprising maps, plans, sections and development and rehabilitation proposals or any one of these to a scale in accordance with the requirements by and to the satisfaction of the Chief Inspector of Mines, such 'Programme of works' shall be submitted to the Chief Inspector of Mines for his approval prior to commencement of mining operations".

Refer to PEPR.

8. "to comply with any variation of the approved 'Programme of Works' in the interest of safety as may be ordered by an inspector of mines".

2. Description of the Environment

The site is situated on dry remote plain where a deposit of fine quality gypsum is mined from an ancient dune system. See *MESA Journal* article at end of this PEPR for gypsum in South Australia.

- Native Vegetation is mainly of mallee and blue bush country with scattered trees which is part of a large grazing property.

See baseline data references 'vegetation description and summary', and site photos appendix page 1 in the Attachment 1 for details of species and weeds Ref: ML665.

- Soil is made up of a thin profile of organic matter where vegetation exists, with bare patches in between. The area is heavily grazed by stock. All topsoil is pushed up into low windrows before excavating the gypsum; there is no overburden of any significance. The topsoil is returned once the gypsum has been removed. The land is returned to grazing with the vegetation being allowed to recover naturally.
- Fauna is confined to sheep and cattle with the occasional kangaroo. Reptiles, birds and invertebrates would be present on a seasonal basis. Feral animals will include foxes and rabbits. The land is under primary industry use.

3. Description of the proposed mining operations

3.1 General description and maps of operations

This site requires only basic mining techniques. Only small amounts of topsoil layer and overburden (up to 2%) are present in the arenaceous topography. When encountered they are stripped away using a dozer, excavator or loader and stored separately along the flanks of the leases for use in rehabilitation. The clean raw gypsum is then extracted by loader, put through a screen and stockpiled. The product is picked up by loader and placed into trucks for customer delivery. The open cut area is located on the fringes of the large drainage depression to the north and west of the leases. A location map, topographical and aerial photographs are provided in the appendices along with methods of working the leases, staging and sequences of rehabilitation, and site photos. *See appendices.*

3.2 Reserves, products and market

3.2.1 *Geological environment*

Gypsum deposits in South Australia are very widespread with 27 known sites of commercial value, ranging from premium products to lower grades with many and varied uses. Gypsum formations were laid down in the Late Pleistocene and Holocene times, about 12,000 years ago. The Morgan site is an old dune type deposit formed east and south of a natural depression. Gypsum is mineral composed of $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ a common mineral of 'evaporates' used in the manufacture of plaster of Paris. This deposit is well known and been mined for many years and does not require further geological surveys or to be proven.

Overburden: As the gypsum is near the surface overburden or waste material is insignificant in volumes. Overburden is unlikely to exceed a few thousand tonnes with topsoil being most of the cover over the raw gypsum. The proportion of material disturbed or uncovered as waste or overburden would be less than 2% over the three leases.

3.2.2 *Reserves and Resources*

The Morgan site is mainly used for agricultural purposes, for soil improvement. The gypsum was laid down from Aeolian influences into a sedimentary layer to a depth of between 1m and 3m. The gypsum product varies in quality over the site. The yield over the 80ha site is estimated at between 200,000 and 250,000 tonnes, based on assessment of aerial photography depicting all open cut areas and projected 2 metre excavation depth over remaining unopened areas. It is difficult to accurately assess the remaining resources as some of the area has not been extracted to maximum levels prior to current tenement holder operations. Since the new tenement holder is mining more efficiently the final depth is attained regularly. Gypsum is mined in shallow strips according to quality and customer requirements, blending from previous open areas as well, over various stages and locations.

3.2.3 *Production rate and products*

Production can vary from 5,000 to 20,000 tonnes per annum, averaging 10,000 tonnes per annum, according to market demands. The product is used in the agricultural and building industries as gypsum. Mine life is estimated at between 20 and 50 years.

3.3 Exploration activities

There are no exploration issues for the gypsum site.

3.4 Mining plan

3.4.1 *Type of mining operation to be carried out*

The type of mining to be carried out is open cut through a low dune deposit. There are no benches, only low faces where the gypsum is sourced with a loader.

3.4.2 *Sequence of mining and rehabilitation operations*

The operation will be mining in its simplest form, with remedial leveling following the worked out areas and progressively rehabilitating the site. The final surface will be left even or slightly undulating to blend with natural drainage patterns of the area.

- Extraction occurs on an intermittent basis (market demands) and will continue from existing workings. The topsoil is stripped off and stored at the perimeters of the stages or the lease to bund the works as shown in the plans in appendix 4. This dictates the advancement of mining and rehabilitation over the leases. The cross section shows the final gradients at the adjoining lands and other leases in the area. Mining will occur on an area no greater than 5ha at any one time with rehabilitation of worked out areas each year.
- The clean gypsum material is then extracted, using low profile slopes or faces, from the exposed surface to a depth of about 1 to 3 metres, with a bulldozer, excavator or loader. Material is screened using a mobile plant brought in for the campaigns. Product is loaded onto trucks or stockpiled.
- Topsoil, subsoil and overburden are stored in separate areas to assist in the rehabilitation process, placed alongside the extremities of the working area all around the leases in low mounds up to 2 metres in height, averaging 500 tonne capacity.
- Staged rehabilitation will occur following the path of mining as shown on the plans when an area is available according to practical, economic and seasonal criteria. Rehabilitation will be undertaken when a winnable depth is attained either when a stage is mined out or following mining if possible. It is envisaged that some rehabilitation will occur annually.
- When an excavation area is completed the floor will be levelled/shaped with a dozer in preparation for final rehabilitation.
- Perimeter and internal slopes/faces will be battered down using a dozer to conform to surrounding contours, around 10 degrees is ideal for the optimum stability and future use, plant regeneration and blending with the surrounding landscape. It is likely that the area will be left fairly flat, if all the dune materials are removed.
- The final levels will be graded according to natural drainage flows, catchment criteria and the landowner requirements.

- Topsoil and any vegetative stubble (debris) will be spread evenly over the area. All soil including subsoil and fine overburden will be returned during the rehabilitation process.
- The natural regeneration of the chenopodiaceous scrubland usually regenerates well after winter/spring rains. The area will be maintained for declared weeds and monitored for weed and erosion in consultation with the landowner.
- There is no infrastructure in the path of mining. Vegetation will be cleared as required and set aside for rehabilitation. Any trees in the path of mining will be saved where possible and left undisturbed from 2 metres from the drip-lines. The area surrounding the trees will be battered off to a gentle slope so as not to leave root zones exposed. No clearance applications are required as the leases were granted prior to the Native Vegetation Act 1991, mining has occurred since 1973 under various operators.

3.5 Mining operations

3.5.1 *Modes and hours of operation*

Operations will be worked on a campaign (intermittent) basis throughout the year, based on market demands, and active only during daylight hours, from 7.00 am to 5.00 pm Monday to Friday and Saturday 7am to noon. There will be occasional hours spent for site and property maintenance, monitoring and inspections as required. There are no receptors.

- Minimum hours the site is worked per year: 10 to 2,000 hours
- Minimum time for each campaign: Few days to three weeks
- Maximum and minimum time between campaigns: Based on orders
- Campaigns will be based on size of orders received for gypsum
- Hours of mining operations during campaigns 1-8hrs p/day
- Days of mining operations during campaign: 1 to 15
- Campaigns will be based on orders received for gypsum
- Tonnage produced for each campaign: 1,000 to 5,000 tonne
- Tonnage produced for each year on average 5,000 - 20,000 tonnes

3.5.2 *Workforce*

One or two operators will be employed at the site during production. Contractors are present on loading trucks and running the power-screen and organizing the stockpiles.

3.5.3 *Use of explosives*

Explosives will not be used.

3.5.4 Type of equipment

Equipment required is as follows:

- A small dozer for stripping and for rehabilitation (occasional).
- One loader (Komatsu WA250) for excavating from the face and loading trucks (on site).
- A diesel fuel trailer will deliver loader supplies occasionally as required (No fuel will be permanently stored on site).
- A mobile screen (diesel powered) for screening (100t/ph) to customer specification (as required).
- A water truck for use during summer to wet down tracks etc. (as required)
- Amenities will be brought in if required; toilets are available in the township of Morgan, ten kilometres away.

3.5.5 Mine dewatering

Not applicable

3.5.6 Stockpiles

Linear and conical product stockpiles, usually up to 5,000 cubic metres and approximately three to four metres high, will be produced during production campaigns and raising stock, using a loader/dozer. Campaigns are usually run for a few days or weeks depending on orders received. Product stockpiles will be located near the mobile plant on ML 665.

Topsoil will be stored in windrows around the perimeter of the opened areas at various stages.

Raw material stockpiles are fairly stable from erosion as vegetation colonizes quickly on the new surface. There will be no stockpiles outside the lease boundaries, only on the working area.

Dust is not an issue due to the lack of receptors. Most dust in the area is generated by heavily grazed primary industry lands in summer and unsealed tracks.

Overburden stockpiles are negligible as the raw gypsum is near the surface. Up to 10000 tonnes is likely over the 80ha site. These are located at various points around the site to aid in battering the perimeters during rehabilitation.

3.6 Mine completion

3.6.1 Description of mine site at completion

The land will ultimately be lowered by the removal of the dune material and left fairly flat and slightly undulating in places where the land marries other leases and former areas of disturbance. The surface drainage patterns will be re-contoured to blend with any natural catchments, run offs and depressions. There will be no interference to natural drainage flows.

The site will be physically stable, with no risk of erosion or slumping. The land will be restored to a similar condition to the surrounding area, a grazing use.

Decommissioning will require the removal of machinery, mobile screening plant and a general tidy up of the immediate area. The quarry operator will liaise with consultants and DSD officers to ensure that compliance is met and there are no long term environmental, social and community issues remaining. The timing of end of mine life is uncertain but would be reviewed as required. Closure would be determined by the market. The likely closure will be around 2070, but this may change. The two smaller leases may be surrendered earlier than the large one.

ML 665: It is likely that this lease will be mined out first and progressively rehabilitated as described in appendix 4 and outlined by the operator.

ML 734: Will be mined from the east starting from the old workings (previous operators) and progress west and connect up to ML 5122 where the land will blend together during final rehabilitation as described in appendix 4.

ML 733: Will be mined out last which will be a continuation of ML 734 workings. Mining to the west will fade into the peg at the triangle as the gypsum becomes non viable near this point. Ref: appendix 4.

At mine closure all mobile equipment, sheds etc will be removed with the land rehabilitated to the full use of the landowner as per consultations at the time. The Operator Compliance Monitoring Plan will shown how this will be achieved.

3.6.2 Rehabilitation liability estimate

The estimated liability costs at end of mine life are low as the site is undergoing progressive rehabilitation in various stages of development. The cost of final rehabilitation is estimated at between \$5,000 and \$10,000 on costing reviewed August 2014. This is based on a maximum of 5ha remaining open for rehabilitation at closure.

The cost breakdown is \$5-6,000 for levelling with a dozer, plus the removal of the shed \$2,000 and supervision and maintenance \$2,000. Contingencies are likely to be low as this site will regenerate naturally.

ML 665 is not likely to have any rehabilitation costs at closure as the entire area (except around the shed) and will have been progressively rehabilitated before entering ML 734 and ML 733.

3.7 Underground workings

Not applicable

3.8 Crushing, processing and product transport

3.8.1 *Crushing plant*

There is no requirement for crushing plant at the operation.

3.8.2 *Processing plant*

A mobile screening plant which will follow the advancing faces (see app 4).

3.8.3 *Process water balance*

Not applicable to this process. Water use is from a shed tank.

3.8.4 *Hours of operation*

Screening will occur only during campaigns, from 7 am to 5 pm. Mobile equipment (loader) will operate between 7 am and 5.30 pm for loading. The frequency of use is likely to be three to four annual campaigns with a period of around two weeks for each campaign, totaling about six to eight weeks per year. Some noise and dust will be generated by the mobile plant and machinery, but would be similar to farm equipment or road noise. There are no receptors. Work will cease on high wind days to reduce environmental impacts. There are no neighbours in close proximity of the leases.

3.8.5 *Type of mobile plant and equipment*

The only requirement will be a mobile screening plant (occasional) and a loader, diesel generated with a capacity of around 100 tonne per/hr. Noise outputs are within EPA standards, there are no receptors.

3.8.6 *Rehabilitation strategies and timing*

Refer to section 3.4.2. and appendix 4 for rehabilitation strategy. Timing will be based on sales, when stages have been mined out in accordance with the ordinal stages.

3.9 Wastes

3.9.1 Overburden and tailings

Only small amounts of overburden (less than 1,000 tonnes are likely at each stage) will be produced as the deposit is clean and at the surface. Waste will be in the form of overburden clay and some limestone. Any overburden encountered will be stored on site for rehabilitation or taken to the old workings for backfilling. Refer to plans for location. There are no tailings.

3.9.2 Processing wastes

Negligible wastes will be processed, produced or manufactured at this operation. There is no waste processing on site other than natural overburden.

3.9.3 Industrial and commercial wastes

No industrial or domestic wastes will be produced or imported on site. Any repairs to machinery will be carried out by a licensed contractor and wastes (consumable) removed at the time of service. A toilet, if required, will be in the form of a mobile unit and will be maintained as required with all waste taken off site. Illegal dumping in the area will be reported.

3.9.4 Rehabilitation and closure strategies

See the *Mining Rehabilitation section of the 'Operator Compliance Monitoring Plan'* and the following:

- Staging as shown on appendix 4 (note: areas within the stages will be progressively rehabilitated when worked out following the course of mining, annually if possible).
- Rehabilitating according to optimum seasonal requirements

The final mined surface will be levelled and contoured to marry in with other rehabilitated and adjacent areas. The topsoil is replaced and allowed to regenerate a natural cover from the seed source within the top cover.

Stage 1 (ML 665), Stage 2 (ML 734) and Stage 3 (ML 733) will be undertaken in order of 1 to 3 as they area mined out.

Timing will be determined on seasons and when areas area fully worked out. As each area within each stage is worked out (no more than 5ha opened up) progressive rehabilitation will occur and if possible annually, as already current practice, undertaken in consultation with the landowner. The success of regeneration is determined by inspections (by the operator and landowner) to verify it is similar to the surrounding area currently grazed.

3.10 Supporting surface infrastructure

3.10.1 Access

Access will continue on existing tracks and from the south along Woods and Forest Road. This route is used by all operators in the area. Tracks on site are already made and no new ones are required.

This is not a public area. Gates and cattle grids are maintained by the landowner. Tracks and roads are maintained and upgraded as required in consultation with the landowner.

3.10.2 Accommodation and offices

There will be no requirement for permanent offices or amenities as the site will be occupied for only short intermittent periods. A small shed may be required for general stores and amenity use.

3.10.3 Public roads, services and utilities used by the operation

The site will operate intermittently on a campaign basis. Traffic movements from the site will amount to one or three trucks per day on average. Traffic use on public roads already exists for mining, agricultural, council and other transport businesses in the area. Farm traffic is a main user of local roads with hay, crop and grain and stock carting. The operator will maintain safe road conditions at the entry/egress point onto the road and provide 'truck entering road' signage as required. If deterioration of the road surface by machinery movements becomes an issue in the future the operator will examine and action any maintenance required. The operators will keep records of any accidents and complaints and investigate to demonstrate no illegal or inappropriate incidents have been caused by use of the site. Mobile phones or two-way radios (UHF) are the only communications required. No other services or utilities are required. Diesel fuel is used for machinery which is brought in on a trailer, as required.

3.10.4 Visual screening

The requirement for screening from the neighbourhood and public is not required as the area is free from any receptors. No visual screening is required.

3.10.5 Fuel and chemical storage

There are no chemicals stored on site. Fuel is from a utility or trailer when required. Spills are dealt with under the EPA guidelines.

3.10.6 Site security

Gates are locked to the property when leaving the site, sheds and equipment are left secure. Note: the site is occupied by more than one lease operator and farm staff.

3.10.7 Silt control and drainage

Silt will not be produced as there is no watering requirement for processing the gypsum. Runoff from normal rainfall will remain on site in depressions and allowed to filter into the surface or evaporate. Runoff from internal tracks will be directed into the low lying areas of the pit away from external roads and natural areas.

3.10.8 Supporting surface infrastructure closure strategies and closure timing

This will only require the removal of mobile equipment. The shed will be determined at closure as the landowner may wish to retain it for own use. Closure timing is estimated between 2050 and 2070.

4. Results of Consultation

There is an agreement between the operator and the landholder/owner and regular consultation occurs regarding land access, weed management and a range of other land management issues. The landowner has fenced the mining areas to exclude stock and roads have been designated within the areas of mining to minimise disturbance. The landowner has expressed that he is satisfied with the operations conducted by the operator and the revegetation efforts conducted so far; in a letter to the DSD dated 12 August 2014. No issues pending as of 12 September 2014.

5. ENVIRONMENTAL OUTCOMES

OPERATOR COMPLIANCE MONITORING PLAN

Outcome	Outcome Measurement Criteria	What will be measured	Locations	Outcome achievement	Frequency	Control for baseline data
PUBLIC SAFETY: The Lessee must, in operating the Leases, ensure that unauthorised entry to the site does not result in public injuries and or deaths that could have been reasonably prevented.	Records of all injuries from unauthorised access demonstrate that the recorded injuries have been independently investigated and the investigation shows that the incident could not have been reasonably prevented through implementation of the control strategies identified below.	Adequacy of control measures to reasonably prevent access.	The mining leases and associated areas.	No injury or death.	As required from incident.	Record of incidents reported to DSD and or Police.
<p><i>Control strategies:</i></p> <ul style="list-style-type: none"> • Maintain in good order fencing, gates and signage on roads showing trucks entering/leaving site. • Maintain register (complaints) for recording all incidents Ref: <i>Appendix 6 - Site operator activity sheet</i> <p>Annexure "B" #8 " <i>To comply with any variation of approved 'programme of works' on the interest of safety, as may be ordered by an Inspector of Mines</i>"</p> <p><i>Evaluation of residual risks:</i> Low <i>Responsibility:</i> mining operator/tenement holder</p>						

Outcomes	Outcome Measurement Criteria	What will be measured	Locations	Outcome achievement	Frequency	Control for baseline data
<p>TRAFFIC:</p> <p>The Lessee must, operating the Lease, ensure that there is no traffic accident involving the public at the mine access points that could have been reasonably prevented by the lessee.</p>	<p>All incidents resulting from traffic accidents involving the public at the mine access points are recorded and independently investigated within one calendar month to show that the incident could not have been reasonably prevented by the lessee.</p>	<p>Complaints/issues and incidents investigations and resolutions achieved.</p>	<p>The mining operations and pathways.</p>	<p>No impacts from traffic movements beyond normal circumstances.</p>	<p>As required from incident.</p> <p>Inspections of road conditions as required annually.</p>	<p>Record of issue or complaint and recorded inspections.</p> <p>Records on the site operator activity sheet.</p>
<p><i>Control strategies:</i></p> <ul style="list-style-type: none"> • Keep access point clear of vegetation and no obstructions. • Provide signage when heavy machinery and plant is manoeuvring onto/off public roads. • Monitor road deterioration caused by operations and repair if required. • Ensure all drivers using site are aware of road safety issues at entrance in respect of traffic activity. • Trucks and equipment are maintained accordingly. • Maintain register for recording all incidents Ref: <i>Appendix 6- Site operator activity sheet</i> <p><i>Evaluation of residual risks:</i> Low <i>Responsibility:</i> mining operator/tenement holder</p>						

Outcome	Outcome Measurement Criteria	What will be measured	Locations	Outcome achievement	Frequency	Control for baseline data
<p>HERITAGE:</p> <p>The Lessee must, in operating the Leases, ensure that no disturbance to Aboriginal or European sites, objects or remains occurs unless prior approval under the relevant legislation is obtained.</p>	<p>Records from the site operator activity sheet will show that work ceased upon discovery of any potential Aboriginal or European artefacts found within the lease, the relevant authorities were notified to assess the significance and work recommenced only after authorisation was granted from the relevant authority.</p> <p>Adherence to Annexure "B" (Ref: ML 665 Lease condition) see below</p>	<p>Records from the site operator activity sheet documenting actions taken by the operator.</p>	<p>The lease area.</p>	<p>No disturbance to Aboriginal or European sites; objects or remains.</p>	<p>When discovery is made.</p>	<p>Assessment and advice from independent expert.</p> <p>Records on the site operator activity sheet.</p>
<p><i>Control strategies:</i></p> <ul style="list-style-type: none"> Employees operating on site will be made aware (inducted) about their obligations in regard to the Aboriginal Heritage Act 1998. Maintain register for recording of all discoveries and data Ref: <i>Appendix 6-Site operator activity sheet</i> <p>Annexure B: #1. <i>"To take care to preserve and protect any item of Aboriginal or European heritage discovered in the course of mining operations and shall cause such item to be reported to the Relics or Cultural Heritage Units of the Department for Environment and shall allow reasonable time for its inspection and documentation".</i></p> <p><i>Evaluation of residual risks:</i> Low (no discoveries known to date) <i>Responsibility:</i> mining operator/tenement holder</p>						

Outcomes	Outcome Measurement Criteria	What will be measured	Locations	Outcome achievement	Frequency	Control for baseline data
<p>WEEDS AND PESTS:</p> <p>The Lessee must, in operating the Leases, ensure no introduction of new species of weeds, plant pathogens or pests (including feral animals), nor sustained increase in abundance of existing weed or pest species in the lease area compared to adjoining land.</p>	<p>Annual inspections on the lease to record weeds, pests and pathogens on the site operator activity sheet will be compared to uncleared vegetation communities adjacent to the mine areas (attachment 1) to demonstrate no new weeds, pest or pathogens nor visual increase in abundance of weeds or pests.</p> <p>Weeds are defined in this condition as any invasive plant that threatens native vegetation in the local area or any species recognised as invasive in South Australia.</p>	<p>Records of occurrence of weeds, pests and pathogens (on the site operator activity sheet).</p> <p>Spread of box thorns.</p>	On the leases.	No new weeds established and weed (box thorns in particular) as required under NRM guidelines.	Annual inspections.	Weeds as compared to uncleared vegetation communities adjacent to the mine leases.
<p><i>Control strategies:</i></p> <ul style="list-style-type: none"> • Operator consults with landowner/other lease holders on all issues regarding weeds and pests for the site. • Regular inspections made to ensure that 'declared weeds' are managed in accordance with the NRM guidelines and legislation. • Control and eradication actions according to NRM guidelines will be undertaken as required by engagement of contractors by landowner or operator. • Report and record illegal dumping in the area to ensure no weeds are brought into the area. • Maintain register for recording weed control measures undertaken on rehabilitated and mine areas, new weeds found, visual inspections of vehicles for cleanliness and consultations with landowner Ref: <i>Appendix 6-Site operator activity sheet.</i> <p>Note: as the land is under grazing and multiple lease holders it will be difficult to ascertain the true source of weeds on to the site.</p> <p><i>Evaluation of residual risks:</i> Low <i>Responsibility:</i> mining operator/tenement holder and landholder/s users</p>						

Outcomes	Outcome Measurement Criteria	What will be measured	Locations	Outcome achievement	Frequency	Control for baseline data
SOIL: The Lessee must, in operating the Leases ensure that all soil quality and quantity is maintained and that operations are likely to cause undue or excessive soil erosion.	Soil mounds and areas rehabilitated on all three leases will be inspected annually for signs of erosion, integrity and stability (as appendix 4) and the inspection details recorded on the site operator activity sheet to demonstrate that control strategies are being carried out in accordance with approved PEPR. Work in accordance with lease condition Ref: Annexure "B" ML 665 (see below)	Integrity and stability of stockpiles and rehabilitated areas.	Stockpile locations and areas of rehabilitation and mine areas.	No loss of soil the quality and viability of topsoil and subsoil.	Annual inspections.	Recorded on the site operator activity sheet.
<p><i>Control strategies:</i></p> <ul style="list-style-type: none"> • Reserve soils in low bunding for short term periods only so as not to sterilize the soil biology by conducting rehabilitation as soon as possible and that soils area only to be used for rehabilitation purposes. • Maintain annual weed and pest control under the NRM Act requirements. • Where possible maintain clean vehicles entering and leaving the site and avoid driving over natural and stockpile areas. • Retain topsoil and un-worked areas with an adequate natural vegetative or re-vegetative cover. • Stormwater and runoff to be captured or directed into low lying areas on site. • In any event of fuel spillage the immediate area will be cleaned away and contaminated material taken to an appropriate site for treatment or disposal. • Maintain records Ref: <i>Appendix 6-Site operator activity sheet.</i> <p>Annexure B: #3. <i>"Not to conduct mining operations on the said land which are likely to cause undue or excessive soil erosion".</i></p> <p><i>Evaluation of residual risks:</i> Low <i>Responsibility:</i> mining operator/tenement holder</p>						

Outcome	Outcome Measurement Criteria	What will be measured	Locations	Outcome achievement	Frequency	Control for baseline data
WASTE DISPOSAL: The Lessee must, in operating the Lease ensure that all commercial or industrial waste is disposed of in accordance with relevant legislation.	Details of any waste disposal, recorded in the site operator activity sheet, demonstrate that all commercial and industrial waste is disposed of in accordance with relevant legislation. Comply with annexure "B" Ref: ML 665 (see below)	Records of disposal showing all waste is disposed of in accordance with relevant legislation.	The mining leases.	Waste is disposed of in accordance with relevant legislation.	When disposal occur.	Recorded on the site operator activity sheet.
<p><i>Control strategies:</i></p> <ul style="list-style-type: none"> • Incidents such as fuel spills are resolved and recorded. • Investigations are made to ensure that waste is managed in compliance with EPA requirements. • Records of waste identified and disposal off site are kept. • The landholder/s signs - off on closure to ensure all waste is removed from the site. • Maintain records Ref: <i>Appendix 8</i>-Site operator activity sheet. <p>Annexure "B" #5 <i>"Not to conduct mining operations on the said land which are likely to cause or contribute to pollution to any river, dam, billabong water course or to any part thereof located on or adjacent to the said land nor to permit any waste to come into contact directly or indirectly with the said river, dam, billabong or water course."</i></p> <p><i>Evaluation of residual risks:</i> Low</p> <p><i>Responsibility:</i> mining operator/tenement holder</p>						

Outcome	Outcome Measurement Criteria	What will be measured	Locations	Outcome achievement	Frequency	Control for baseline data
<p>NATIVE VEGETATION:</p> <p>The Lessee must, in operating the Lease, ensure no clearance or damage of native vegetation occurs other than in the path of mining as given in the ADP 12/7/85. This is understood to be the entirety of all three leases in pursuant to sect 5(1)(zda) of the Native Vegetation Regulations 2003. The lessee will not conduct mining operations on the said land which area likely to interfere with, damage or destroy any protected wildflower or protected native plant (Annexure "B" #6).</p>	<p>Inspections and annual photo monitoring will show that clearance is contained within the leases and that no unauthorised clearance outside the path of mining has occurred.</p> <p>Vegetation surveys conducted by D. Keane (Botanist) on 12 Oct 2012 found that no protected wildflower or protected native plants are present on the three leases.</p>	<p>Native vegetation cover and condition as determined by photos and inspections.</p>	<p>The mining leases and photo locations identified in the photo guide.</p>	<p>No damage or clearance of native vegetation outside path of mining.</p> <p>No protected wildflower or protected native plant will be interfered with, damaged or destroyed.</p>	<p>Annually for photo monitoring. Inspections at the discretion of the compliance officer.</p>	<p>Photos taken at identified photo points an 12 Oct 2012.</p>
<p><i>Control strategies:</i></p> <ul style="list-style-type: none"> Plant, vehicles and equipment are parked away from undisturbed native vegetation and use established tracks for access. Undertake progressive rehabilitation as soon as possible to preserve and encourage the regeneration of the native vegetation. Only vegetation in the path of mining within stages of development is to be cleared as depicted originally in the ADP 1985/028 (dated 12 July 1985 and shown in Appendix 4 of this PEPR.. Consult with landowner after rehabilitation to manage stock grazing. Maintain register for recording inspections and monitoring Ref: <i>Appendix 6-Site operator activity sheet.</i> <p><i>Evaluation of residual risks:</i> Low</p> <p><i>Responsibility:</i> mining operator/tenement holder</p>						

Outcome	Outcome Measurement Criteria	What will be measured	Locations	Outcome achievement	Frequency	Control for baseline data
<p>MINE REHABILITATION AND CLOSURE:</p> <p>The Lessee must demonstrate to the satisfaction of the Director of Mines that the following mine closure outcomes (in so far they may be affected by mining operations) are expected to be achieved and sustained after mine closure.</p> <p>Integrate and harmonise final landforms and vegetation with surrounding landscape.</p> <p>No more than 5 hectares will be open to mining at any time.</p>	<p>Photographs and visual site inspection with landowner and DSD at mine closure provide evidence that closure outcomes have been achieved.</p>	<p>Closure activities.</p>	<p>The leases and photos monitoring points given on app 5.</p>	<p>Earth works completed including battering as designed, successful re-vegetation and physical stability.</p>	<p>On mine completion.</p>	<p>Photos and records of final rehabilitation and mine completion show evidence.</p>
	<p>Aerial and ground photo and visual site inspection with landowner and DSD at mine closure provide evidence that site gradients blend with surrounding contours and land conditions is re-established on the rehabilitated areas.</p>	<p>Visual impact of steep inclines or entrapments.</p>	<p>The leases and adjacent land.</p>	<p>Harmonised landform covered with native vegetation for grazing.</p>	<p>When final rehabilitation takes place on mine completion.</p>	<p>Records of final rehabilitation and mine completion show evidence.</p>
	<p>Annual photographs from adjacent lease pegs and or visual site inspections with the lease holder and DSD of areas open to mining and progressive rehabilitation provide evidence that closure outcomes have been achieved.</p>	<p>Open mine area and area under rehabilitation.</p>	<p>The leases.</p>	<p>Final rehabilitation no greater than 5ha.</p>	<p>When final rehabilitation takes place on mine completion.</p>	<p>Records of final rehabilitation and mine completion show evidence.</p>

The risks to the health and safety of the public and fauna are as low as reasonably practical.	Aerial and ground photos as per photo guide and visual site inspection with landowner and DSD at mine closure provide evidence that the site is safe, level and offers no potential for entrapment.	Batter slopes are as designed, pit floor is level, no potential for entrapment of stock.	The lease areas.	Smooth even, compact surface free of hazards.	When final rehabilitation takes place on mine completion.	Records of final rehabilitation and mine completion show evidence.
The site is physically stable.	Inspections with landowner and DSD at mine closure provide evidence that the site is physically stable with no evidence of slumping or erosion greater than surrounding land.	Visual evidence of erosion or slumping.	The lease areas.	No erosion greater than surrounding lands.	When final rehabilitation takes place on mine completion.	Records of final rehabilitation and mine completion show evidence.
No industrial or commercial waste left on site.	Inspections demonstrate no commercial or industrial waste is left on site.	The presence of commercial and industrial waste.	The lease areas.	No waste left on site.	At mine closure.	Records of inspections show evidence.
Pre-mining land use is re-established.	Aerial and ground photos as per photo guide and visual site inspection with landowner and DSD at mine closure provide evidence that the site has returned to grazing/native vegetation.	Presence of vegetative cover for grazing purposes.	The lease areas.	Pre-mine viable grazing conditions exist.	When final rehabilitation takes place at mine completion and mine closure.	Records of mine completion and consultation with landowner.

Control strategies:

- Commence rehabilitation as soon as possible to return the land to condition similar to surrounding landscape.
- Staging progressive rehabilitation during mining, starting with reshaping the worked out areas from the perimeter (as per PEPR sect 3.9.4 and appendix 4).
- Battering final perimeter slopes to blend with abutting land to a near level surface (no greater than 1 in 10).
- Rehabilitation to facilitate and imitate natural drainage in the area.
- Weed control conducted on rehabilitated areas to increase rate of natural re-vegetation
- All waste to be removed after completion and closure.
- Consult with landowner after rehabilitation to manage stock grazing and improve success of rehabilitation.
- Records from the 'Site operator activity sheet' from all environmental components (above) will be examined on an annual basis to ensure that any non- conformance is or has been acted upon as stated in the PEPR. If required a re-assessment of the issue/s with new actions introduced.

Evaluation of residual risks: Low (negligible)

Responsibility: Mining operator/tenement holder

Recording on the *Site Operator Activity Sheet* will include the following:

- All activities relating to the operations and management of the site
- Photos taken (date) and their photo point on a plan
- Inspections and monitoring to comply with the PEPR
- Complaints and resolutions regarding aspects of mining operations
- Site visits from DSD compliance officers etc
- Consultations with landowner and documented
- Weed control undertaken and documented
- Rehabilitation undertaken (dates and photos)
- Visual inspection and photos of vegetation as required (see Attachment 1) for data base

6. New Environmental Risk

There have been no changes to the environmental risk since the original submission. With regard to native fauna there is no risk of impact as the land is used for grazing and only itinerant kangaroos frequent the area. The clearance of native vegetation is slow and over a long time frame so no immediate impacts are likely.

7. Evaluation of Residual Risk (Summary of impact events)

Table 1: Definitions of risk factors for the mine operations

Likelihood of occurrence	
Virtually impossible	Never occurred before and not expected to (<5% chance)
Rare	May occur but not likely (<10% chance)
Unlikely	May occur occasionally but not likely to (<25% chance)
Likely	Will occur during the life of a mine (>50% chance)
Virtually certain	Will occur for certain (>80% chance)

Severity of consequence (ABCD or E denotes the degree of impact)	
Negligible	Possible impacts in some form but likely to be insignificant
Minor	Limited occurrence but not significant
Major	High degree of risk or impact but could be overcome
Severe	High risk and concern with environmental damage occurring
Extreme	Disastrous impacts on the environment and loss of habitat/vegetation and long term or permanent pollution issues.

Table 2: Summary of environmental effects over the site

Risk assessment matrix			Likelihood of consequences				
Summary Table			1	2	3	4	5
			Virtually impossible	Rare	Unlikely	Likely	Virtually certain
Severity	E	Negligible effects	<i>Waste disposal.</i>	<i>Public safety. Traffic. Heritage. Native vegetation. Mine rehabilitation and closure.</i>	<i>Weeds and pests. Soil.</i>		
	D	Minor effect					
	C	Major effects					
	B	Severe effects					
	A	Extreme effects					

8. Applicable Legislation and Standards

Aspect	Legislation	Documents	Contacts
Local planning	Development Act 1993	DC Development Plans	DC Morgan & Riverland
Mining	Mining Act 1971 Works and Inspection Act 1920	Regulatory Guideline No.6 (Extractive) Determination documents. And general mine occupation procedures/safety documentation.	DSD - Greg Marshall GPO Box 1264 Adelaide SA 5001 Glen Orr – DSD Compliance Officer
Aboriginal & European	Aboriginal Heritage Act 1988	Policy and protocols	Report to DSD
Air quality	Environment Protection Act 1994	Schedule 1	Report to DSD
Health and safety	Work Health and Safety Act 2012	The Regulations	Report to DSD
Noise	Environment Protection Policy (noise) 2007	Part 1,5 Division 1 (sect 21 & 23)	Report to DSD
Roads	Road Traffic Act 1961	Part 2 (driver duties and other road users)	Report to DSD
Soil and weed control Fauna	Natural Resources Management Act 2004	Guidelines and policy	Local NRM Board (under DEWNR Regional Office)
Native vegetation	Native Vegetation Act 1991	Guidelines for a NV SEB Policy. Sept 2005. A Guide to the Exemptions 1991	DSD WLBC/DEWNR
Water	NRM Act 2004	Guidelines and legislation	DEWNR

9. References

- Guidelines for the preparation of Mining Programs (DSD) and Ministerial Determination 1 December 2011
- DSD website (SARIG) for bulletins and publications
- Aerial photos by Google Earth and Natural Maps
- Mining Act 1971 and associated documents, MESA Journal etc
- Preparation of a Mining and Rehabilitation Compliance Report (DSD)
- Lease Conditions (annexure B for ML 665)
- Client information

10. DESCRIPTION OF THE RECEIVING ENVIRONMENT

10.1 Local community

The site located in an isolated area and situated in a semi desert and rural setting with scattered station farms. The site lies 10km NE of the Murray River township of Morgan and 160km from Adelaide. There is no likelihood that any community will be impacted by this operation. Morgan has a population of 426 (2006).

10.2 Land use

The land is used for grazing purposes and gypsum mining. Historically the area was opened up for exploration and farming. There are no known Council or political changes to the land use in the near future. The local area is covered with many mining leases. There are no easements or other infrastructure affected by this proposal.

10.3 Proximity to infrastructure and housing

There is no proximity infrastructure or housing within the area. There are no exemptions required under *Section 9 of the Mining Act 1971*. The nearest farm house is over 5km away and there are no dams or other infrastructure within 150 metres. There are no receptors.

10.4 Amenity

Scenic or aesthetic values will not be impacted upon by this operation. The site is located in a remote area in semi desert grazing country.

10.5 Noise, dust and air quality

This operation has no noise or dust impacts, given that the surrounding land is used grazing and exposed gypsum mining. There are no receptors.

10.6 Topography and landscape

The land and surrounding topography is characterized by a flat dry scrub plain. There are no creeks or drainage areas within the leases. The gypsum deposit is in a dune situation mostly above the surrounding plain.

10.7 Climate

Annual rainfall is scarce in this semi desert region which is near the Goyder line where rainfall is less than 10 inches and average of 254mmm (BOM). The average temperatures range from 34 degrees in summer to 16 degrees in winter. Winds are around 13-17km/h from the north.

10.8 Geohazards

There are no known structural instabilities at the site as the site consists of ancient dune deposited. There are no known mineral/materials that can cause health or hazardous impacts on this site.

10.9 Hydrology

There are no creeks, water bodies, wetlands or other catchments within the proposed mine areas. A large drainage (dry depression) area lies to the west and is not impacted by operations. The site is not within the River Murray Tributaries Area (*River Murray Act 2003*).

10.10 Groundwater

The mine site is above any known water table. Mining is only 1 to 3 metres deep so ground water will not be intersected at any time during the life of the mine. Ref: SARG, local knowledge and topographical mapping.

10.11 Vegetation, weeds and plant pathogens

The land has been grazed for over 100 years with both cattle and sheep. The ground cover consists of mainly native semi desert scrub of mallee and chenopods. Some incidental weeds (non-declared) are also present. Pests would include the local feral animals such as foxes, rabbits etc. the land is grazed all months of the year. There are no known pathogens. As the leases have been in place for some time it is not subject to SEB application. Ref: *Attachment 1 for vegetation summary and lease condition #6 and sect 4 Operator compliance monitoring plan.*

10.12 Fauna

Fauna will not be impacted upon. The land is open grazing land. Kangaroos graze the area, little natural habitat remains over the gypsum mine area. The surrounding land surface is compact.

10.13 Topsoil and subsoil

Topsoil is thin (<10mm) as the gypsum is exposed at the surface with some vegetative cover. All soils are stored separately around the perimeter of the pit for follow up rehabilitation.

10.14 Heritage (Aboriginal, European and Geological)

The land where mining is proposed has no registered site for Aboriginal or European culture; there are no geological features or monuments.

10.15 Proximity to conservation areas

There are no conservation areas nearby or that would be affected by this operation.

10.16 Pre-existing site contamination and previous disturbance

There is no known site contamination or previous disturbance. The site has been grazed of natural vegetation since early settlement of the state of area (1880's).

11. APPENDICES

- Location Map Appendix 1
- Topographical Map Appendix 2
- Site map aerial photo Appendix 3
- Working plan & cross section Appendix 4
- Site Photos (4 pages) Appendix 5
- Site operator activity sheet (compliance) Appendix 6

Attachment 1 Vegetation and weed summary (database information)

SARIG lease map

SARIG Tenement list of operators

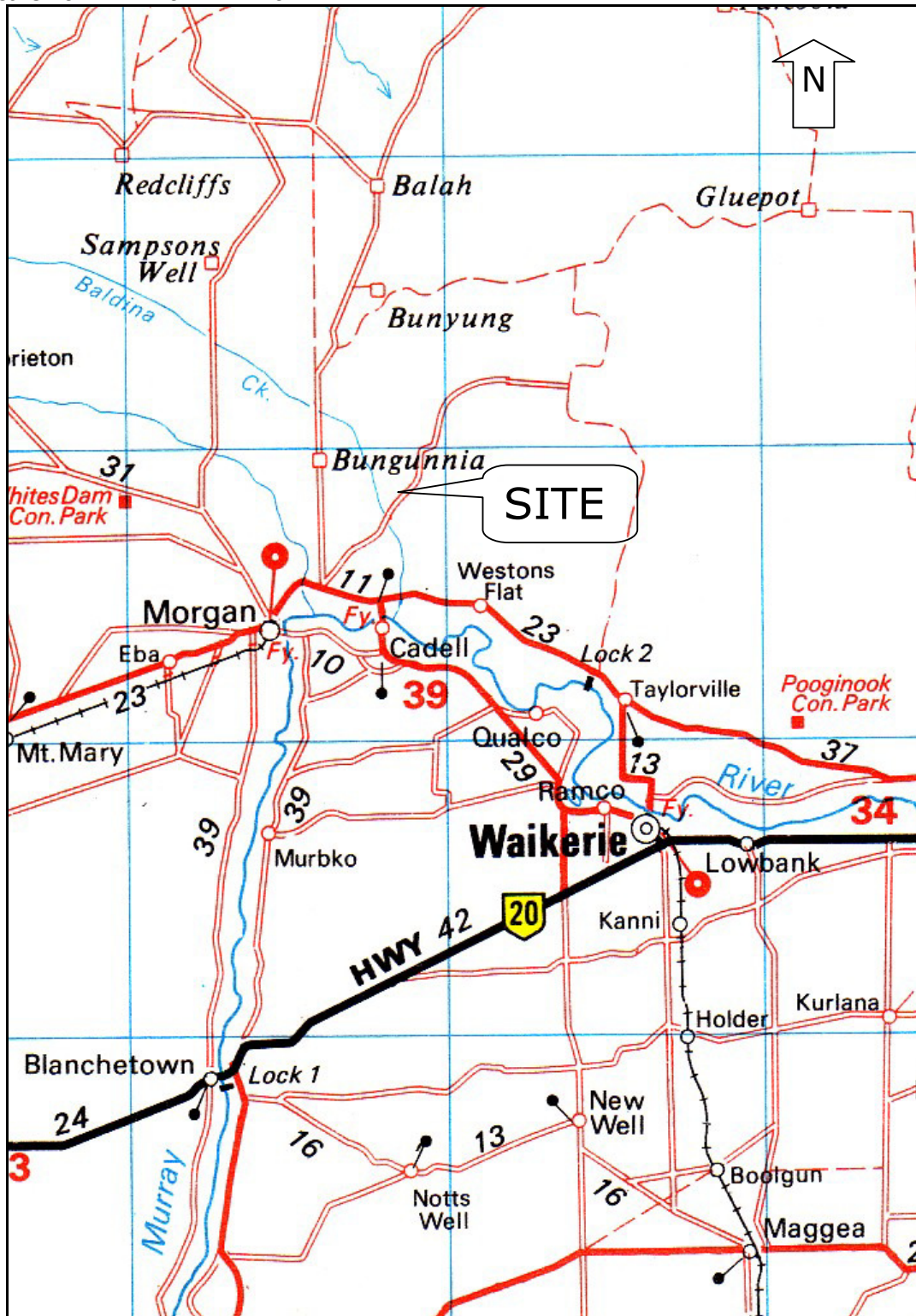
Aerial drainage map

Gypsum article – MESA Journal

CD PDF (back cover)

Appendix 1 LOCATION MAP

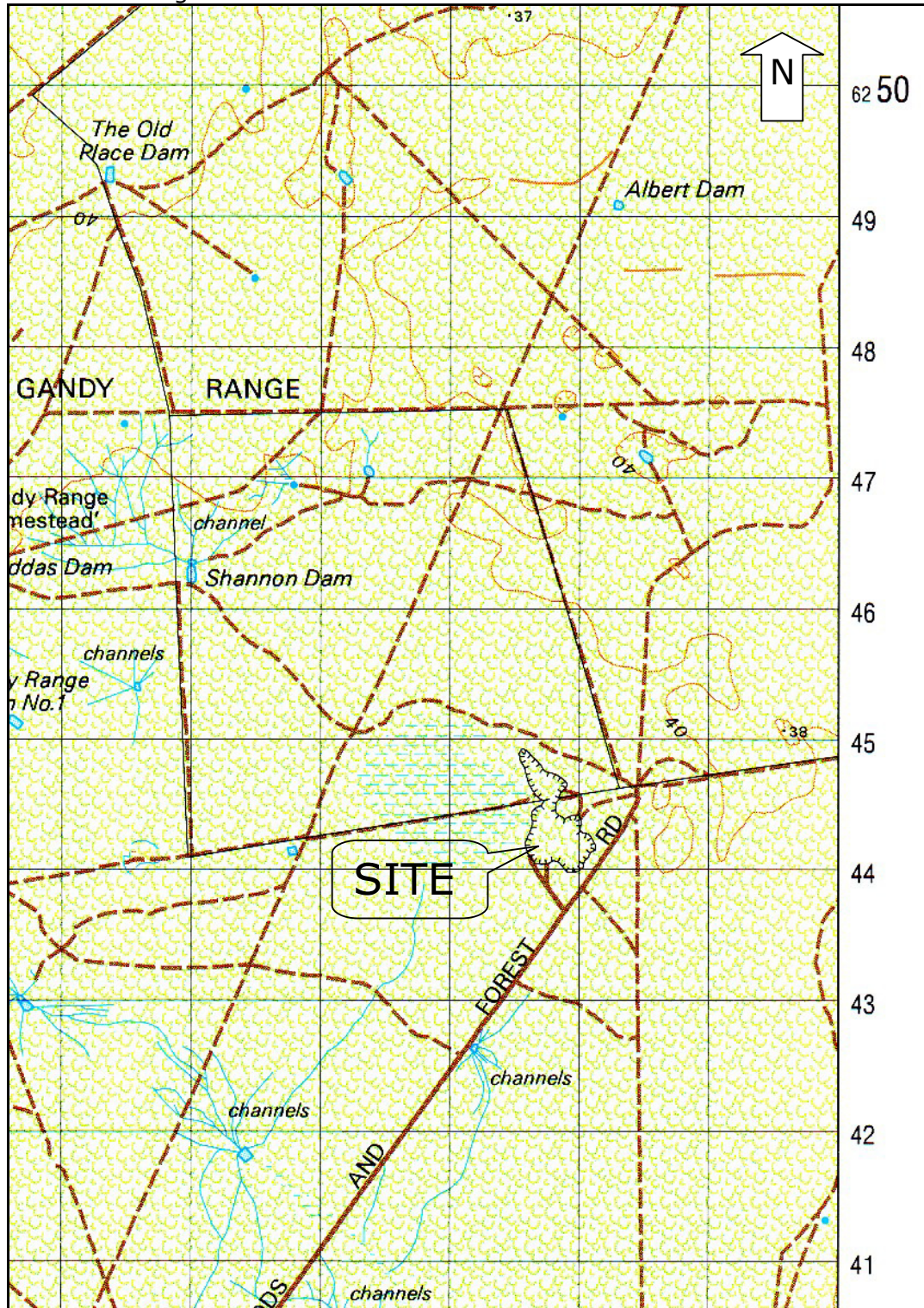
Scale: 0-----10-----20km



Appendix 2

TOPOGRAPHICAL MAP

Scale: 1000m grids

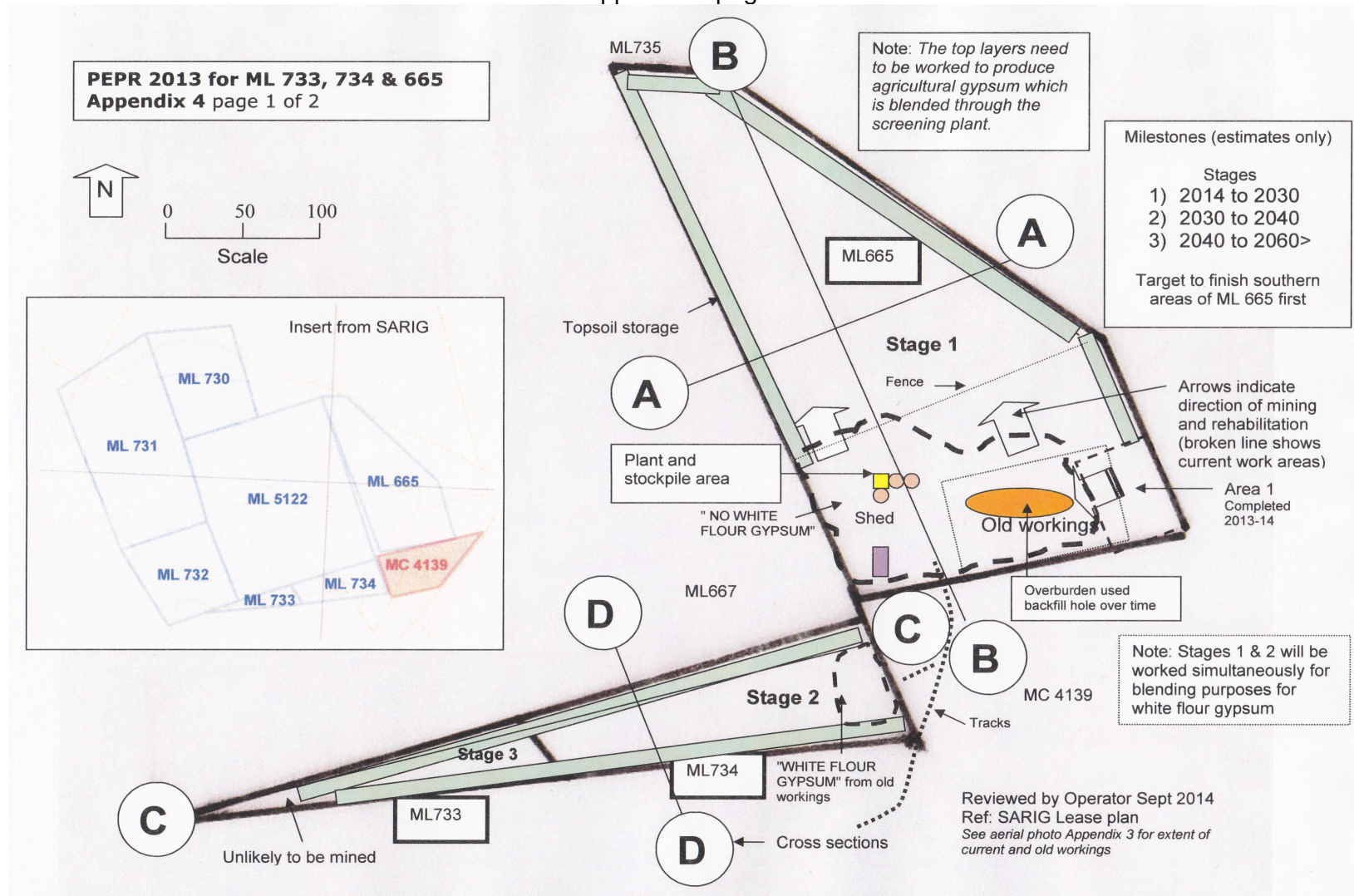


Appendix 3
PEPR ML 733, 734 & 665 (2014)

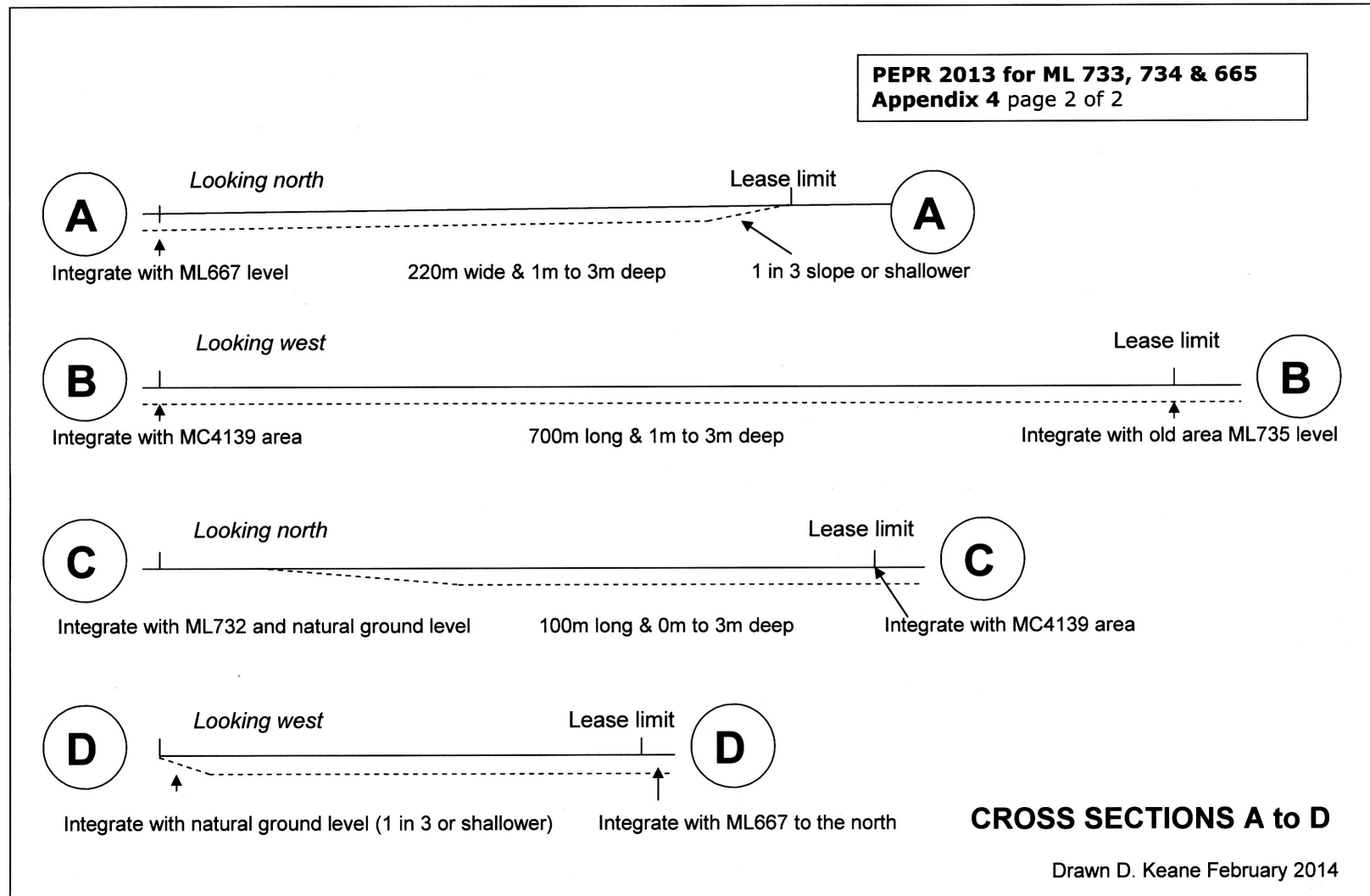
AERIAL MAP SHOWING GYPSUM MINE AREAS
(APPROX) AND ACCESS TRACKS



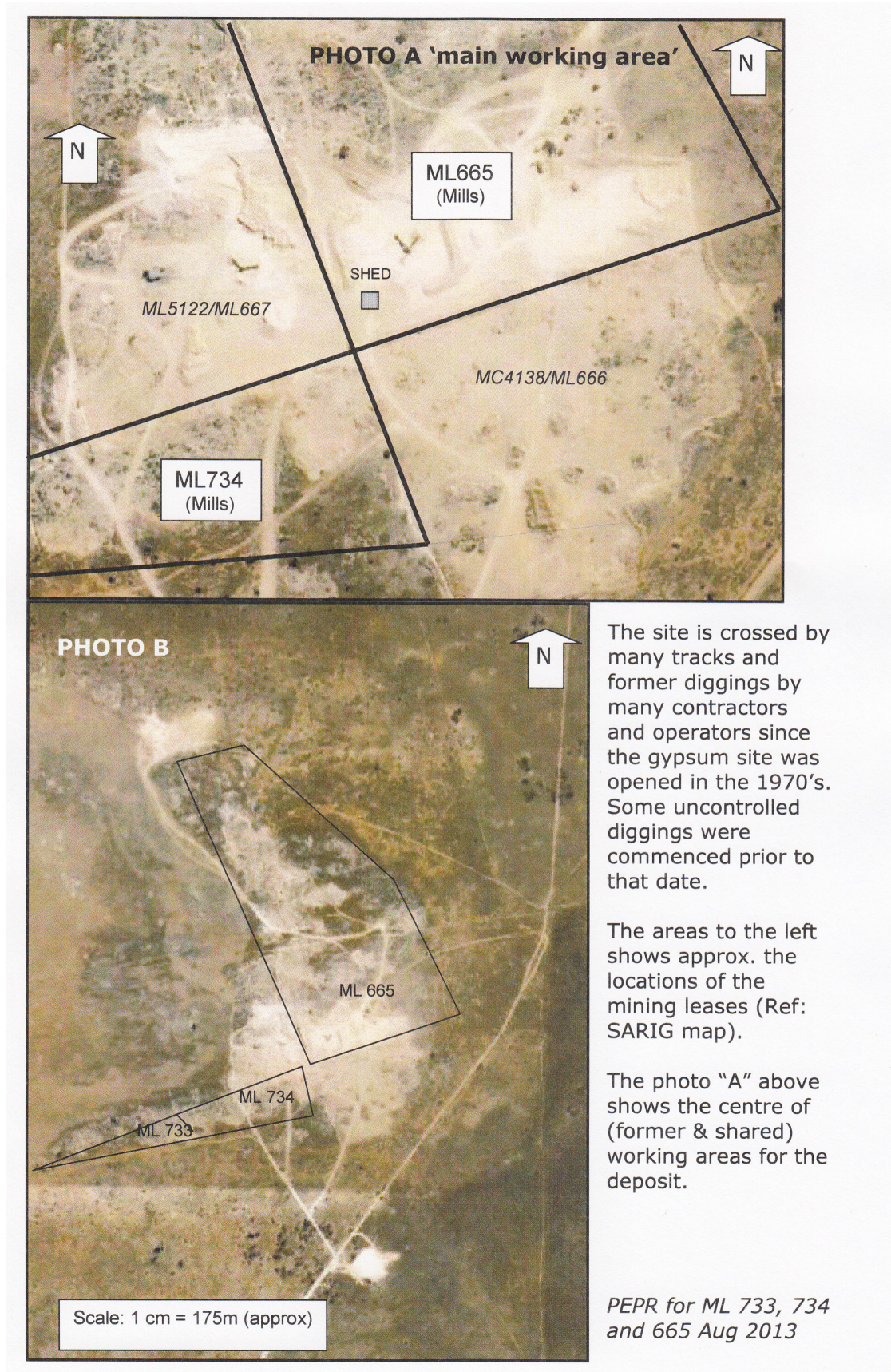
Appendix 4 page 1



Appendix 4 page 2

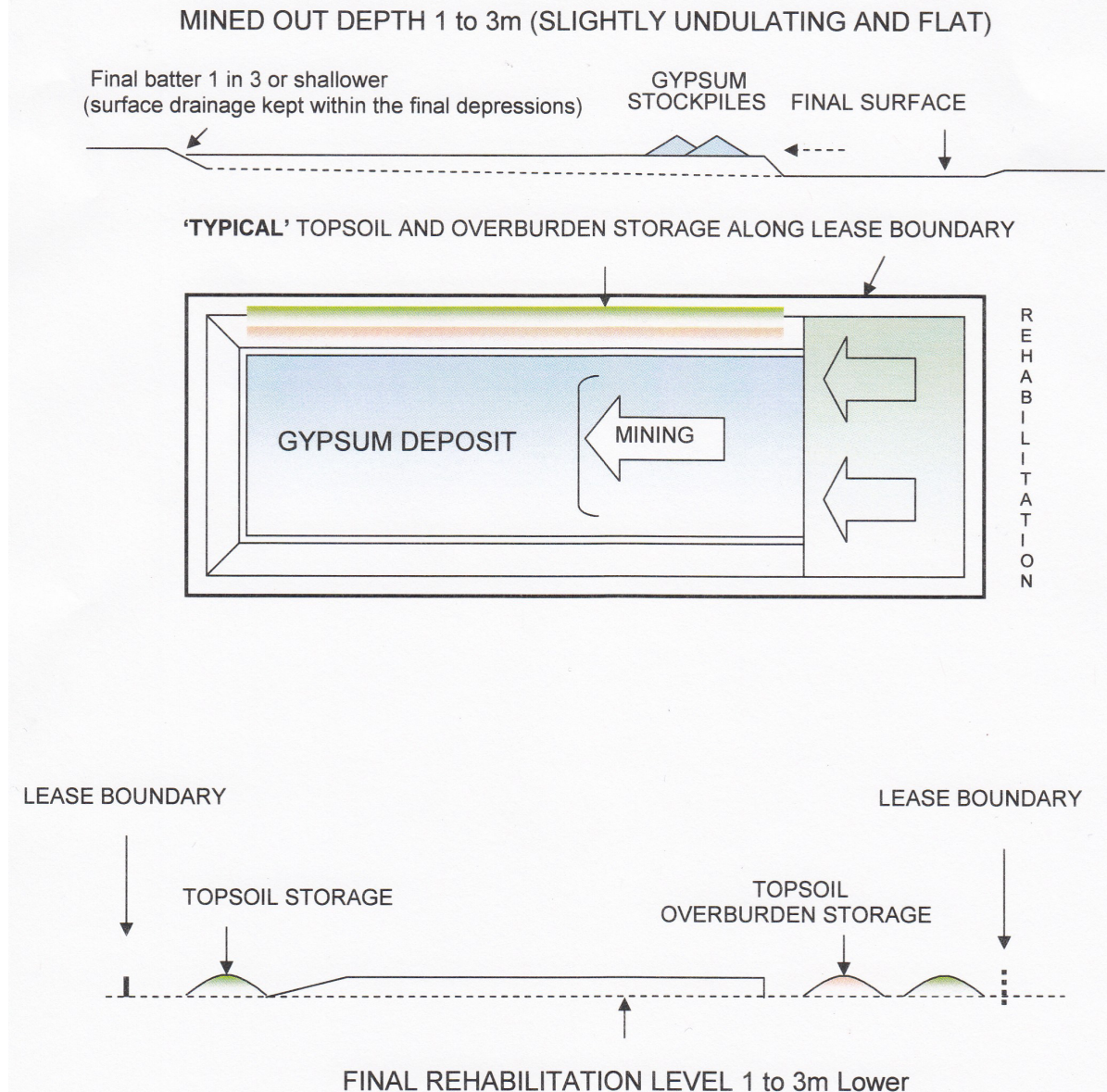


Appendix 4 page 3



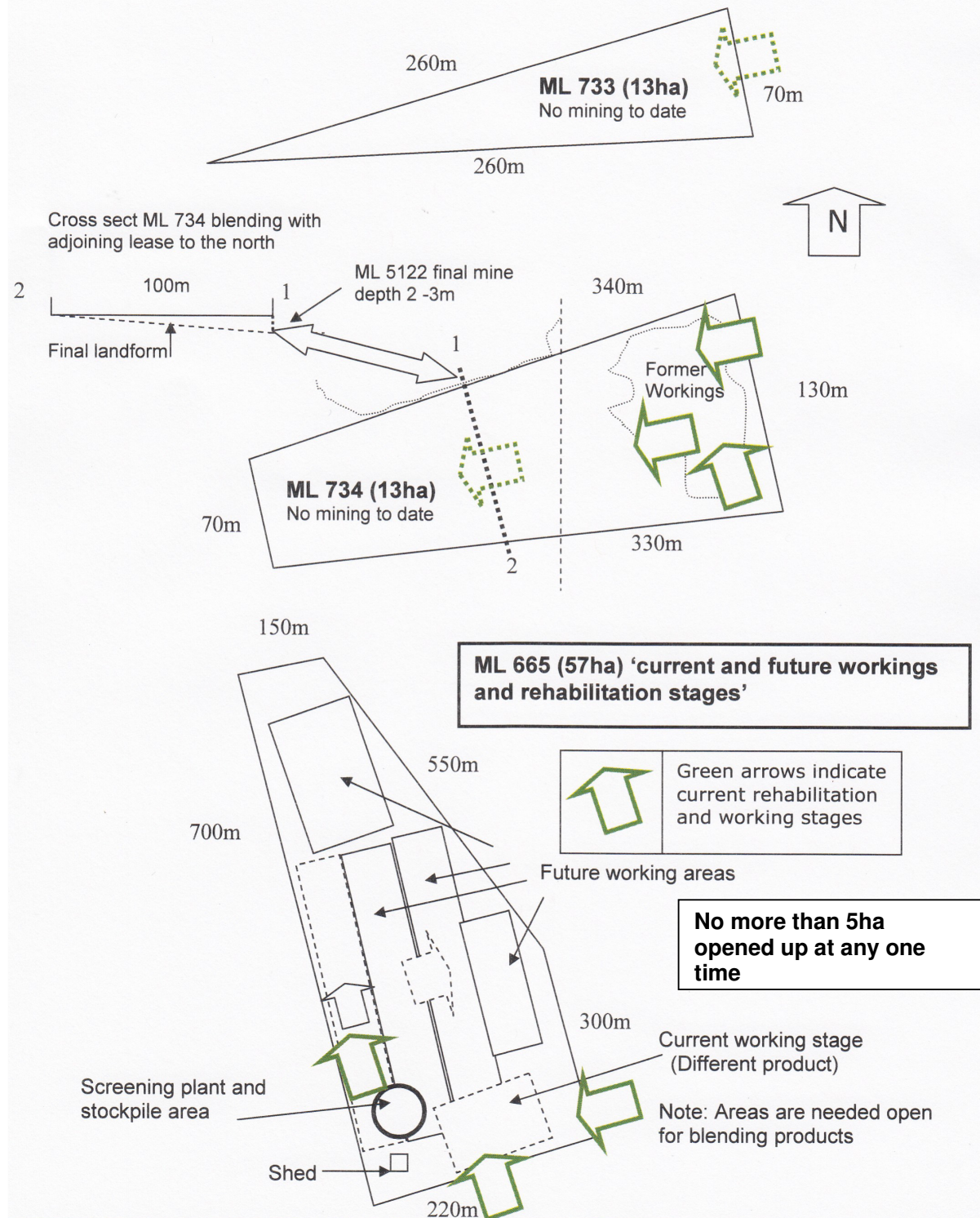
Appendix 4 page 4

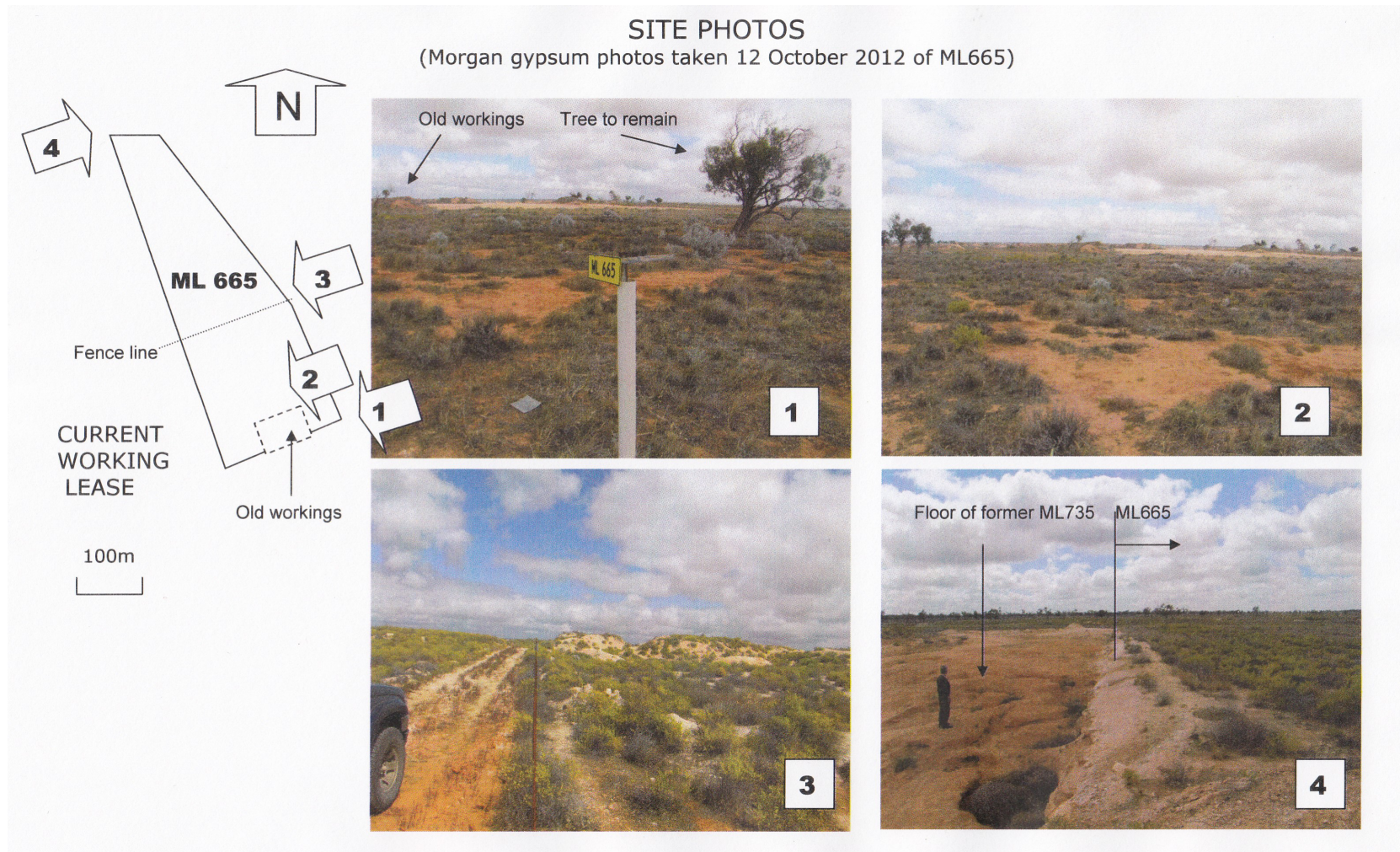
CROSS-SECTION (Both east and west) SHOWING THE PROPOSED WORKING METHOD AND PLAN OF CONCEPTUAL OR FINAL REHABILITATION FOR THE THREE LEASES SHOWING TOPSOIL AND OVERBURDEN TEMPORARY PLACEMENT



Appendix 4 page 5

THE THREE 'MILLS FREIGHTLINES' MINERAL LEASES
(Approximate scale 'No distances given on ML documents')

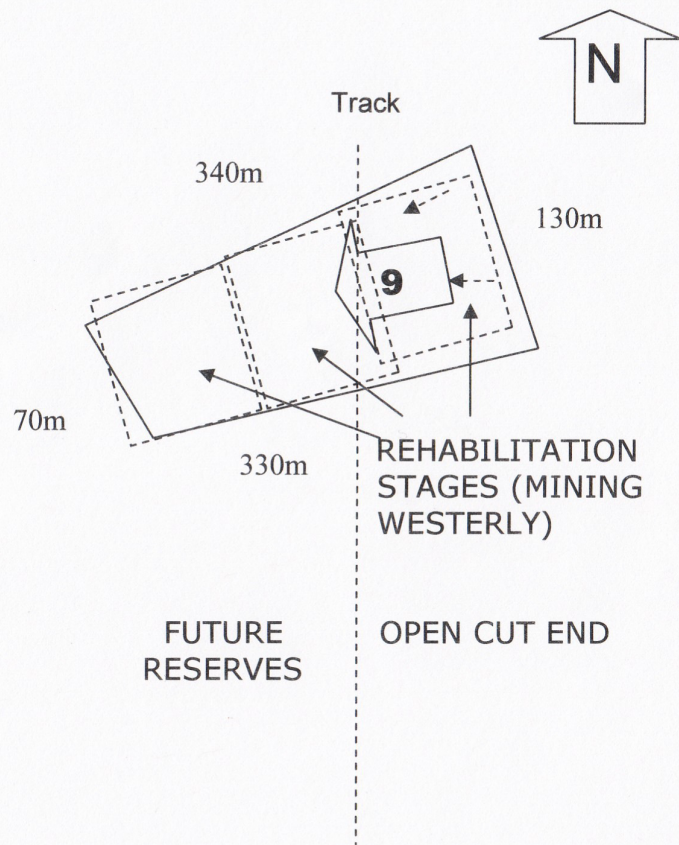






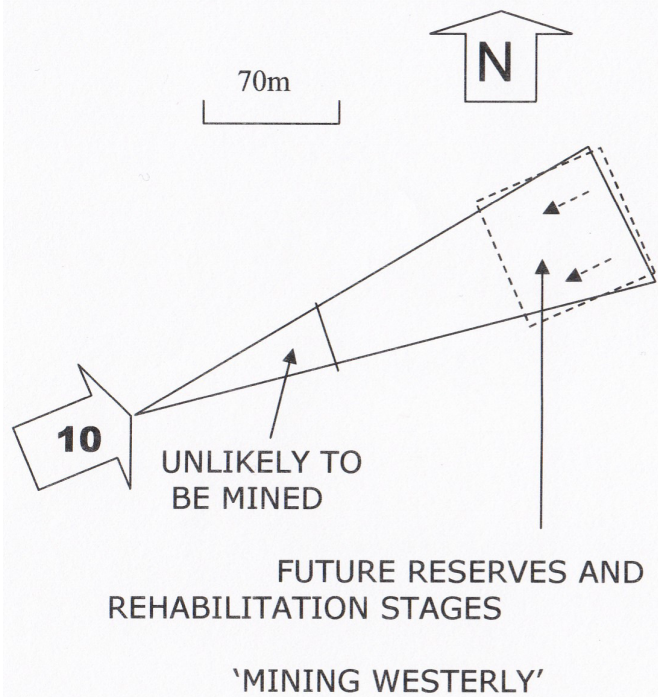
SITE PHOTOS
(Morgan gypsum photo 12 October 2012)

ML 734



SITE PHOTOS
(Morgan gypsum 12 October 2012)

ML 733

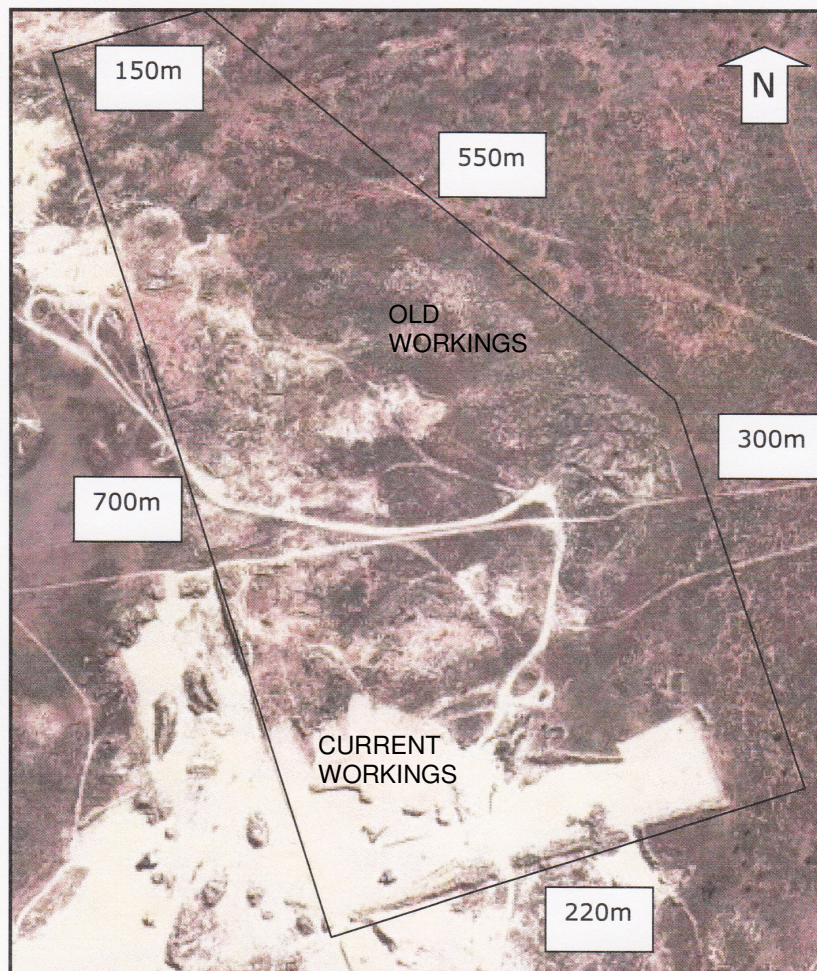


Appendix 6
SITE OPERATOR ACTIVITY SHEET
Monitoring and compliance record

DATE	TOPIC	ACTION TAKEN	ACTIONER	DATE CLOSED

Attachment 1

“VEGETATION DESCRIPTION AND SUMMARY OVER ML665”



A ground survey conducted on 12 October 2012 by D. Keane (*Botanical Consultant*) indicated a highly disturbed site, both from past and present activities (mining and grazing). The native vegetation is comprised of common 'mallee species' and chenopodiaceous under-shrubs. The current mine areas are a dot in comparison with the hundreds of km² of heavily grazed surrounding lands. The mine site can not be effectively controlled for the detrimental affects on the vegetation as it is under grazing pressures. Some old and wind battered isolated trees exist and consist of low mallee and she-oak. There are no significant or conservation rated species found during the survey. To my knowledge there are no known protected wildflower or protected native plant species present. Smaller understorey plants were absent and have been grazed out. There is a little more diversity on the dune areas rather than the flat surrounding plain. The only 'declared weed' found was the exotic box thorn. Some minor introduced weeds/grasses were present, assumed as being brought in by stock as pasture species.

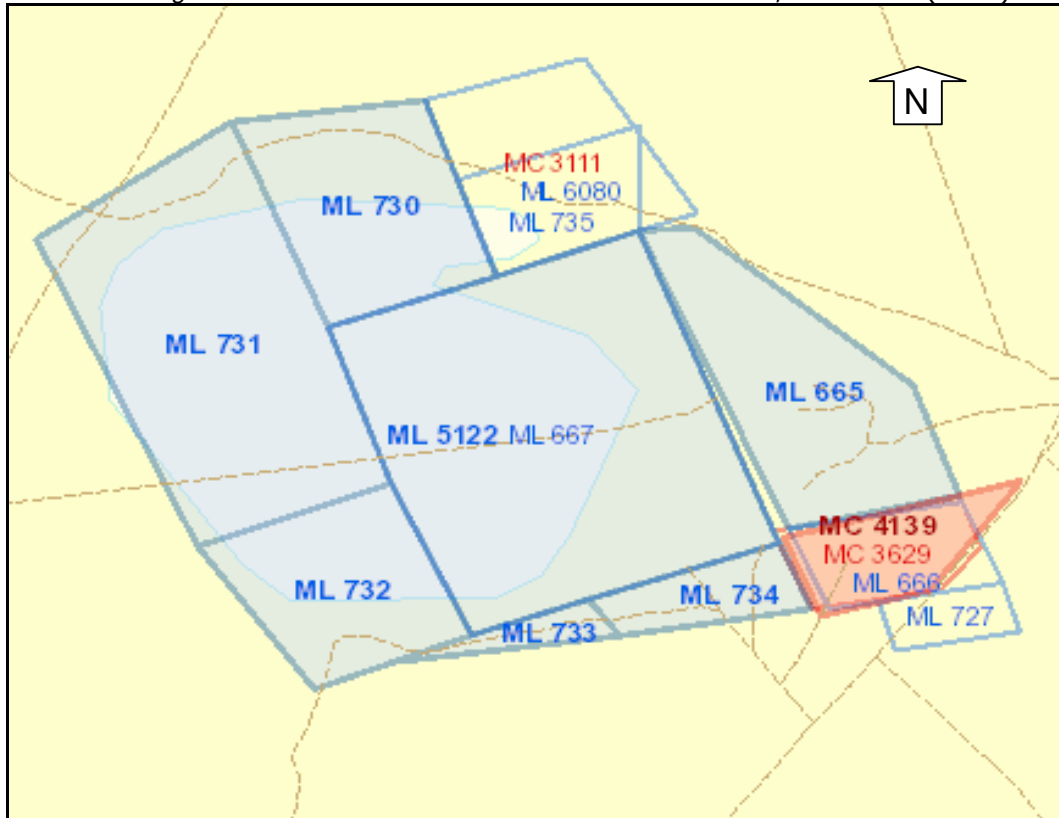
The Mill's Leases mostly chenopods "blue bush and black bush" *Atriplex cinerea*, *lindleyi*, *paludosa* complex; *Maireana pyramidata*, *sedifolia*; *Sclerolaena divaricata*; 'common twinleaf' *Zygophyllum* sp. In my experience (D. Keane, botanist and rehabilitation expert) of rehabilitated land after mining, if no invasive weeds are present, the land regenerates more readily and with a greater number of species. The downside for this site is that stock will always be present. Note: Vegetation is similar on all other leases.

Ref: Photos in appendix 5 page 1 for monitoring condition 'control site' of the vegetation.

SARIG. MINING TENEMENT RECORD

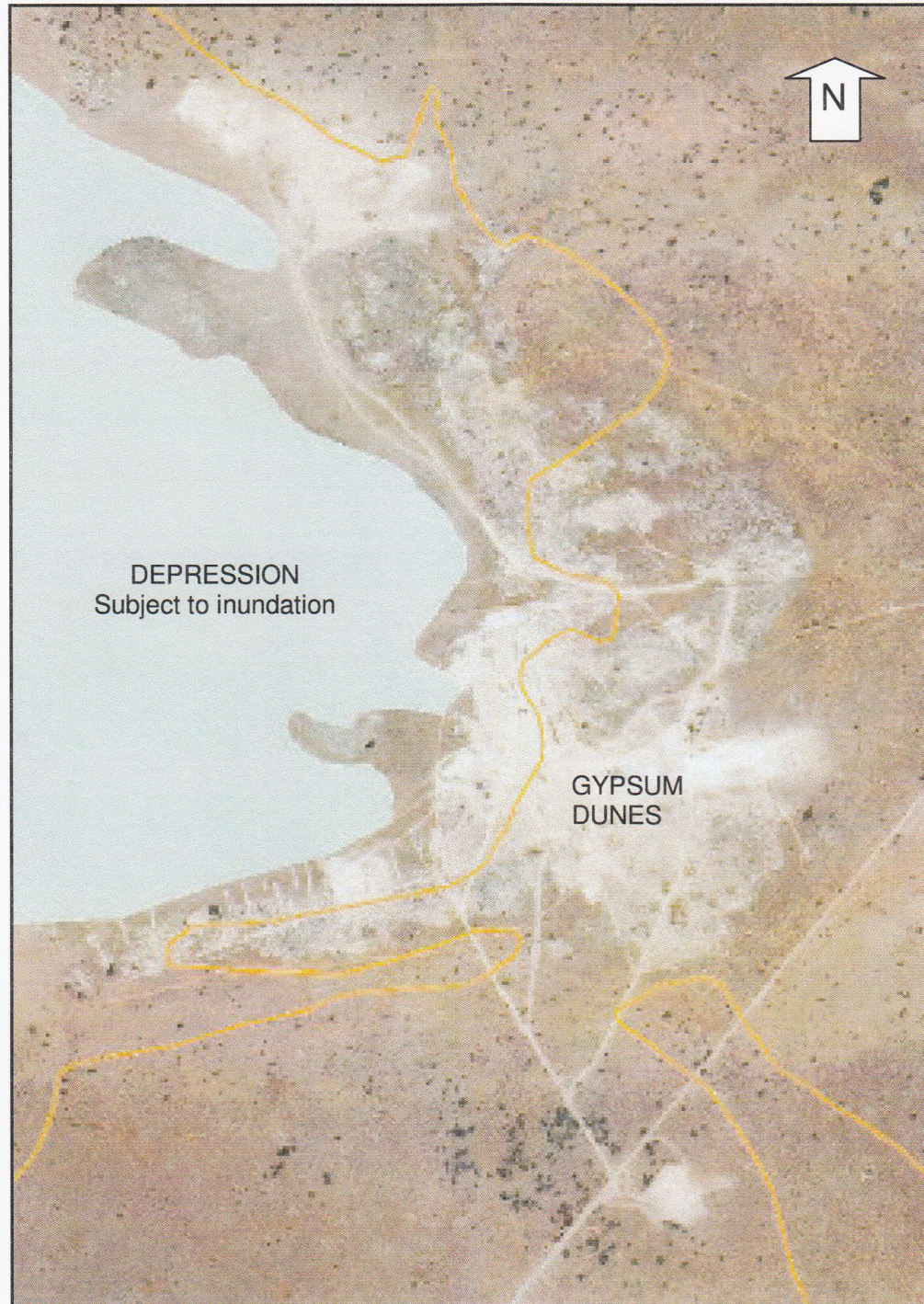
Ref: DSD 2 August 2013

PEPR ML 733,734 & 665 (2014)

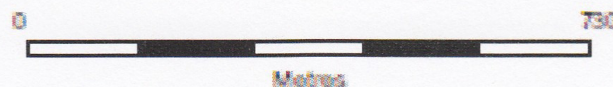


Tenement #	Tenement Holder	Commenced	Expiry
ML 655	Mills Freightlines Pty Ltd	1/4/1981	30/6/2016
ML 733	Mills Freightlines Pty Ltd	1/7/2002	1/7/2016
ML 734	Mills Freightlines Pty Ltd	1/7/2002	1/7/2016
ML 730	WI & RI Neldner	1/7/1973	30/6/2015
ML 731	WI & RI Neldner	1/7/1973	30/6/2015
ML 732	WI & RI Neldner	1/7/1973	30/6/2015
ML 5122 (ML667)	WI & RI Neldner	18/4/1983	30/6/2015
ML 6080	Craig Marshall	18/8/2000	17/8/2007
ML 735	Craig Marshall	18/8/2000	17/9/2007
ML 666	Craig Marshall	6/8/2009	5/8/2010
ML727	PIRSA	9/9/1949	9/9/1949

AERIAL MAP SHOWING MAIN GYPSUM MINE AREAS AND ACCESS TRACKS



Nature Maps 2012



Gypsum in agriculture

— quality standards in place as demand grows



John L. Keeling and A. Max Pain (Principal Geologists, Mineral Assessment Branch, Office of Minerals and Energy Resources)
T. Adrian Beech (CSIRO Land and Water, Adelaide Laboratories)

Introduction

SA gypsum production in 1999 was 1.8 Mt, of which almost 300 000 t (17%) was for agricultural uses. This is a four-fold increase on the 1993 production of agricultural gypsum and reflects a sustained growth in demand, particularly since 1995 (Fig. 1). The period since 1993 has seen the discovery and development of new gypsum resources in the Meningie district, formation of an incorporated Gypsum Industry Association of South Australia (GIASA) to promote and develop standards for agricultural gypsum, and significant investment by Processed Gypsum Products Australia Pty Ltd in upgrading crushing and screening facilities at their Blanchetown deposit to meet expanded production targets. The introduction in late 1999 of new quality standards for agricultural gypsum in SA was the catalyst for a baseline sampling program by PIRSA of current producers, the results of which are summarised in this article.

Gypsum in agriculture

Gypsum is used in agriculture primarily to improve productivity on sodic soils. It

is also a cost-effective source of sulphur, and is widely applied to soils showing sulphur deficiency or for crops requiring high levels of sulphur.

Soil sodicity is a significant problem in Australia, affecting almost one-third of all soils, including a third of all agricultural soils. It is a more widespread form of land degradation than soil salinity and causes poor water infiltration, surface crusting, erosion and water logging. The cost to agriculture is estimated to be in excess of \$2 billion/year in lost production. Sodic soils result from the build up of sodium ions adsorbed onto the surface of clay-sized particles in the soil. A sodic soil is defined as one in which >10–15% of the clay's negative charge is balanced by sodium ions. Monovalent sodium ions have a much weaker attractive electrostatic force to bind clay particles than is the case with divalent cations such as calcium or magnesium. The application of low salinity water on sodic soils, by rainfall or irrigation, causes dispersion of the clay particles leading to breakdown of the soil structure, clogging

of pores, surface sealing, crusting and hardsetting (Naidu *et al.*, 1993). These processes, combined with an induced higher incidence of water logging and erosion, reduce seedling emergence and crop establishment, resulting in increased crop losses.

The application of gypsum to sodic soils provides a source of calcium ions to replace sodium which, provided that drainage is adequate, will be mobilised away from the crop root zone. Calcium ions act to stabilise clay aggregates and help to re-establish soil structure and thereby improve permeability. The effectiveness of the treatment will depend on a variety of factors which can be assessed by appropriate soil tests. Application rates are influenced by the amount of sodium to be replaced and can vary from 1 to 10 t/ha of pure gypsum. Natural gypsum sources vary in the level of impurities and particle size, which need to be taken into account when determining the rate of application and effectiveness. Repeated applications may be required to successfully ameliorate the soil.

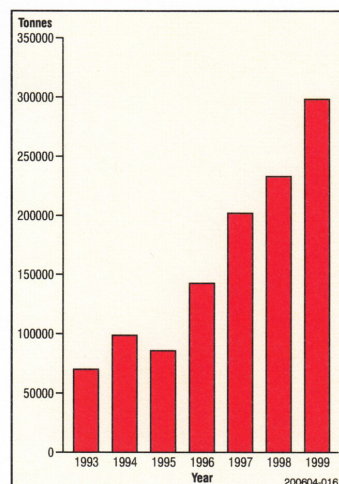


Fig. 1 SA gypsum sold for agricultural purposes, 1993–99.



Splitting and weighing gypsum samples at Elephant Lake. (Photo 47712)

Information



Crushing and screening plant at Blanchetown gypsum deposit. (Photo 47713)

Gypsum is a source of sulphur and is an effective means of treating sulphur deficiency in soils. Sulphur is a plant nutrient essential for the formation of proteins. Sulphur deficiency in soils can lead to reduced plant growth and lower protein levels. This is more common on light textured soils in higher rainfall areas and more often affects crops that have a higher sulphur content, such as canola. Plants can only take up sulphur in the form of soluble sulphate ions. Pure gypsum contains 55.8% SO_4^{2-} or 18.6% sulphur by weight. For canola, application rates of 5–15 kg/ha of sulphur every 3–5 years is often sufficient to prevent sulphur deficiency, depending on soil texture and rainfall. This equates to an application rate for pure gypsum of approximately 25–80 kg/ha.

Geology of SA gypsum deposits

Widespread formation of gypsum during the Late Pleistocene and Holocene times in SA produced numerous deposits suitable for commercial exploitation. These can be broadly classified as either coastal salinas or continental playas. Coastal salinas are gypsum in-filled salt lakes, up to 20 x 8 km. The lakes formed as a result of sea-level rise which drowned interdunal valleys in Bridge-water Formation carbonate dunes adjacent to the present coastline (Warren, 1982). The lake deposits are important resources for the plaster and cement industries, with the largest development being Gypsum Resources Australia (GRA) Pty Ltd's operation at Lake MacDonnell (Fig. 2); 1999 production was 1.3 Mt.

Continental playas are inland salt lakes in which gypsum deposition

occurred under different climatic conditions to the present day; the last major phase of playa gypsum formation was 18 000–16 000 years ago (Bowler, 1978). Continental playas typically formed as depressions in a clayey substrate where the watertable is normally below the surface of the lake sediment. The lake filled only after heavy rain and, as the water evaporated, the salinity increased and fine-grained gypsum was precipitated. When the lake dried out, the top of the gypsum sediment was eroded by deflation into lunettes around the margin of the lake. Either the accumulated lake sediment or the adjacent lunettes contain the bulk of the resource. Playa lake deposits provide most of the gypsum used in agriculture. Some playa deposits are also important sources of cement-grade gypsum and can contain substantial resources suitable for plaster manufacture. Major SA deposits are at Blanchetown, Cooke Plains, Lake Malata, Gordon Lagoon, Everard, Morgan, Rotten Lake and Meningie (Fig. 2).

Natural gypsum product used in agriculture shows a wide variation in grade and physical characteristics that reflect variation in the geological setting of deposits. Common impurities include calcium and magnesium carbonates, quartz sand, clay, common salt and organic matter. Grain size varies from fine crystalline gypsum silt, typical of lake sediments in the Meningie deposits, through free flowing, medium to coarsely crystalline gypsum sand (gypsarenite or seed gypsum), typified by lunettes mined at Cooke Plains and Morgan, to partly cemented gypsarenite (Blanchetown) and, rarely, very coarse lens-shaped gypsum crystals, both of which may require crushing to meet size grading specifications. Most gypsum

deposits also develop a surface layer of fine-grained gypsum silt (gypsite or flour gypsum) which forms by dissolution of gypsarenite exposed to rainfall infiltration followed by recrystallisation on evaporation. In some deposits, the gypsite layer may be several metres thick and of higher grade than the underlying gypsarenite.

Quality legislation

In 1997, GIASA sought State Government cooperation with the introduction of standards for gypsum used in agriculture, in line with those already adopted in Queensland and Victoria. After a period of industry consultation, PIRSA Farm Chemicals Group introduced to Parliament regulations under the *Agricultural Chemicals Act 1955* that included a quality grading system and labelling requirements for agricultural gypsum. The amendments to the regulations were gazetted on 30 September 1999 and are summarised in Table 1.

Table 1 Quality standards applicable to gypsum products used as fertilisers.

Grade	
Premium	At least 16.7% w/w sulphur (89.7% $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$)
Grade 1	At least 15% w/w sulphur (80.5% $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$)
Grade 2	At least 12.5% w/w sulphur (67.1% $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$)
Grade 3	At least 10% w/w sulphur (53.7% $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$)
Size grading	At least 80% <5.6 mm
	At least 50% <2 mm
Moisture content	
Maximum permitted is 15%	
Heavy metals (max. levels permitted — g/kg)	
Cadmium	0.01
Mercury	0.005
Lead	0.1

Labelling requirements

Gypsum products sold for agricultural use must be accompanied by advice which includes the following minimum information:

- Grade (Premium, First, Second or Third)
- Natural gypsum content (w/w% $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$)
- Calcium content (w/w% Ca)
- Sulphur content (w/w% S)
- Percent passing 2 mm sieve
- Percent passing 5.6 mm sieve

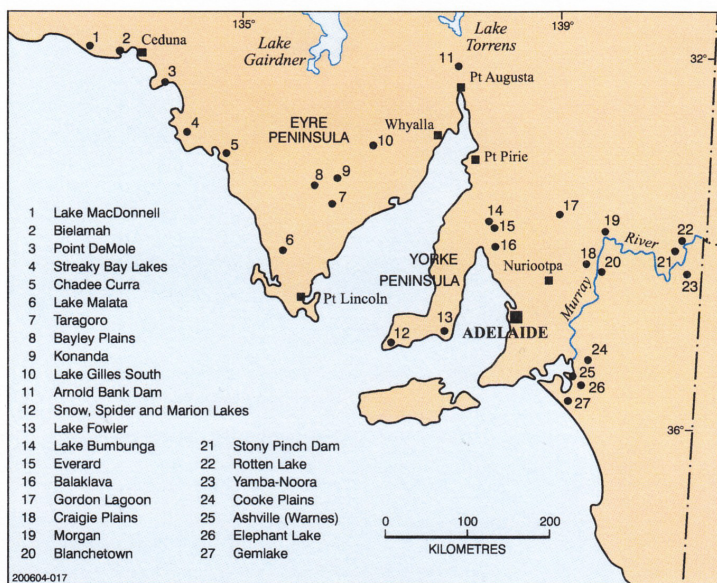


Fig. 2 Gypsum deposits in South Australia.

- If sodium content exceeds 0.8% w/w (equivalent to 2.0% NaCl), the label must note that continual application may have a detrimental effect on soil and/or a warning that the fertiliser is not suitable for reclamation of saline sodic soils.

Sampling program

To assist with introduction of the new legislation, PIRSA undertook a sampling program of gypsum stockpiles, where available, during January–March 2000. All 33 pits in SA currently producing gypsum product for agriculture were visited. The results were communicated to individual producers in May. Samples were collected using 1 and 2 m long, 50 mm diameter polypipe driven into the stockpile at a large number of points. These were reduced on site using a sample splitter to give ~5 kg bulk samples, which were sealed in plastic bags to minimise moisture loss. Where the miner produced more than one product, samples were taken from each of the stockpiles.

The results of 28 samples reported in Table 2 are considered representative of stockpiles from recent production at 23 mining operations.

Analytical methods

The experience of GIASA members is that gypsum analyses can show wide

variation between testing laboratories. In part this is due to individual laboratory protocols on sample drying and the degree to which free moisture and water in the crystal structure of gypsum are removed prior to analysis. For this project, all samples were analysed by the CSIRO Land and Water Analytical Chemistry Unit, Adelaide; the full method is outlined below. While methods vary between laboratories, this will not necessarily affect the validity of the result. However, when comparing

results between laboratories it is important to understand the basis on which the results are reported.

From each bulk sample, an ~10 g subsample was accurately weighed into an aluminium container and dried overnight at 60°C. The free moisture content was calculated from the weight loss. The dried sample was finely ground, 0.4 g weighed into a glass beaker, and 10 mL concentrated nitric acid added. The sample was digested on a hot plate at 150°C for 30 minutes until 2 mL of acid remained. Water was added to dilute to ~100 mL, warmed and decanted through a washed, tared Whatman No.42 (2.5 µm pore size) filter paper into a 250 mL volumetric flask. A further 100 mL of water were added to the residue, warmed, and the solution and remaining residue washed through the filter paper into the flask. Any remaining residue was transferred to the filter paper and washed with further water to make the final volume up to 250 mL. The filter paper was dried at 60°C and weighed to determine the weight of insoluble residue.

The solution was analysed by Inductively Coupled Plasma Optical Emission Spectroscopy (ICPOES) for Al, B, Ca, Cd, Co, Cu, Fe, K, Mg, Mn, Mo, Na, P, Pb, S and Zn. The concentration of elements in the original sample was calculated to the oven-dry basis. Silica content (SiO₂) of the dried, ground sample was determined separately by X-ray fluorescence (XRF) spectroscopy.



Sampling stockpiles of gypsum from the Blanchetown deposit. (Photo 47714)

Information



Gemlake gypsum stockpiles. (Photo 47715)



Gypsum screening plant at the Everard deposit. (Photo 47716)



Loading gypsum at the Cooke Plains deposit for transport to NSW. (Photo 46772)

The amount of gypsum in the sample was determined from the sulphur content and calculated by multiplying the sulphur percentage by 5.37. The calculation assumes that all the sulphur is contained in gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$). The sodium

chloride equivalent was calculated by multiplying the sodium concentration by 2.54. Calcium carbonate equivalent was determined by measuring the volume of CO_2 evolved from a weighed subsample of the dried, ground sample.

The as-received sample was sieved through 5.6 and 2 mm sieves. The weight of sample retained on the 5.6 mm sieve and the weights of sample passing the 5.6 and 2 mm sieves were used to calculate the fraction of sample passing each sieve size.

Discussion of results

The results summarised in Table 2 indicate the range of natural gypsum products currently available in SA for agricultural use. The grades are representative of gypsum, on a dry weight basis, held in stockpiles at the time of sampling. These may change over time due to variations within individual deposits and it is the responsibility of producers to provide up-to-date analyses of the products they have for sale.

In this survey, all samples met the specifications for size grading and all had concentrations of cadmium and lead below the specified maximum levels. Concentrations of NaCl ranged from 0.04 to 1.3%, all below the 2% level required to carry a warning label. Gypsum grades, on a dry weight basis, ranged from a low of 38.9% to over 90%. All samples contained some free moisture in the range 0.3–10.7%. Free moisture content will vary depending on the nature of the gypsum deposit and the weather conditions at the time of sampling. Both the grade of the gypsum and the moisture content need to be taken into account when determining the quantity of gypsum supplied and the application rate.

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