ENSHAM RESOURCES PTY LIMITED

LATEST ADDITION

ENSHAM COAL PROJECT
YONGALA MINE

ENVIRONMENTAL MANAGEMENT OVERVIEW STRATEGY
NOVEMBER 1992

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SECTION A

ENVIRONMENTAL MANAGEMENT OVERVIEW STRATEGY

1.0 INTRODUCTION

This Environmental Overview Strategy (EMOS) has been prepared to cover the development of the Yongala Mine which is the initial phase of the Ensham Coal Project. The Yongala area lies immediately to the north of the main Ensham area and is being developed first while factors which presently inhibit the development of the Ensham area are resolved.

Ultimately the Yongala mine will be integrated with the Ensham Mine.

The Yongala Mine is proposed to be an opencut coal mining operation using a single dragline for overburden removal and producing 900,000 tonnes of product coal per annum.

Mining will be conducted in three pits designated Yongala South (YS), Yongala Central (YC) and Yongala North (YN). Only Pit YC will be mined during the first five years. Experience gained in mining Pit YC will be utilised in planning the other pit areas.

This document supports the Yongala Mining Lease Application.

1.1 Yongala Area Exploration History

The right to the Ensham area was granted to the original Ensham Joint Venture in 1984 and the initial phases of exploration covering potential opencut coal reserves were undertaken over the three year period 1985 to 1987. The main target coal seams for exploitation were the Aries–Castor seams. The area of the Exploration Permit (EP505C) is shown on the Regional Locality Map (Figure 1).

The first holes in the Yongala area were drilled as part of the 1986 drilling programme with the first hole being drilled within the boundary of the Yongala property in April, 1986. During the 1986 drilling programme, 30 boreholes were drilled within the Yongala area for a total of 2043 metres and included one large diameter corehole and one slim corehole. Analysis of these cores indicated that the Pollux seam improved significantly in quality compared to elsewhere in the Exploration Permit area and was of export quality in the raw

state. During 1989, further drilling was carried out with the aim of defining the extent of the Pollux seam throughout the Yongala area.

In 1991 a more extensive exploration programme was undertaken within the Yongala boundary. Analysis of 16 coreholes confirmed the excellent quality of the coal and the specific characteristics that would enable the coal to be marketed in the raw state. In May 1992 a 1 tonne sample was forwarded to Japan for combustion testing purposes.

In-situ opencut reserves of Pollux seam coal down to an economic mining ratio of 12:1 are currently estimated at approximately 30 million tonnes. Significant additional reserves of coal suitable for underground extraction are known within the area.

In November 1990, the Minister for Resource Industries granted the present Joint Venture the rights to the area under EP505C and in April, 1992 the Minister granted to this new Joint Venture a Mineral Development Licence (MDL 117) over a portion of the Yongala area.

On June 25, 1992, an application was made for a Mining Lease (MLA 70049) covering part of Portion 3, Parish Yan Yan, County Talbot, "Yongala". This move was a further step in a progressive strategy which began in 1986 to develop an export coal mine utilising the available high quality resource of the EP505C area.

1.2 Yongala Development

Feasibility studies for the development of a coal mine on the EP505C area commenced in 1986 and have continued since that time. The first potential development was based on mining the Aries-Castor seam where it coalesces into a common 4m to 6m thick seam and which is located on Figure 1 under the description "Ensham Mine Lease". The mine identified was an opencut dragline operation involving three draglines and with a planned production tonnage of 3.6 million tonnes per year.

In January 1991, application was made for two mining leases (7459 and 7460) which covered the proposed mining area. Attached to the mining lease applications was an Impact

Assessment Study (IAS) which had been prepared earlier to guidelines which had been provided by the Queensland and Commonwealth Governments. However these applications are still in the Warden's Court due to a series of legal actions between the original Joint Venture partners.

The exploration for the Pollux seam identified sufficient coal reserves north of the Ensham mine to offer the possibility of mining a high energy steaming coal which would not require washing in order to meet export specifications. Further, this site was not subject to the same legal difficulties that had delayed the development of the Ensham mine.

Ensham Resources is contractually committed to supplying a minimum quantity of 350,000 tonnes per annum to the export coal market commencing in early 1994 and it is considered that the international market can support the planned production level of 900,000 tonnes per annum.

The current overall development plan is to commence development of the Ensham Coal Project on EP505C with a small mine at Yongala using only the YC Pit for the first few years until the market can support a larger operation. For the first five years the coal from Pit YC will be railed from an extension to the existing Fairhills rail siding. To maintain the required supply of Pollux seam coal, Pits YS and YN will be phased in as coal from Pit YC is depleted. As demand increases the Ensham mine will also be developed and the Yongala pits integrated with it. From that time the coal will be railed through the Ensham rail loop and spur line.

The development of an economically viable mine at Yongala poses some special considerations because of its small size relative to most of the coal mines in Central Queensland. The Yongala mine cannot support the level of capital expenditure, particularly on infrastructure, which characterises the existing large coal mines. The development proposed includes many innovative approaches to construction, operations and workforce as a means of overcoming the above difficulty to ensure that this operation can be developed as a sustainable and viable operation.

The environmental requirements and investigations for the Yongala area have been discussed with officers of The Department of Minerals and Energy and The Department of the Premier, Economic and Trade Development. Results of those discussions were that the environmental requirements for the Yongala area would be satisfied by adopting the strategies defined for the Ensham mine in its final Impact Assessment Statement (IAS) augmented by an Environmental Management Overview Strategy (EMOS) for the Yongala mine. The scope of environmental investigations for the EMOS was agreed and is included as Appendix 1 to this report.

The IAS has been approved by the Queensland and Commonwealth Governments.

2.0 PROJECT DESCRIPTION

2.1 Geology/Coal Quality

2.1.1 General

A detailed geological description is included as Appendix 2 from which the following summary is drawn.

The coal reserves within the Exploration Permit area occur within the Late Permian Rangal Coal Measures. The main seams present are, in ascending stratigraphic order, the Pollux, the Castor and the Aries seams. Exploration has generally concentrated on a large opencut resource (the "Ensham" opencut area) along the eastern boundary of the Exploration Permit area where various splits of the Aries and Castor seams coalesce to form a 4–6 metre thick seam at shallow depth.

Reserve drilling undertaken in 1985 and 1986 indicated that the Pollux seam improves significantly in quality at the northern end of the Ensham opencut area. In 1991 a drilling program was instigated to investigate the extent and quality of the improved Pollux seam within the "Yongala" area.

The 1991 drilling program verified an average Pollux seam thickness of 2.58 metres over a strike length of 5.5 kilometres and laboratory testing identified the Pollux seam as a by–pass quality steaming coal with low ash (±10%) and high energy (±7100Kcal/kg) characteristics (whole seam basis).

2.1.2 Stratigraphy

The generalised stratigraphy of the region is depicted in Figure 2. The uppermost significant seam encountered in the Yongala area is the A21 seam which has a thickness ranging from 0.50m to 1.81m and averaging 1.33m. A thin (average thickness 0.44m) A22 seam is generally present about 1–2m below the A21 seam but it is not considered to be of economic significance in this area.

The interburden between the A22 seam and the underlying Castor seam varies from around 5 metres in the south of the area to 23 metres in the north in the region where the Castor seam coalesces with the underlying Pollux seam.

The Castor seam shows a considerable variation in thickness from an average 0.7m in the south of the area to around 1.7m in the north although the seam remains relatively high in ash content throughout the Yongala block. The interburden between the Castor seam and the underlying Pollux seam is about 25 metres in the south of the area and thins to the north. In the far north of the area the Castor and Pollux seams coalesce.

The Pollux seam is the lowermost significant seam intersected in the Yongala area and the primary mining target. The seam is characterised by a consistent thickness averaging 2.58m, a low raw coal ash content (average 10.61%), and high raw coal energy (7100 Kcal/kg) on an air dried basis.

2.1.3 Reserves

Mineable in–situ reserves have been calculated for the Pollux seam and the A21 seam within MLA 70049 using data from the 1991 drilling programme. Table 2.1 shows these calculated reserves. A further 7.3 Mt of Castor seam is also present but has been excluded from the reserves at this stage because of its high ash (>25%) and low yield (<50%).

Marketable reserves have been calculated for Pit YC by applying mining recovery factors and allowing a 100% yield as the coal does not require washing. Table 2.2 summarises these reserves.

Table 2.1

Yongala MLA Mineable *In-situ* Reserves

Seam	YS Pit (tonnes)	YC Pit (tonnes)	YN Pit (tonnes)	Remaining MLA (tonnes)	Total (tonnes)
A21	-	702,000	-	4,181,000	**4,883,000**
Pollux	2,660,000	4,981,000	3,610,000	8,629,000	**19,880,000**
Total	**2,660,000**	**5,683,000**	**3,610,000**	**12,810,000**	**24,763,000**

Table 2.2

Pit YC Marketable Reserves

Seam	Mineable *In situ* Reserves (tonnes) A	Mining Losses (tonnes) B	Marketable Reserves (tonnes) A-B
A21	702,000	121,000	581,000
Pollux	4,981,000	493,000	4,488,000
Total	**5,683,000**	**614,000**	**5,069,000**

The mining losses noted in Table 2.2 are to account for the following:

- Allowance for coal extraction losses of 100mm from the roof of each coal seam as it is exposed, and from the floor of each coal seam to minimise the risk of dilution taking the unwashed coal out of specification.

- Exclusion of all areas of coal less than 0.5m thick.

- In-situ tonnages are stated at inherent moisture (approximately 3.5%). A moisture correction was made to reflect the 8% total moisture content of actual product coal.

Although Pit YC contains only 20% of the mineable in-situ coal within MLA 70049 it is planned to recover the remaining 80% firstly by the development of Pits YN and YS and secondly by extension of reserves to the down dip areas on the western side of the three initial pits.

Mining loss and moisture adjustments will be made to the YN and YS pit reserves as mine planning progresses and more knowledge is gained from further drilling and actual mining in Pit YC.

2.2 Mining Methodology

2.2.1 Pit Layout

Three pits designated as Yongala South (YS), Yongala Central (YC) and Yongala North (YN) have been defined to extract the Pollux and A21 seams at Yongala. Pit YC was selected for initial development because it is structurally undisturbed and has the longest strike length.

The Pollux seam LOX runs south to north along the base of a gently sloping valley. It dips at 3° to 4° to the west over most of the area so that the pits are bounded by the Pollux LOX on the eastern side and the maximum economic depth on the western side.

The southern extent is bounded in part by several hills which place the seams beyond the economic open-cut depth, and by the proximity of the boundary with the future Ensham mine area. Pit development south of Pit YS will be delayed until it can be merged with the northern end of the Ensham mine.

At the northern end of Yongala the seam strike changes from north-south to east-west following the curve of the regional syncline. The change occurs sharply along the boundary of Pits YC and YN so that while the YS and YC pit strips run north-south the Pit YN strips will run east-west. This means that the spoil from Pits YS and YC will be cast to the east while the spoil from Pit YN will be cast north.

At the current stage of planning all three pits have been designed down to the 12:1 overburden ratio line based on the Pollux and A21 seams. The majority of drilling has been concentrated in the area between the Pollux and A21 seam subcrops. Since the A21 subcrop line corresponds closely to the Pollux 12:1 overburden ratio contour, the highwall limits of the pits are generally just west of the A21 LOX. Thus very little A21 seam is included in the pit reserves. As further drilling and seam modelling better defines the A21 seam it is expected that extensions to the western limits of the opencuts will become possible within the mining lease area.

2.2.2 Creek Diversion

The channel of Boggy Creek coincides approximately with the LOX line and it is therefore necessary to create a diversion channel for the creek. The proposed location for the diversion channel is approximately 200m east of the LOX line. This provides room for emplacement of the boxcut spoil. The diversion channel has been designed for a 20% Annual Exceedance Probability (AEP).

The right to construct the diversion, and its design, are subject to the approval of the Queensland Water Resources Commission under the provisions of the Water Resources Act 1989. A design report (BHPE 1992b) including hydrological considerations has been prepared and submitted to the Commission for approval.

2.2.3 Mining Method

Overburden Excavation

Mine planning has been based on the use of a Marion 8050 dragline as the primary equipment for overburden removal. Rehandle estimates and scheduling rates are based on this machine working a standard extended bench method, although this may be varied to suit site conditions encountered during mining. Overburden depths range from 20m to 55m so that at no point is the dragline beyond its dig depth in the YC pit. Rehandle across the pit varies from 30% in the boxcut area to 27% in the second strip and then up to a maximum of 41% as the mining depth increases in subsequent strips. Initially only the Pollux seam will be uncovered and the Castor seam will be discarded with the overburden. By the fourth strip the A21 seam will start to appear in the highwall and it will be necessary to work a two pass dragline sequence to mine both the Pollux and A21 seams.

As the dragline will only be working over a 3km strike length it will be possible to use a single stubline from the 66kV feeder. It will not be necessary to carry out regular stubline relocations. The dragline will always work to the north or south from the central ramp, always exposing coal away from the ramp. There will generally always be a mining face available on either side of the ramp.

Inspection of the core and drill cuttings indicates that overburden blasting will not be required. The top sections of overburden consist of sand and highly weathered clay. These grade down into highly plastic mudstones and sandstones which should be diggable for the dragline without blasting. It is considered that maintaining open blastholes will be difficult in the upper sandy materials and it is doubtful as to whether blasting will be effective in moving or loosening the mudstones and sandstones above the coal.

2.2.4 Coal Mining

Both the Pollux and A21 seams range from 2.0m to 2.6m thick. Inspection of the core suggests that the coal is weak enough for seams of this thickness to be mined unshot and unripped using a large wheel loader. It is expected that up to 100mm of coal will be lost from the roof of each seam as it is exposed. This is less than commonly experienced by open-cut operations but the elimination of overburden blasting will result in much less disruption to the seam roofs. A further loss of 100mm has been allowed for the coal seam floors. This is because the immediate floors consist of soft, dark, coaly mudstones and it considered preferable to leave some coal in the floor rather than risk dilution in the high quality raw coal product. If coal ripping is required special care will need to be taken to ensure that the floor material is not mixed with the coal.

2.2.5 Coal Haulage

Coal will be hauled from the face over an 8km haul road to a crushing and loadout station located adjacent to the Gregory railway line.

It is planned to purchase three bottom dump coal haulers. The bottom dump trucks will place the coal in low rows at the crusher area. Cycle time estimates show that it will only be necessary to have two trucks available to haul coal during each day shift.

2.3 Infrastructure

2.3.1 General

The facilities to support the Yongala mining operation have been designed for minimum capital cost.

2.3.2 Industrial Area

The mine support industrial area will be located on the eastern side of the mining area close to the haul road. The industrial area will consist of a small workshop sized to carry out routine and simple breakdown maintenance functions.

Adjacent to the workshop will be a small store enclosure constructed to house basic stock items.

A small office facility will be constructed to house the mine management staff and will provide administrative services for the mining operation.

2.3.3 Crushing and Loadout

The coal crushing and load-out sequence is shown in Figure 3. Two wheel loaders will be used to reclaim coal from the run of mine (ROM) stockpile to feed the crusher, and to load train wagons from the crushed coal stockpile. These loaders will be fitted with $14m^3$ coal buckets.

The crushing circuit commences with coal being loaded into a bin from the ROM stockpile. The coal falls onto a feeder which passes coal into a 3m diameter, 7m long rotary breaker. The 65 mm dia. holes on the breaker are sized so that most of the coal will break and pass through for direct conveying to the product stockpile.

A rail spurline will be constructed on the Gregory railway just south of the Fairhills siding. A 100m length of this spurline adjacent to the product stockpile will be used for loading the

rail wagons. Each train will have a capacity of 2,750t made up of 51 wagons carrying 54t each. The two wheel loaders working together will be able to load a train in 2 hours.

2.4 Supporting Services

2.4.1 Rail

The transporting of 900,000 tonnes per annum of Yongala coal will be carried out under an agreement to be entered into between Ensham Resources and Queensland Railways. The coal will be hauled to the Clinton Coal Facility in Gladstone from the siding to be constructed close to Yongala on the main Gregory line.

Queensland Railways has agreed to the use of a double header electric train (two electric 110 tonne locomotives) hauling 51 bottom dump wagons. This is a smaller train than the average central line train which consists of four electric locomotives and 102 wagons hauling 5,500 tonnes of coal, but is designed to suit the temporary nature of this rail storage and loading facility.

Trains to be loaded with coal from the Yongala mine will reverse into the siding from the existing Fairhill Loop. Upon completion of coal loading, the train will pull forward into the Fairhill Loop and after the locomotives have been repositioned, the train will travel south to Gladstone. Overhead electric wiring on the new siding will be terminated prior to the loading area to enable the safe use of wheel loaders in the train loading operation.

The average turnaround time for the train is expected to be in the range of 25 – 30 hours for the haul distance of 352 kms. The annual task of hauling 900,000 tonnes will require 327 train trips. Trains will be loaded at a rate of 1,500 tonnes per hour by the two wheel loaders and unloaded at the Clinton Facility at a rate of 4,000 tonnes per hour through the Gladstone Port Authority's facilities.

2.4.2 Port

Yongala coal will be exported through the Clinton Coal Terminal at the Port of Gladstone. This is a common user coal export terminal servicing the rail unloading, storage and shipping of coal for a number of export coal mines.

The terminal commenced operations late in 1980 and at present, exports up to 15 mtpa of coal. The terminal was developed initially to serve the Gregory Mine and has been progressively expanded to service the needs of other mines in the Central Queensland area. Further expansion is currently underway with an ultimate capacity in excess of 30 mtpa possible.

The Clinton Coal Facility is owned and operated by the Gladstone Port Authority and can cater for vessels in the 25,000 – 220,000 DWT range.

With the commissioning of the wharf extension to the Clinton Coal Facility in August 1989, a dual berth now exists for loading vessels. The berths are both designed to handle vessels up to about 220,000 DWT. Loading however is still carried out by the one mobile gantry loader which traverses between the berths. The new berth achieves quicker turnaround of vessels since the loader is able to shift from No. 1 to No. 2 berth to commence loading the next vessel in berth. A second rail unloading facility was commissioned in 1991.

Vessels are loaded by means of a travelling gantry loader at a loading rate of 4,000 tonnes/hour.

A ninth stockpile area has recently been completed and the facility now has a stockpile capacity of 2.5 million tonnes. Sufficient stockpile and handling facilities are either in place now or will be constructed prior to the time the first Yongala coal is received at the port.

2.4.3 Power

Electric power for the dragline operation and support services at Yongala will be provided by Capricorn Electricity from their Lilyvale substation. Power for the main Ensham mine will be provided by a short extension from the Yongala mine area when this section of the project proceeds.

High Voltage Supply

Electricity will be transmitted to the Yongala site via a 66kV transmission line from the Lilyvale substation located approximately 34km north of the mine site. This transmission line will terminate at the Yongala mine area and will later be extended to the main Ensham mine. Supply will be extended to the infrastructure and pit areas via overhead 11kV lines.

Site Distribution

It is proposed to extend the 11kV power supply from an 66kV/11kV substation, installed under the 66kV line from the Lilyvale substation, via 3.5km of 11kV overhead line to the accommodation and workshop/office area, and via a further 7.5km of 11kV overhead line to the train loadout area.

A pole-mounted 11kV/433V transformer will be installed adjacent to the accommodation area to supply the accommodation main distribution board and the workshop and office distribution board. A further pole-mounted transformer will be installed adjacent to the train loadout facility to supply the train loadout switchboard which will incorporate motor control functions.

The railway siding will be floodlit to allow train loading at night as required by Queensland Railways.

2.5 Operations Strategy

An innovative approach has been planned for operations and manning in order to achieve the high level of productivity necessary to make such a relatively small mine economically viable. The approach is based on the following inter-related strategies:

- A multi-skilled workforce that eliminates demarcation disputes and reduces overall manning.
- A roster system which is based on working 12 hour shifts for seven days, followed by seven days off work.
- A single 12 hour day shift for operations and maintenance staff except for dragline operators and support staff who would operate two shifts per day.
- Accommodating the workforce on site in motel style units and with meals provided.

Discussions have commenced with the Coal Mining Union (CFMEU) on the broad outline of working arrangements.

The workforce will start and finish work at Yongala. Recruitment would carefully consider the effects of proposed working arrangements not only on the potential employee but also on their family. While there are families where the proposed lifestyle would not be appropriate, it is considered that many in the area bounded by Springsure, Blackwater, Emerald, Clermont and Anakie, and extending to Rockhampton would find the seven day on / seven day off roster attractive.

The workforce will travel to Yongala by a number of routes (viz; Wyuna Road, Gregory Mine Road, and Blackwater via Bedford Weir). With the roster system proposed a minor increase in local traffic will be caused once a week. Manning for the proposed operation will result in a maximum of 35 personnel on site in any week with the remaining 29 personnel rostered off.

The proposed organisation structure is shown in Figure 4.

2.6 Accommodation

2.6.1 General

The concept of providing permanent single accommodation on the mine site varies from the normal arrangement in the Bowen Basin of providing detached housing in a nearby town for the mine workforce and families.

With the work roster requiring the employee to work seven (7) daily twelve hour shifts and then have the next seven (7) days away from the mine site, a total of 28 employees will be working the day shift each week with seven employees working the night shift. Each of these employees will have meals provided in the central messing and recreational complex.

2.6.2 Accommodation for Workforce

A high standard of motel style accommodation will provide comfortable living conditions for employees during the seven days rostered–on at the mine site.

Each employee will have their own self–contained, air–conditioned, furnished, single accommodation unit which will consist of a lounge room, bathroom, bedroom, store room and verandah.

Two single accommodation units will be available in each of 33 separate buildings. A central hard stand area will be provided for employee car parking.

The General Manager and Division Managers will be accommodated in houses that are to be purchased in Emerald. These four employees will work a normal 5 day week.

2.6.3 Catering

Accommodating the mine workforce at the mine site and working a seven days on/seven days off roster system necessitates the provision of a catering service to supply meals.

The caterers will provide all meals to suit the two 12 hour shift operation in a central complex which will consist of a canteen building, a kitchen, toilet facilities and a games/sports room with bar provisions. These buildings will be joined by a covered outdoor area.

The caterers will be responsible for the weekly cleaning of the accommodation units and the weekly changing and laundering of linen in the units. There will be daily cleaning of the canteen and the games/sports room.

A laundry facility will be provided complete with washing machines and dryers for the use of the employees for laundering their clothes.

3.0 ENVIRONMENTAL IMPACTS AND CONTROLS

Environmental impacts and control strategies for the resources, values and issues agreed to within the scope of environmental work (Appendix 1) are discussed in the sections following. Where information has been based on detailed field surveys and studies, a summary and interpretation has been provided in the relevant section with the complete detailed study\survey included as an appendix.

Figure 5 illustrates the proposed development schedule for Yongala. The primary components include the pre-mining environmental studies, the mine establishment phase and the mining phase. At the time of writing the EMOS, the environmental studies phase had been completed. The interrelationship between mining and the environmental components relevant to Yongala are discussed in Section 7.3.

The detailed analyses for this report have been based on the initial mining area of Pit YC. The principles outlined will apply to subsequent mining areas as they are brought into production.

4.0 LAND RESOURCES

4.1 Description of Existing Land Resources

This section considers various attributes of the physical environment which will be affected by or have some impact upon the proposed mining operation. Specific aspects, which have been considered in detail in Appendix 3, include;

- Surface geology.
- Landform and related soil type.
- Soil physical and chemical properties and soil erodibility.
- Existing land use and current condition.
- Land suitability for agricultural/pastoral purposes.
- Characterisation and handling of overburden materials during the mining operation.
- Various aspects of land care and rehabilitation including the availability and use of topsoil resources.

The key elements of the land resources evaluation are summarised in the sections following.

4.1.1 Land Use and Current Condition

The only current land use within the study area is beef cattle grazing on predominantly native pastures of low to moderate productivity with some areas of introduced pasture species, mainly Buffel grass. The Yongala property which comprises the major part of the area of

interest for the mining project is currently in a moderately to severely degraded condition. The rating of "Erosion Status" in Table A3.1 in Appendix 3 largely reflects the current condition of the land in that those areas which are potentially susceptible to land degradation due to the existing soil types and drainage conditions, are already in a substantially degraded condition.

In places deep erosion gullies have developed along many of the gently inclined natural drainage ways (see Figure 6) within the property. The size and severity of gullying is largely attributable to the occurrence and generally dispersive nature of the surficial soils and substrate materials in those areas, exacerbated by the effects of uncontrolled surface water runoff resulting from high intensity storms. Quite commonly the initiation of these "badlands" type of erosion features can result from overgrazing by stock and other animals, or may be due to local soil/drainage effects. Whatever the cause, once developed to an advanced state, these types of erosion features are difficult and expensive to contain and rehabilitate successfully.

Elsewhere on the property, mainly on the gently inclined mid-slopes below the red (lateritic) soil crestal plains, frequent small to locally quite extensive occurrences of surface scalding (bare areas) are evident. These areas may also reflect local soil/drainage effects, such as downslope subsurface drainage discharge zones with possible increased salinity or even higher nutrient levels which pre-dispose those areas to concentrated grazing by cattle. Irrespective of the origin of these features, once the areas become devoid of surface vegetative cover they are susceptible initially to sheet erosion and to the subsequent development of increasing levels of gully erosion.

4.1.2 Land Capability/Land Suitability

Land capability refers to the evaluation of land attributes for broadly defined land uses using current technology and management. A land capability evaluation provides a means to identify appropriate end land uses and subsequently determine rehabilitation strategies and techniques. Land suitability, on the other hand, refers to the evaluation of land attributes based on the requirements for a specific crop or crop group, using current technology and management.

Whilst the land at Yongala may be available for other land uses – for example as a commercial forest or as a native fauna reserve, only the land suitability classification for beef cattle grazing on improved pastures has been assessed in this report. This is because of the existing and previous land use history and the limited potential for other agricultural uses. In deriving the land suitability classes for cattle grazing on improved pastures, the approach outlined by Shields and Williams (1991) for a land resource survey and evaluation of the Kilcummin area Queensland, has been adopted.

Table A3.5 in Appendix 3 summarises the process and limitations considered in deriving the land suitability class ratings and provides an additional evaluation of potential grazing management options relevant to the various types and classes of land assessed.

The assessments have been made on a land unit basis and the occurrence of the various land suitability classes determined are shown on Figure 16 in Appendix 3. Table A3.5 also includes indicative stocking rates for occurrences of the various soil/landscape units identified in terms of unimproved and improved pasture conditions. The indicated stocking rates have been determined in consultation with the Queensland Department of Primary Industries in Emerald (pers. comm. G. Bourne).

Accordingly, given the fairly diverse ranges of land types which are included within the designated mine site development area (i.e. the study area), the estimated overall average stock carrying capacity in the unimproved state is of the order of 1 beast per 15 ha of land.

4.1.3 Spoil characterisation

The spoil characterisation study detailed in Appendix 3 indicates that overburden materials likely to be encountered during mining operations will not generate acid mine drainage, are generally low in salinity compared to most Bowen Basin overburden materials, are highly sodic in the surface strata decreasing in sodicity with depth, and are low in nutrients. The high sodicity materials are likely to affect plant germination and for this reason use of topsoil is considered desirable. No other limitations have been identified.

4.1.4 Topsoil Resources

The spoil characterisation study has identified the need to use topsoil replacement as an important means of achieving a successful land rehabilitation strategy in terms of revegetation potential. In order to assess the suitability of soils within the study area for rehabilitation purposes, representative profile samples of each of the main soil types were submitted for chemical and physical characterisation. The results of the testing programme undertaken are summarised in Tables A3.3 and A3.4 in Appendix 3.

A topsoil suitability assessment and an estimate of resource depth has been undertaken based on a soil type/land unit basis. The topsoil resource assessment is presented in Table A3.6 in Appendix 3.

The term topsoil generally refers to that part of the profile which has the highest organic matter content including seed stock and micro–organisms. However certain profiles have a subsoil layer which may provide a useful supplementary resource when good topsoil resources are limited. Accordingly the topsoil resource assessment in Table A3.6 (Appendix 3) also includes an assessment of additional useable subsoil resources which may be useful in the rehabilitation process.

The availability of topsoil resources and indicative soil stripping depths within the study area are shown in Figure 17.

In summary, the best quality topsoil resources will be available from the brigalow, and brigalow–blackbutt soil landscapes (terrain units Qa2/5.1, Cz2/5.1 and Cz3/5.1–4.3). From these areas, the upper 25 cm of the profile will provide a substantial volume of topsoil. Accordingly this layer as well as the ash bed derived from clearing and burning, will be stripped and stockpiled. The uppermost material has sufficiently fine soil structure to provide the preferred growing medium for Buffel grass and other introduced pasture species. Monitoring of rehabilitated areas will refine the preferred topsoil handling procedure.

The surficial soil layers of the texture contrast soils within Soil Group 4 will provide a useable resource. The uppermost 15 cm with the ash bed combined will provide the best

quality material but close supervision during stripping operations will be necessary as these soil types often have a poor quality subsurface (A2) horizon which may not be suitable for rehabilitation use.

In general, the gradational red earth soils including the lateritic variants have acceptable textural properties for topsoil use. However they are normally deficient in nutrients due to strong leaching. Hence heavy fertiliser applications will be necessary. Apart from the access road and haul road, the mining operations do not affect significant areas of these soil types.

4.2 Impacts on Land Resources

The method of open–cut mining inherently produces complete disturbance of land areas associated with the open–cut, out–of–pit spoil emplacements, haul roads and other infrastructure development. For the Yongala mine, the areas listed in Table 4.1 will be affected in this way.

Table 4.1

Area Affected by Mining and Associated Activities (Pits YS, YC and YN)

Site	Area (ha)
Open – Cut	285
Out–of–Pit Emplacements	150
Haul Roads	15
Infrastructure	1–2
Dams	1–2

The activities listed above will result in major changes to both land capability and land use in the short term.

The existing land use and associated suitability for the Yongala area has been discussed in Section 4.1. The progressive rehabilitation strategy and landform design proposed for

Yongala and outlined in Section 4.3, aims to install a similar land use as exists currently for the majority of the area to be disturbed. Some areas such as the leading face of the out–of–pit spoil emplacement and the final void will be rehabilitated to a land system suitable for native vegetation species and wildlife habitation.

Changes in land suitability in the longer term are presented in Table 4.2 which has been estimated from figures presented in Appendix 3. The basis for the evaluation of land suitability in the post–mining situation is based on Section 4.3.2 of Appendix 3. This table indicates that for disturbed areas resulting from mining operations at Yongala there will be a net loss of Class 2 and Class 3 land along with a net gain of Class 4 and Class 5 land.

Table 4.2

Pre–Mining and Post–Mining Land Suitability
Disturbed Area Analysis (Pits YS, YC and YN)

Suitability Class	Pre–Mining Situation		Post–Mining Situation	
	Area (ha)	%	Area (ha)	%
2	92	21	0	0
3	231	53	155	35
4	109	25	155	35
5	3	1	125	30

The proposed decommissioning strategy will remove all infrastructure that is not of any use to these final land uses.

The Boggy Creek diversion will also remain, however this is considered to be a replacement of an existing watercourse and as such is not a change of land use.

4.3 Control Strategies/Proposed Rehabilitation Techniques

4.3.1 General

Due to the number of variables (rainfall, temperature, site conditions, etc) that are able to affect the success of a rehabilitation programme, the procedures specified in this report are proposed as guidelines which will provide the best chance for the ongoing success of the rehabilitation programme.

4.3.2 Vegetation Clearing

Vegetation clearing will be conducted as a first step in the rehabilitation programme. Trees and undergrowth will be progressively cleared by bulldozer in advance of mining operations. Log piles will be burnt shortly before topsoil removal with ash being collected along with the topsoil.

4.3.3 Topsoil Management

The importance of topsoil to the rehabilitation programme from the chemical perspective has been identified by the spoil characterisation study (Appendix 3). Furthermore, the topsoil layer generally contains plant nutrients, organic matter, microbes and has a water holding structure not usually available in the overburden materials. Therefore, topsoil management and re-use has been accorded a high priority in the overall management plan.

Stripping of topsoil will, as far as is practicable, be undertaken during the dry season and not following any prolonged wet periods. This will reduce the potential for soil compaction and for degradation of the soil structure due to mechanical handling of soils when in a wet condition.

Topsoil stripping depth classes for all areas to be disturbed for the life of the mine have been determined and are provided in Figure 17. Stripping depth boundaries will be pegged to provide an indication to operators of the expected changes in stripping depth.

Useable topsoil resources for the YC pit area have been determined as being 375,000 m^3 resulting in sufficient material being available to provide a nominal cover of 15 cm over reshaped areas allowing for some losses in handling.

At the commencement of mining operations, it will be necessary to stockpile all stripped topsoil until such time as reshaped areas are available to receive freshly stripped topsoil. The stripping and respreading of topsoil in one operation will always be carried out in preference to stockpiling.

Changes in soil properties will occur immediately the soils are stripped and stockpiled. However, most changes in physical and chemical properties of the soils are likely to occur within the first 12 months of storage. Thereafter, changes, if any, are likely to proceed at a slow rate. Biological changes, such as a decline in mycorrhiza propogules and seed viability are likely to occur with extended storage periods if ameliorative measures are not adopted. It is planned therefore, to seed all stockpiles which will be retained for periods of 3 months or more with the pasture species planned for revegetating reshaped areas. This practice will also reduce the potential for weed infestation and the resultant weed seed store accumulation in the stockpiled soils.

At infrastructure sites, soils will be stripped to the depths prescribed in Appendix 3, stockpiled temporarily and then utilised for rehabilitation. However, as required by local authorities and land owners, designated areas will be left ungrassed as firebreaks for the protection of property.

Topsoil replacement will be conducted as near as is practicable to the sowing period. To achieve this schedule, a realistic target rehabilitation area will be determined each year by the Manager–Operations and Environment (MOE) after giving due consideration to the time required for each component rehabilitation procedure and the time available prior to the onset of the sowing period.

For topsoil that is being stripped concurrently with the topsoil replacement operation, the following principles will apply;

- access and departure roads to the designated area will be established and adhered to;
- equipment will work, wherever possible, along the contour;
- equipment will not traverse previously dumped topsoil.

For the above principles to be met, topsoiling will commence at the top of a slope and proceed downslope as depicted in Figure 7.

Following topsoil respreading, vehicular access to the designated rehabilitation area will be restricted.

4.3.4 Overburden Placement

The spoil characterisation study (see Appendix 3) indicates that acid mine drainage will not be experienced. The spoil characterisation testing undertaken indicates that the spoil material will present less problems to plant growth than for overburden typically found in the Bowen Basin region. However, the material is moderately saline, highly sodic and prone to dispersion. The progressive rehabilitation programme and use of topsoil management methods proposed will alleviate spoil deficiencies and minimise the potential for erosion.

Based on the results of the spoil characterisation study (Appendix 3), it is considered that the nature and stratigraphy of the overburden is such that selective handling of any discrete strata is not warranted during the mining operation.

4.3.5 Landform Design and Reshaping

Two different approaches to rehabilitation will be adopted at the Yongala mine. For Pit YC the major proportion of the disturbed area consisting of approximately 150 ha will be rehabilitated to an undulating landform of conventional convex/concave slopes. Slope angles in this area will be limited to a maximum of 15% with average slopes marginally less than this.

The remaining area consisting of approximately 60 ha and including the leading face of the box-cut spoil emplacement and the final highwall and lowwall area will remain at angle of repose. This batter configuration will have an overall slope of 38° and an estimated maximum batter height of 35 m.

It is proposed to adopt a similar approach to rehabilitation for the other Yongala pits, however this will depend upon the success of the Pit YC rehabilitation as well as rehabilitation experience gained during the Pit YC operation.

Angle of repose rehabilitation is currently being trialled at a number of other open-cut coal operations in the central Queensland region. Support for this method is claimed from experience with constructed civil works and early results from Oaky Creek Mine (Lefebvre et al 1992).

It is proposed to monitor the rehabilitated angle of repose slopes to validate their stability and success of vegetation establishment. Proposed monitoring methods include the following:

- Visual inspections to determine the stability of the landform on the macro level will be undertaken on an ongoing basis.

- Sediment levels within the pit water dam will be monitored on an annual basis and related to the catchment area of the dam to estimate gross soil loss rates.

- Total suspended solids loads and flow rates will be monitored in Boggy Creek during runoff events and used to estimate gross soil loss rates from the proportion of Boggy Creek not affected by mining.

It is considered that the specification of appropriate and achievable criteria for a new operation is not feasible at this stage and may pre-empt the results of on-site and other research programmes (the University of Queensland is currently undertaking research to determine appropriate post-mining landscape parameters). For this reason it is proposed to develop criteria based on the results of the progressive rehabilitation programme and of the monitoring programme. Criteria developed for the angle of repose rehabilitation will cover

such parameters as soil/spoil chemical and physical parameters, vegetative (basal and canopy) cover, floristic species diversity and faunal invasion observations. Carrying capacities for the conventional rehabilitation areas will also be established and compared with determined pre-mining stocking rates (see Section 4.1.2). Such criteria will be able to be determined from the proposed monitoring programme (see Section 4.3.11).

Should rehabilitated areas be determined not to have achieved developed criteria then a combination of lower slopes and more intensive vegetation techniques will be utilised to achieve stability. The lower slopes will be achieved by pulling back the outside edges of the spoil to a nominal 1V:6H slope and placing the material on top of spoil from the later strips as shown in Figure 8.

Figure 8 provides a typical east-west cross-section showing the objectives of the reshaping programme.

In general, surface runoff from rehabilitated areas will be ponded internally. For Pit YC drainage will be directed to the north and south away from the central pit ramp. Any external drainage flows leaving the spoil emplacement will be intercepted by catch drains and directed to the pit water dam.

Contour banks will be established as a last phase of the reshaping programme. Contour bank locations and sizing will be determined based on reshaped landform, appropriate discharge points, slope length, and catchment area in accordance with accepted engineering methods. Contour banks will be compacted, topsoiled, cultivated and sown with selected pasture grass species chosen from those proposed for the revegetation programme. Banks will be inspected following sizeable rainfall events and those which are found to scour prior to the establishment of a moderate vegetative cover will be repaired as required.

Reshaping and revegetation will be undertaken on a progressive basis, i.e. when it is determined that an area of spoil dump will no longer be disturbed by subsequent mining operations then reshaping and revegetation will commence.

4.3.6 Revegetation – Undulating Pasture Area

Cultivation will be undertaken aiming to produce deep furrows along the contour. These contour furrows will achieve erosion control during the plant establishment phase as well as the keying of topsoil and subsoil layers, and the formation of a range of micro–climates and seed beds.

Surface cultivation will extend beyond the designated rehabilitation area to include equipment access roads where applicable. Surface cultivation will be carried out together with sowing as a one–pass operation.

Pasture species and native tree selections and sowing rates for revegetation purposes will be determined from on–site experience. Initial species and rates will be selected from the lists shown in Tables 4.3 and 4.4. All pasture legumes will be inoculated prior to sowing.

An application of 300 kg/ha of a starter type fertiliser will be made in conjunction with sowing. 50 kg/ha of fertiliser will be mixed with the seed and spread during sowing with the remaining fertiliser being spread subsequently.

Table 4.3

Pasture Grass Species for Revegetation

Scientific Name	Common Name	Rate kg/ha
Grasses		
Bothriochloa pertusa	Indian blue grass	4–10
Bothriochloa insculpta	Creeping blue grass	4–10
Cenchrus ciliaris cv Biloela	Buffel grass – Biloela	8–12
cv Gayndah	– Gayndah	8–12
Chloris gayana cv Pioneer	Rhodes grass – Pioneer	10–15
cv Callide	– Callide	10–15
Cynodon dactylon	Green couch	8–12
Panicum maximum var. trichloglum cv Petrie	Panic – Petrie green	8–12
Setaria incrassata	Purple pigeon grass	8–12
Sorghum spp. *hybrid* cv silk	Silk sorghum	10–15
Legumes		
Macroptilium atropurpureum cv Siratro	Siratro	5–10
Medicago sativa cv Trifecta	Luceme	5–10
Medicago spp.	Medic species	5–10
Stylosanthes guianensis var *intermedia* cv Oxley	Oxley fine stem stylo	8–12
Stylosanthes scabra cv Seca	Seca shrubby stylo	8–12

4.3.7 Revegetation – Batter Areas

Areas to be left with angle of repose batters will be rehabilitated with a mix of pasture grasses and native tree and shrub species selected from Tables 4.3 and Table 4.4.

Table 4.4

Native Tree Species for Revegetation

Scientific Name	Common Name	Rate kg/ha
Native Trees		
Acacia harpophylla	Brigalow	0.5
Acacia rhodoxylon	Rosewood	0.5
Acacia salicina	Cooba/Sally wattle	0.5
Acacia shirleyi	Lancewood	0.5
Casuarina cunninghamii	River Oak	2.0
Eucalyptus crebra	Narrow-leaved Ironbark	2.0
Eucalyptus maculata	Spotted gum	1.0
Eucalyptus melanophloia	Silver-leaved ironbark	1.0
Eucalyptus microtheca	Coolabah	1.0
Eucalyptus tereticornus	Forest Red Gum	1.0
Native Shrubs		
Acacia conferta	Crowded-leaved wattle	0.5
Acacia fimbriata	Brisbane wattle	0.5
Acacia ixiophylla		0.5
Acacia leiocalyx	Black wattle	0.5
Acacia macrodenia	Zigzag wattle	0.5
Acacia semilunata		0.5
Acacia semirigida		0.5
Acacia spectabilis	Pillaga wattle	0.5
Acacia stenophylla	River cooba	0.5
Cassia brewsteri	Leichardt bean	0.5

Hard-coated native species such as Acacias will require pre-treatment to break their dormancy. This will be achieved by placing the seed in boiling water for two to five minutes.

4.3.8 Erosion Control

Field observations and the materials testing programme undertaken has highlighted the potential for dispersion of many of the soil types present on site. The vulnerable areas identified (refer Table A3.1 Appendix 3), have been considered in the design of roads and associated drainage works.

Design of the access road and permanent haul roads within dispersive soil areas will ensure that excavation is minimised as much as practicable i.e. the formation will be built above the dispersive soil layer rather than excavating into or through those layers. Attention will also be given to scour protection both upstream and downstream of any culverts, which will generally be provided by rip rap.

The construction of the proposed diversion channel will intercept several existing and actively eroding gullies in dispersive soil situations. The base level of the diversion channel will in places be below the level of these existing erosion gullies. Where the presence of the diversion channel will lead to accelerated rates of erosion in adjacent undisturbed areas rock protection will be utilised.

As indicated in Appendix 3 the proposed mine area is currently in a seriously degraded state, primarily due to overstocking and lack of management of run-off in the dispersive soil areas. There is a lack of grass cover generally, some extensive local areas of scalds, and gully erosion on drainage channels leading into Boggy Creek. The Boggy Creek channel is subject to erosion during flow events. Mining, by effectively destocking areas surrounding the active pit, will promote recovery of the grass cover in these areas. The access road construction will effectively treat the drainage gullies it traverses and greatly retard further erosion in those gullies. However, existing gullies and scalds will remain and those not disturbed by mining operations will extend naturally with time.

4.3.9 Post Establishment Management

As discussed previously (Section 4.3.1), rehabilitation methods will be developed over the life of the mine through experience at the site. Throughout the mine life, the annual rehabilitation programmes will be monitored to create a database of on-site experience. During the initial rehabilitation seasons, appropriate criteria will be developed and rehabilitation methods will be refined to achieve these criteria. (See also Section 7.2).

The following are some of the aspects which will be refined and modified from initial site experience:

- Surface preparation
- Species selection
- Initial and annual fertiliser programmes

Management of rehabilitation areas will continue throughout the mine life and although it is difficult to specify the full range of management issues that will be encountered, it is likely that the following will be addressed:

- Fertiliser topdressing programmes
- Fire control – fire is to be restricted from rehabilitated areas until pastures and native trees and shrubs are of a sufficient age to withstand fire pressures.
- Access restriction and fencing – access to rehabilitated areas will be under the authority of the Manager–Operations and Environment. Fencing will be undertaken for stock management purposes.
- Vegetation management – species densities and weed species introduction is to be monitored and managed.
- Drainage system management and maintenance.

Subsequent to lease relinquishment, Ensham Resources will have lost management control over this area and will not be responsible for deteriorating land conditions that may arise if subsequent management practices employed by the landowner are unsatisfactory.

4.3.10 Implementation of the Rehabilitation Programme

Ensham Resources will employ a Manager–Operations and Environment whose responsibilities will include the following:

- supervision of clearing and topsoil management operations,

- co–ordination of reshaping and revegetation procedures,
- maintenance of drainage systems during the life of the mine,
- ensuring that adequate erosion control procedures are undertaken on all disturbed surfaces and embankments,
- monitoring of annual rehabilitation progress.

4.3.11 Monitoring

Topsoil nutrient and salinity testing will be conducted on an annual basis. It is envisaged that this will comprise a single composite sample at each of two depths per 20 ha of rehabilitated area. Analysis will include salinity, pH, and major elements.

Vegetation cover of both rehabilitated areas and selected control areas will be monitored on an annual basis. This will be achieved either by a short–focus telescope method and/or by airphoto interpretation. This will assist in monitoring the progress of the rehabilitation programme as well as providing an indication of the species composition and comparisons with adjacent unmined areas.

Visual inspections to determine the stability of the landform on the macro level will be undertaken on an ongoing basis.

Sediment levels within the pit water dam will be monitored on an annual basis and related to the catchment area of the dam to determine gross soil loss rates.

Total suspended solids loads and flow rates will be monitored in Boggy Creek during runoff events and used to establish gross soil loss rates from the proportion of Boggy Creek not affected by mining.

A cost control system will be established to enable costs associated with rehabilitation activities to be closely monitored.

4.3.12 Annual Rehabilitation Schedule

The progressive nature of the proposed rehabilitation programme is illustrated in the development schedule (Figure 5). Figure 9 indicates the annual rehabilitation schedule.

5.0 WATER RESOURCES

5.1 Surface Water Resources

5.1.1 Description of Existing Catchment Area

A full description of the regional drainage pattern is provided in the Ensham IAS (HDM 1991). The proposed Yongala mine site is located in the upper half of the Boggy Creek catchment. Boggy Creek like most creeks in the area, consists of a fairly well defined main channel, with sufficient capacity to handle the more frequent flood flows, and a substantial floodplain over which less frequent excess flows pass.

The total catchment of Boggy Creek is approximately 114 km^2 in area. The catchment area upstream of the northern end of the proposed Boggy Creek diversion is approximately 38 km^2. Boggy Creek is an intermittent watercourse with an elongated catchment area. This results in a rapid rise and fall response to storm events.

Two stock water dams exist on the upper reaches of Boggy Creek above the location of the proposed mine and there is evidence of a third dam whose wall has been breached. No other dams exist on Boggy Creek, however a number of minor stock water dams are located on tributaries to the creek. No stock water dams are located on the reaches of Boggy Creek below the location of the proposed mine and no other beneficial uses of water exist within the catchment.

The surface water quality of Boggy Creek and the Nogoa River is discussed in the Ensham IAS (HDM 1991). A water quality monitoring programme was established in 1991 and has collected additional data to that presented in the IAS. A summary of relevant water quality monitoring data collected since October 1991 is provided in Appendix 5. As Boggy Creek only flows intermittently, the only water quality data available have been obtained via rising stage samplers. The results obtained indicate that Boggy Creek maintains a very high suspended solids loading during the rising stage of natural flow events.

5.1.2 Impacts on Surface Water Resources

Boggy Creek Diversion

The primary impact on surface water resources is the disruption of Boggy Creek that will be caused by mining the coal reserves located under the creek. As discussed in Section 2.2.2 the approval of the Queensland Water Resources Commission is being sought for construction of a creek diversion channel to the east of the existing watercourse.

The current Boggy Creek watercourse is in an active state of erosion as evidenced by visual observation and water quality monitoring results. General design criteria have been applied to the diversion such that scour of the channel and downstream sediment deposition will not increase. Preliminary design for the diversion channel provides for a bed width of 10 m and side slopes of 1 V:2 H. These design parameters are based on a 20% AEP flood flow.

At the downstream transition between the channel and the natural creek bed, earthworks construction will ensure that existing flow conditions are maintained.

Water Supply

Potable water will be supplied either by groundwater or will be trucked to the site.

Water for dust suppression and washdown purposes will either be obtained from groundwater supplies or generated from within the mining area catchment which is bounded by a series of surface runoff diversion drains (see Figure 10). Any rainfall collected by the pit, or surface runoff from spoil emplacements or other disturbed areas will be transferred by a system of pumps and drains to a pit water dam located immediately to the south of the pit area. The pit water dam will be equipped with a standpipe and pump so that water is available for haul road watering and other mine uses.

5.1.3 Control Strategies

Boggy Creek Diversion

As mentioned previously the Boggy Creek diversion will be designed such that upstream and

downstream scour of the watercourse and subsequent deposition does not exceed pre-existing levels. The fencing of the mining lease to exclude stock will assist in the regeneration of vegetation adjacent to the diversion channel.

Mine Water and Stormwater Runoff

Control strategies for mine water and stormwater runoff have been integrated into a water management system based upon the segregation of various quality waters. The water management system proposed for the Yongala operation is schematically illustrated in Figure 10.

Runoff water from undisturbed catchments will be intercepted by diversion drains which will carry these flows to Boggy Creek downstream of the pit water dam.

Stormwater runoff from the spoil emplacements will flow either to the pit water dam via low-wall drains, or to the pit. As successive strips are rehabilitated and internal drainage developed, then the total runoff volume reporting to the pit water dam will decrease.

Water accumulating within the pit will be pumped to the pit water dam via pipeline when sufficient operating capacity is available within the dam. Pit water, based on investigations undertaken for the Ensham Project (BHPE 1992a) is likely to be moderately saline and slightly alkaline.

The use of undisturbed catchment diversion drains will result in a varying disturbed catchment area dependant upon the stage of mining and the area of internal drainage. It is estimated that this area will vary from a minimum of 120 ha to a maximum of 250 ha. As stated above, surface runoff from this area will be directed to the pit water dam either directly or via the pit. The pit water dam will have a capacity of 40 ML. Water from the pit water dam will be used for mine purposes.

Insufficient climatic and hydrological data are available for the Yongala area for a detailed water balance to be undertaken. However, interpolation of the results of the Ensham Coal Project Water Management Report (BHPE 1992a) to the upper reaches of the Boggy Creek catchment, as well as indications from the various drilling programmes that groundwater

accessions to the pit will be minimal (almost all holes drilled were found to be dry), indicate that the Yongala Mine will be a net user of water.

To assess the sizing of the pit water dam, a catchment yield analysis was undertaken. Estimated rainfall intensities for various durations and recurrence intervals (BHPE 1992b) were utilised along with temporal patterns extracted from Australian Rainfall and Runoff (IEAust 1987) to generate design storm hyetographs applicable to the pit water dam catchment. A design average recurrence interval of 1 in 10 years was selected based on Department of Environment and Heritage guidelines (DEH 1990) for a low hazard water quality and catchment areas ranging from 120 to 250 ha were assessed. A loss model consisting of an initial loss of 35 mm and a continuing loss of 2.5 mm/hr (BHPE 1992b) was applied to determine the rainfall excess.

Results of this analysis indicate that runoff volumes of 30 to 65 ML will occur during the critical duration design storm for disturbed areas of 120 ha and 250 ha respectively. A varying proportion of this water will flow directly to the pit water dam with the remainder being retained within the pit for subsequent pumping to the pit water dam. It is estimated that the proportion of runoff flowing to the pit water dam will vary from between 50% to 70%. These figures indicate that for a 1 in 10 year storm event and where the stage of mining is such that the maximum catchment area reports to the pit water dam, the pit water dam is likely to overflow. It is considered that the situation where the maximum catchment area is reporting to the pit water dam will only occur for a short period of time, and that for most events less than 1 in 10 reccurence interval, all runoff water will be contained within the dam.

The pit water dam will be protected by an emergency spillway to allow for overflow during extreme wet weather events. Water leaving the dam under these conditions will have undergone sedimentation in the pit water dam prior to overflow, and is expected to be of a quality better than or similar to that generated by the natural Boggy Creek catchment under extreme runoff conditions. Under such extreme weather conditions, dilution levels afforded by Boggy Creek will be high.

The techniques of waste segregation and management developed for Pit YC will be applied to subsequent mining areas.

The pit water dam will be relocated when mining in Pit YS commences.

Sewage

A package sewage treatment plant will be installed to provide secondary treatment of sewage generated on site. Sewage treatment plant effluent will be stored in a lagoon prior to disposal either by evaporation or by spray irrigation as required.

Loading Facility Stormwater Runoff

All stormwater generated from the loading facility and stockpile area will be collected by surface drains and directed to a sedimentation basin.

Monitoring

The water quality monitoring network established for the Ensham mine will be utilised to assess any impact on downstream waters.

5.2 Groundwater Resources

5.2.1 Description of Groundwater Resources

The regional geology for the proposed mine site has been described previously in Section 2.1.

Only limited hydrogeological investigations have been carried out within the Yongala mine area. This description of the hydrogeology of the area has been determined from information from the exploration borehole logs, standing water level measurements, chemical analyses of selected water samples and the geology of the area. Reference has also been made to the hydrogeology of the adjacent Ensham project area.

It appears that the primary groundwater system in the Yongala area comprises deep aquifers possibly associated with the Permian coal bearing strata.

It is considered that, as in the Ensham mine area, the Permian coal seams at depth in the

Yongala area may be aquifers. During the 1991 drilling programme almost all exploratory bores were reported as dry when drilled. However, standing water levels interpreted from geophysical logs taken some time after drilling indicate water levels below target seam depth in most cases. The permeability of the rocks, however, appears to be very low.

Based on water quality analyses of samples taken from bores located in the north of the Ensham mine area, the quality of water within these formations is variable but generally poor. Total dissolved solids concentrations from the bores in this area vary between 11,882 mg/L and 20,120 mg/L. Principal ions are Na and Cl and there is a high concentration of sulphate (708.6 mg/L to 913.5 mg/L). These waters are unsuitable for human or stock consumption.

Where boreholes intersect zones of increased recharge (e.g. faults or fracture zones) the quality of waters has been observed to improve significantly. A water sample was collected from an unpurged bore (2186) located within the Yongala area in an adjacent valley to the east of Boggy Creek. This sample had a total dissolved solids concentration of 4,370 mg/L which although suitable for stock watering, is unsuitable for human consumption. Investigations into the possibility of this area providing a potable water supply are continuing.

There is one water producing bore located adjacent to Boggy Creek near the northern end of the proposed mining area. This bore is currently used for stock watering purposes and, according to the landowner, depth to water is 53 m, well below the coal seam. No information is available relating to bore construction, lithology or water quality and it is therefore not possible to identify the source of water from this bore.

5.2.2 Impact on Groundwater Resources

Water Supply

It is intended to use runoff water collected from the pit and other disturbed areas as well as any groundwater intercepted by the pit for dust suppression purposes.

The potential for groundwater from the abovementioned zones of increased recharge to supply potable water for the workforce manning the mine is being investigated. Initial indications are that this water may not be suitable for human consumption however further testing is to

be carried out to confirm this. If suitable quality groundwater cannot be found on site, Emerald town water will be trucked to site.

Mining

Seepage from the coal seams into the pit will be transferred to the pit water dam and used for mine purposes.

An impact on the limited groundwater resources in the area may result if mining affects the only known stockwater bore on the Yongala property. If this impact eventuates an alternative stockwater supply will be provided.

Dewatering of the Permo–Triassic formations will be localised to the immediate vicinity of the mine due to the low permeability of these formations. However dewatering along the water bearing fracture and fault zones intersected by the mine will be much more extensive. If the only known stockwater bore is located in such zone then it is likely to be affected by mining.

The spoil characterisation study (see Appendix 3) indicates that acid mine drainage will not be produced. Therefore contamination of groundwater systems due to acid mine drainage is not expected.

5.2.3 Control Strategy

No significant impacts to the local groundwater resources are anticipated.

6.0 OTHER ENVIRONMENTAL IMPACTS AND CONTROLS

6.1 Noise and Air Quality

6.1.1 Air Quality and Noise Impacts

The major potential noise sources associated with the Yongala open-cut coal mining operation include haul trucks, the dragline, rail loading activities and possibly explosives. The major potential air quality impact is that arising from dust emissions caused by overburden and coal handling operations and blasting.

There are no residential premises within a 10 km radius of the proposed Yongala Mine site. Based on the results of air quality modelling and noise predictions undertaken for the proposed Ensham Mine to the south, and the distance to individual residences and residential areas, it is considered that there will be no nuisance caused by either noise or dust emissions from Yongala.

Ongoing air quality monitoring will continue throughout the life of the mine in conjunction with the Ensham environmental monitoring programme to confirm that air quality impacts do not attain nuisance values.

6.2 Conservation Values

6.2.1 Description of Biological Environment

A biological survey of the Yongala area was conducted and is detailed in Appendix 4. Mapping of the vegetation was carried out initially by reference to aerial photography, and verified by subsequent ground truthing. A fauna survey of the area was undertaken in conjunction with the vegetation survey.

The mine site and its surrounds include a number of vegetation communities with brigalow being the dominant species. The study area has been the subject of heavy grazing which has contributed to the generation of a number of scalded areas, generally on the lower hillslopes. Woody regrowth is a common feature of the study area including several *Acacia* spp., and understorey species.

6.2.2 Impact on Flora

None of the vegetation communities identified on the site are considered to have any particular significance, and all are well represented elsewhere in the region.

6.2.3 Impact on Fauna

The fauna of this area is relatively depauperate, a function of both the habitat and limited foraging opportunities. Water is available from a number of small dams established for stock watering purposes, however no permanent waterholes are present on the watercourses in this area.

Appendix 4 concludes that the absence of preferred habitat within the study area for the types of endangered species found within the brigalow belt, makes their presence in the Yongala area unlikely.

6.2.4 Control Strategies for Fauna and Flora

Based on the minimal impact on flora and fauna declared by Appendix 4, no control strategies are considered necessary with regard to the fauna or flora on the area to be disturbed by mining.

6.3 Heritage and Cultural Values

6.3.1 Impacts on Heritage and Cultural Values

An archaeological reconnaissance of the proposed Ensham Open Cut Area was conducted in November 1985 (ANUTECH, 1985). Whilst numerous open sites were located, the archaeological sensitivity of the areas was determined to be low and the potential for archaeological research limited.

The Department of Environment and Heritage register has been examined for the Yongala area and revealed that no other archaeological surveys have been conducted in this region.

There have not been any buildings or sites of non–aboriginal heritage value recorded in the Yongala area.

6.3.2 Control Strategies

No control strategies are considered necessary.

6.4 Social Issues

6.4.1 Impacts on Local Communities

The operations strategy has been detailed in Section 2.5. Manning for the proposed operation will result in a maximum of 35 personnel on–site during any one seven day period with a further 29 personnel rostered off and not on site.

It is considered that targeting the local workforce pool for recruitment of the small number of employees required will benefit the local community by the provision of jobs and additional local income without additional impact on local services.

The workforce will travel to the Yongala site once a week by a number of routes (viz; Wyuna Road, Gregory Mine Road, Blackwater via Bedford Weir) and hence will cause only a minor increase in road traffic in the area. This increase in traffic flows will occur only of the end at each work period i.e. once every seven days.

6.4.2 Control Strategies

No control strategies are considered necessary.

7.0 MONITORING, RESEARCH AND OVERVIEW SCHEDULE

7.1 Monitoring

A monitoring programme recording meteorology, noise, and air and water quality has been in place since October 1991 for the adjacent Ensham site. Monitoring of these parameters will be expanded to cover the Yongala site. Table 7.1 provides a summary of the monitoring provisions proposed for the Yongala site which have been outlined in previous sections.

7.2 Research

As mentioned previously, the rehabilitation methods utilised at Yongala will be developed through experience gained by monitoring each annual rehabilitation programme. It is also hoped to gain rehabilitation experience that will be applicable to the Ensham site.

As discussed in Section 4.3.5, it is considered that the specification of appropriate and achievable criteria for a new operation such as Yongala is not feasible at this stage and may pre-empt the results of on-site and other research programmes. It is therefore proposed to develop rehabilitation criteria based on the results of the progressive rehabilitation programme and of the monitoring programme. Criteria developed for the angle of repose rehabilitation will cover such parameters as soil/spoil chemical and physical parameters, vegetative (basal and canopy) cover, floristic species diversity and faunal invasion observations. Carrying capacities for the conventional rehabilitation areas will also be recorded and compared with determined pre-mining stocking rates (see Section 4.1.2). Such criteria will be able to be determined from the proposed monitoring programme (see Section 4.3.11).

7.3 Overview

A general overview schedule linking the various phases of mining and environmental management for the first 4 years of operation is presented as Figure 26.

Table 7.1

Summary of Environmental Monitoring Programme

Resource	No. Monitoring Sites	Monitoring Frequency	Monitoring Method	Parameters Measured
Land/Rehabilitation	All rehabilitated areas as well as a representative sample of adjacent unmined land.	Annual	Air photo interpretation	Canopy cover
	All rehabilitated areas as well as a representative sample of adjacent unmined land.	Annual	Short focus telescope	Basal cover Species composition
	All rehabilitated areas as well as a representative sample of adjacent unmined land.	Annual	Visual inspection	Macrostability/erosion
	2 x composite samples from ten sites, depths 0–10 cm and 20–30 cm	Annual	Laboratory analysis	pH, N, P, K, S, major ions, organic matter, EC, CEC, ESP
	1 (Pit water dam)	Annual	Staff reading	Sediment level
Surface Water Resources	2 x 5 (5 bottle rising stage samplers)	Following significant rainfall events	Laboratory analysis	Partial and full suites[1]
	1 (Boggy Ck Diversion)	Following significant rainfall events	Water level recorder	Water level
	1 (Pit water dam)	Quarterly	Laboratory analysis	Partial and full suites[1]
Groundwater Resources	1 (water supply bore – if utilised)	Quarterly	Laboratory analysis	Partial and full suites[1] Water level
	1 other bore	Annual	Laboratory analysis	Partial and full suites[1]
Air Quality	11–12 sites (including 8 Ensham sites)	Monthly	Laboratory analysis	Dust deposition

Notes: 1 Partial analysis includes field determination of pH and conductivity, as well as laboratory analysis of TSS.
Full analysis includes field determination of pH and conductivity, as well as laboratory analysis of TSS, TDS, EC and major ions and metals.

8.0 REFERENCES

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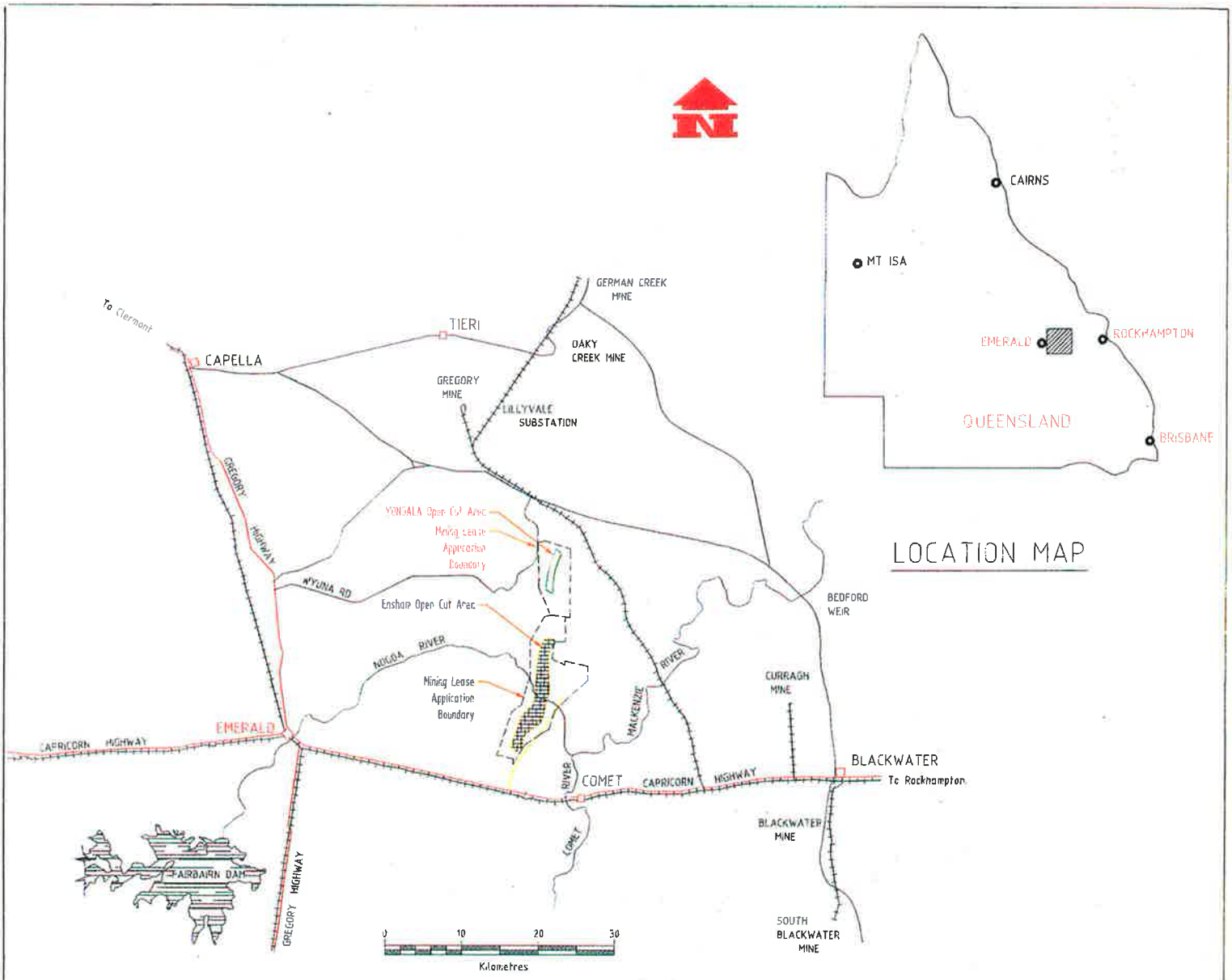
Shields, P.G. and Williams, B.M. 1991, *Land Resource Survey and Evaluation of the Kilcummin Area Queensland*, QDPI – QV91001 – Land Resources Bulletin.

SECTION B

FIGURES



DATE OF LAST EDIT= 5/8/92 CAD FILE : 2853

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Brisbane, 4000
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	Signature	Date
DRAWN	D.C.LYONS	31.7.92
DRN. CHK		
ENGINEER		
ENG. CHK		
SUBMITTED FOR APPR.		
ENSHAM Eng. APPROVAL		

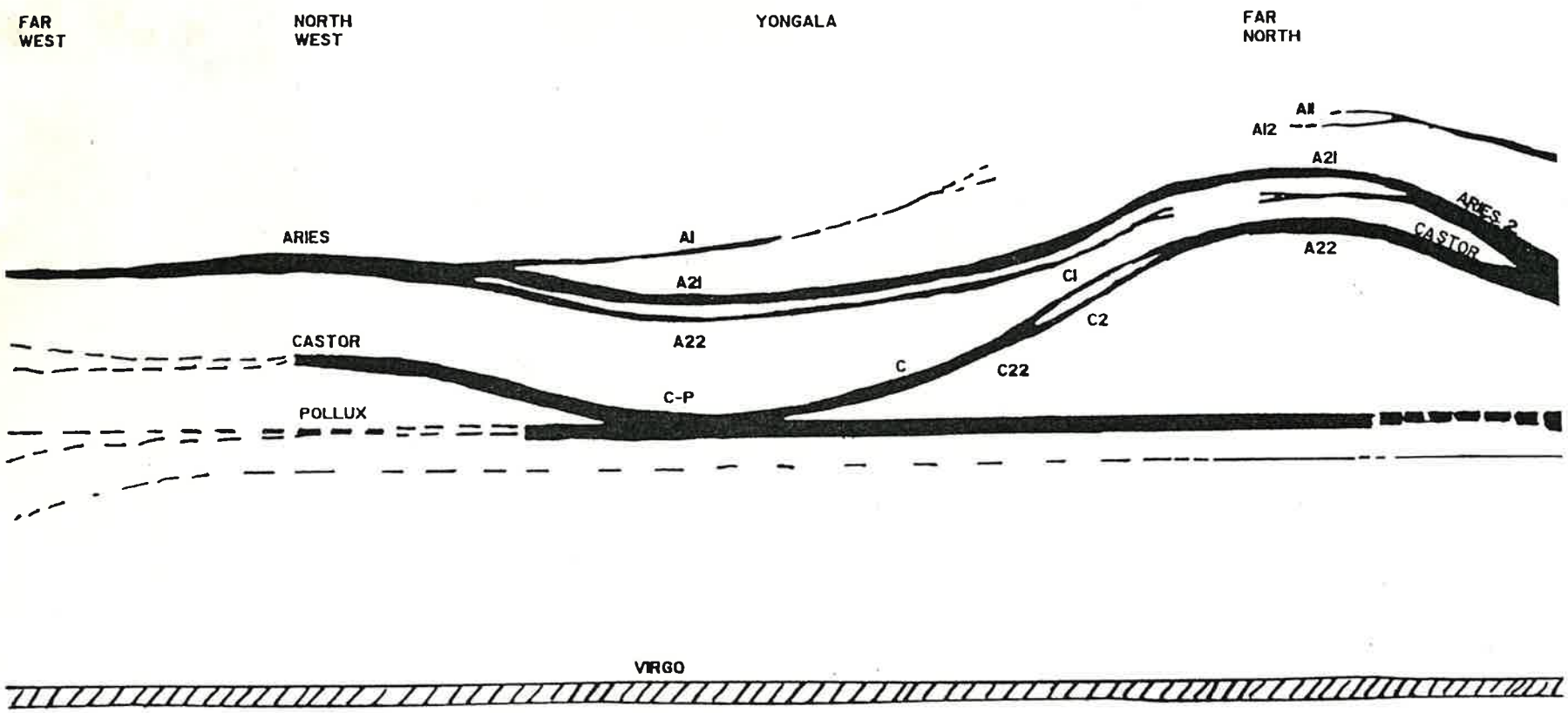
ENSHAM COAL PROJECT

YONGALA MINE
REGIONAL LOCALITY MAP

SCALE AS SHOWN

ENSHAM DRG No. 2853 0

FIGURE 1



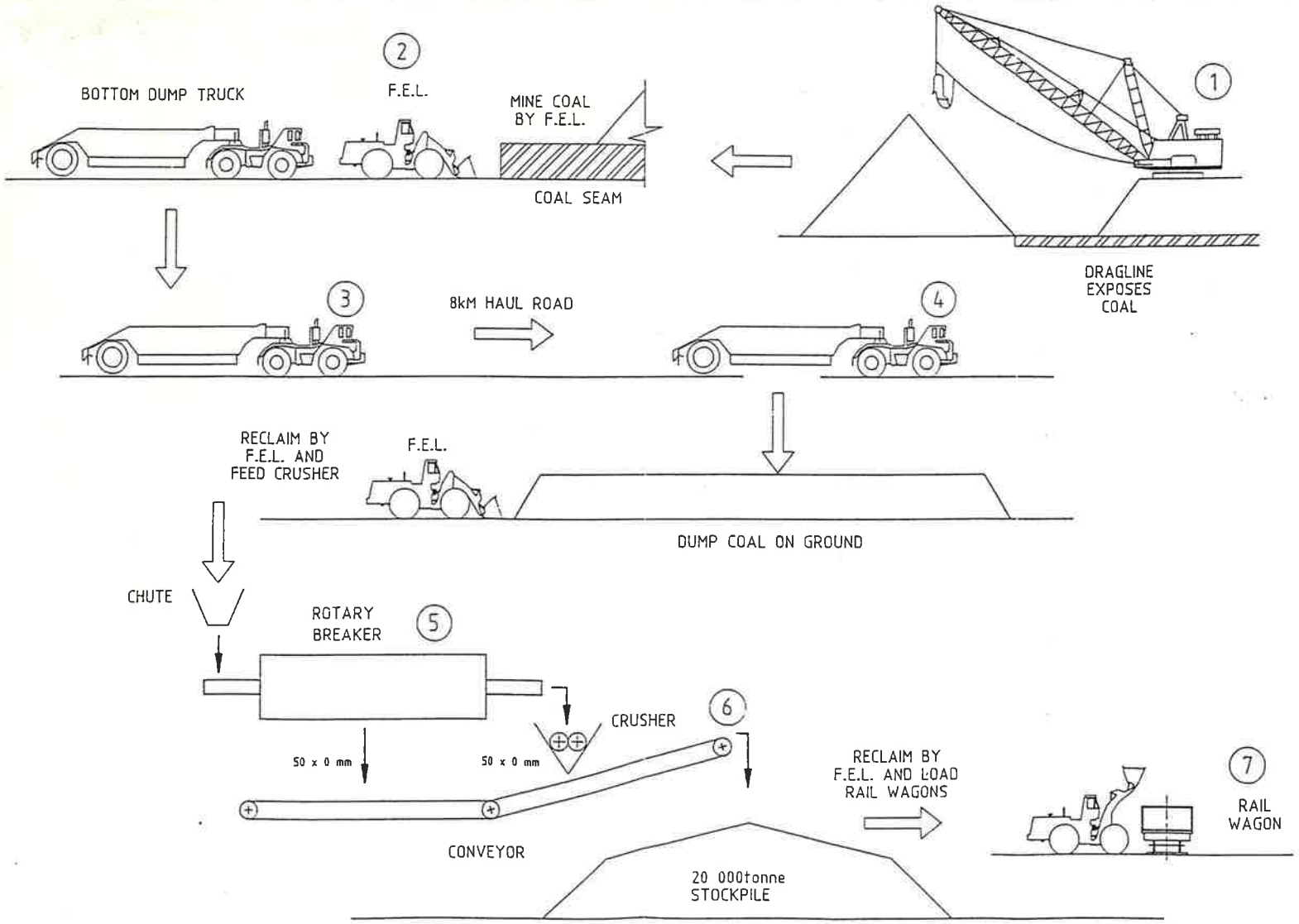
ENSHAM COAL PROJECT – YONGALA MINE

GENERALISED STRATIGRAPHY

HOLLINGSWORTH DAMES & MOORE

File Ref. HOBO345

FIG. 2



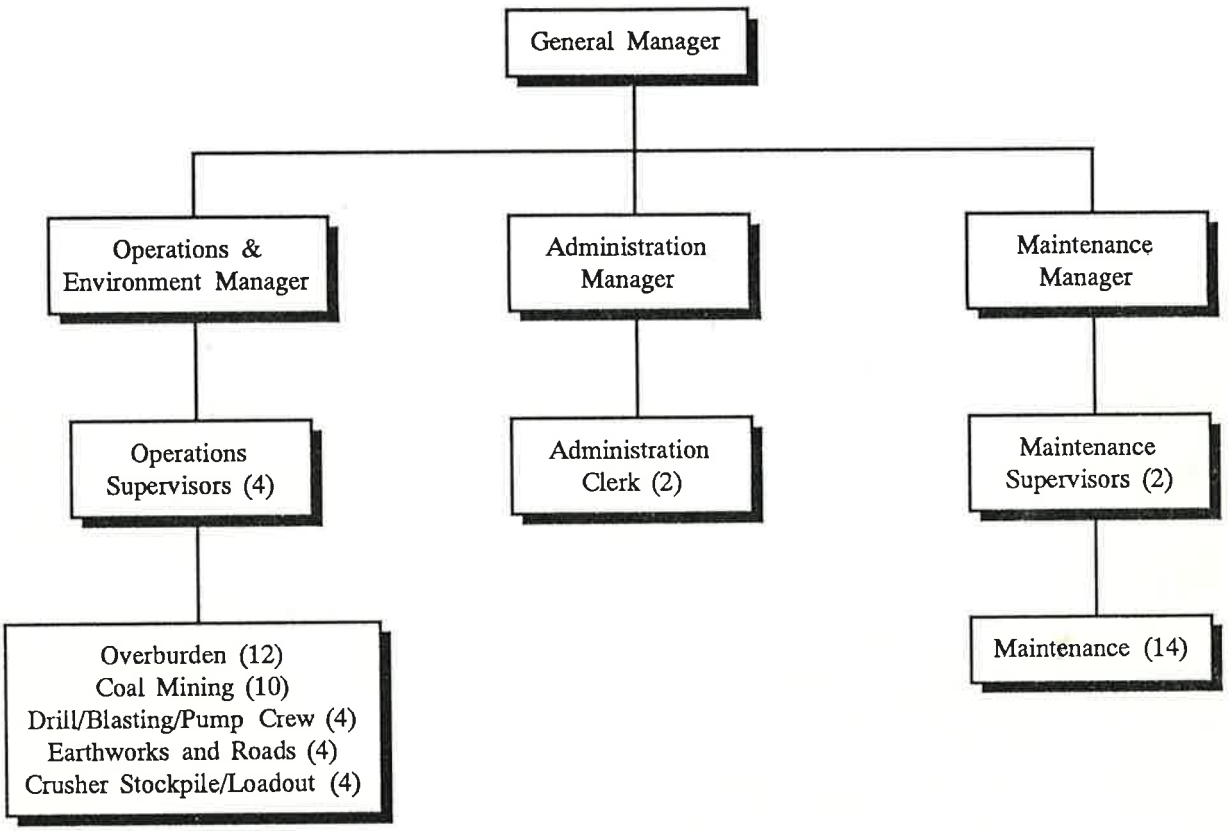
ENSHAM COAL PROJECT – YONGALA MINE

PROPOSED FLOWCHART

HOLLINGSWORTH DAMES & MOORE

File Ref. HOBO 345

FIG. 3



Note: Relief (14)

ENSHAM COAL PROJECT - YONGALA MINE

ORGANISATION STRUCTURE

HOLLINGSWORTH DAMES & MOORE

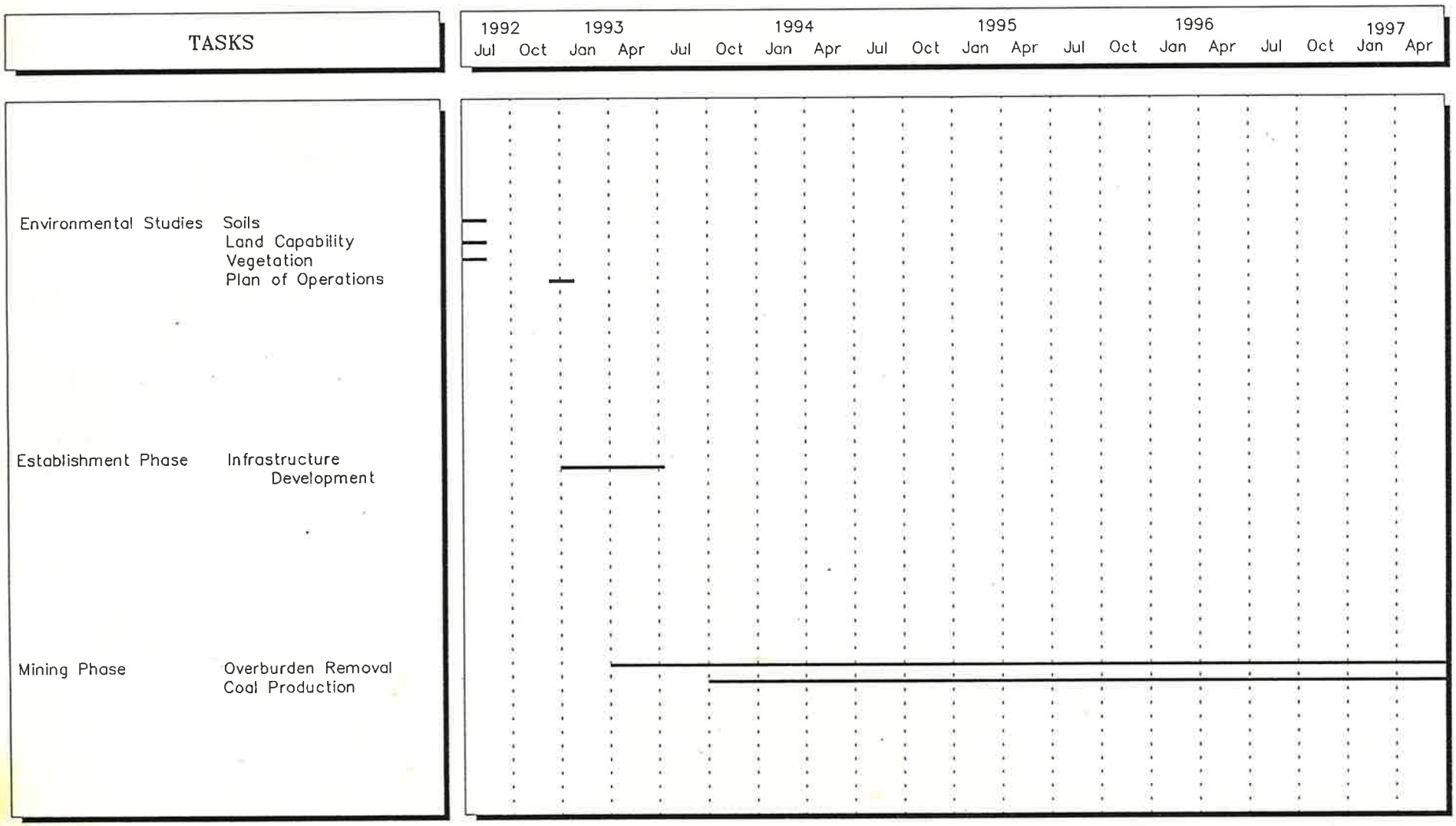
File Ref. HOB0345

FIG. 4

HOLLINGSWORTH DAMES & MOORE

Figure 5

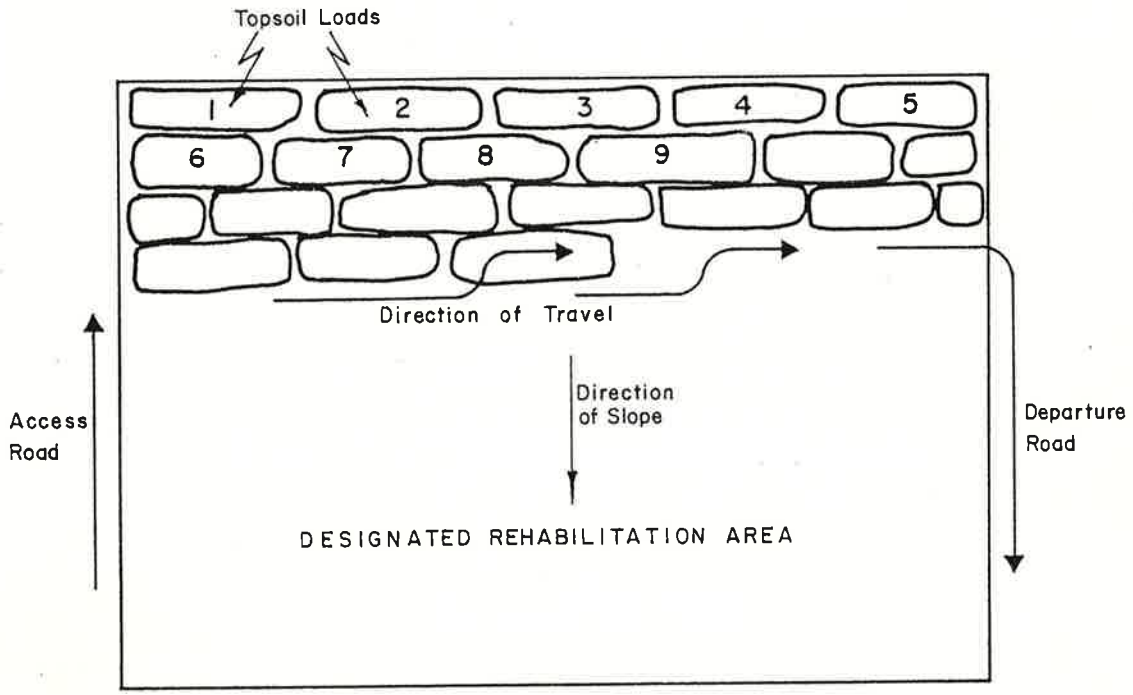
Ensham Coal Project – Yongala Mine
Development Schedule



Deep gullying associated with dispersive soils

Scald area with severe sheet erosion

FIGURE 6



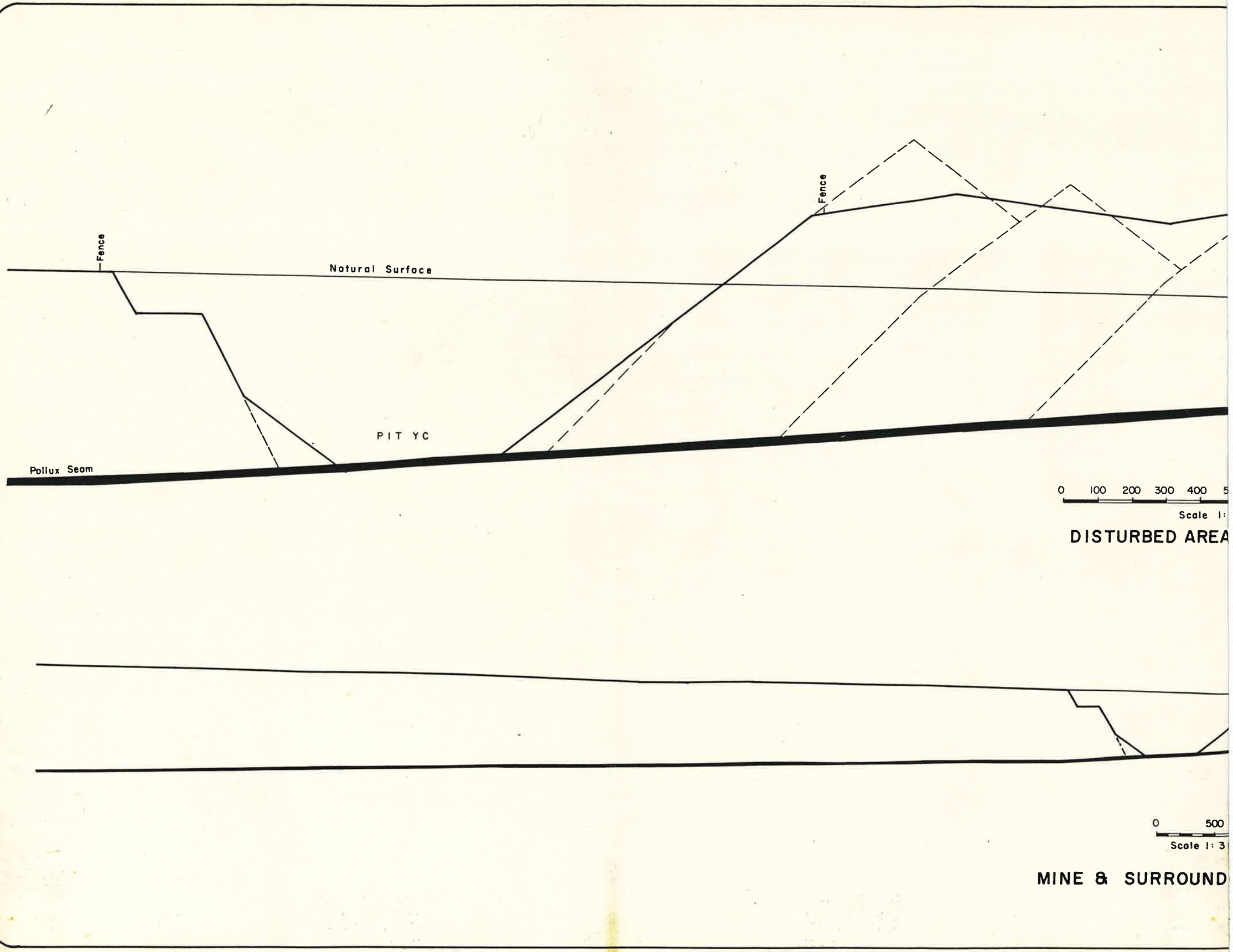
ENSHAM COAL PROJECT - YONGALA MINE

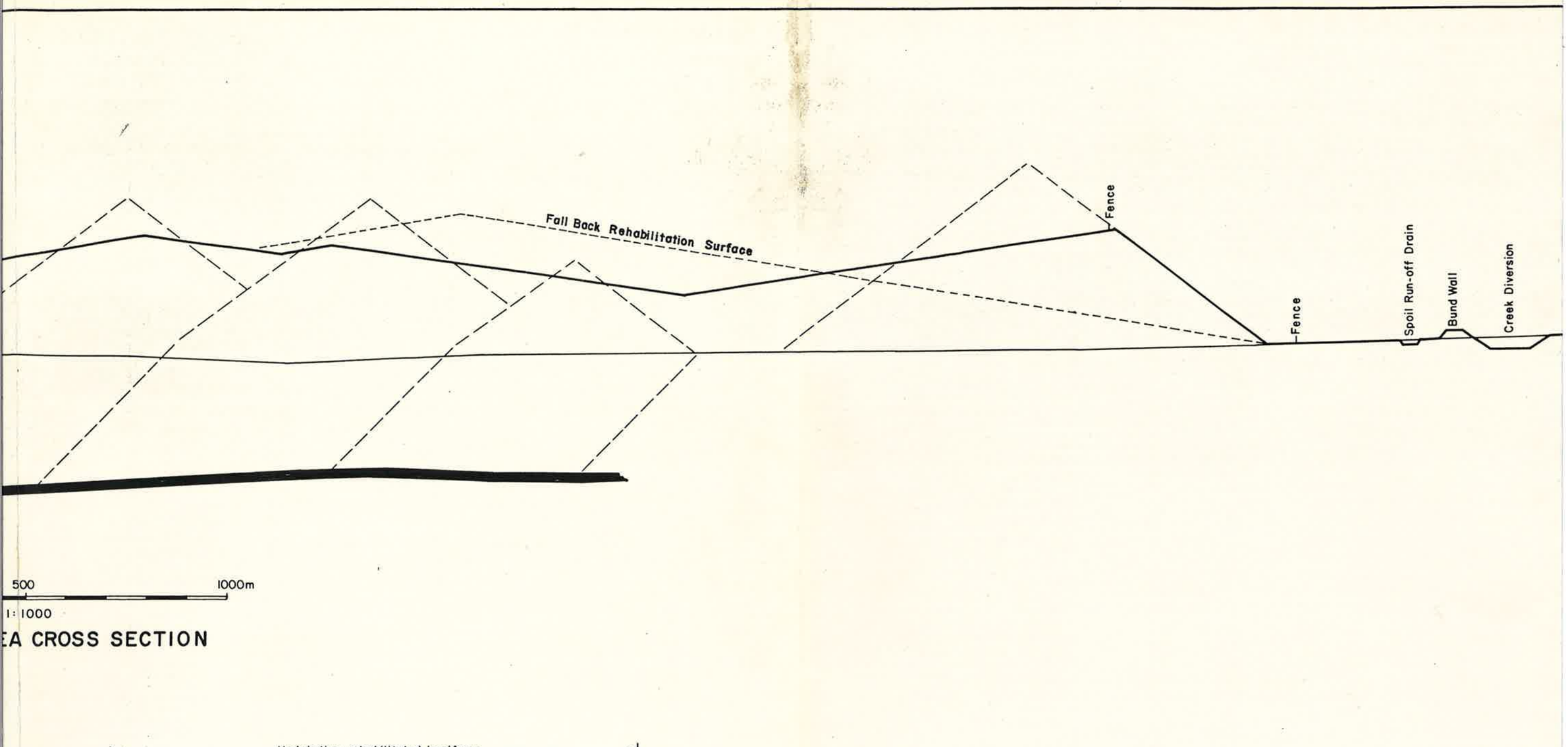
TOPSOIL SPREADING SEQUENCE

HOLLINGSWORTH DAMES & MOORE

File Ref. HOB0345

FIG. 7

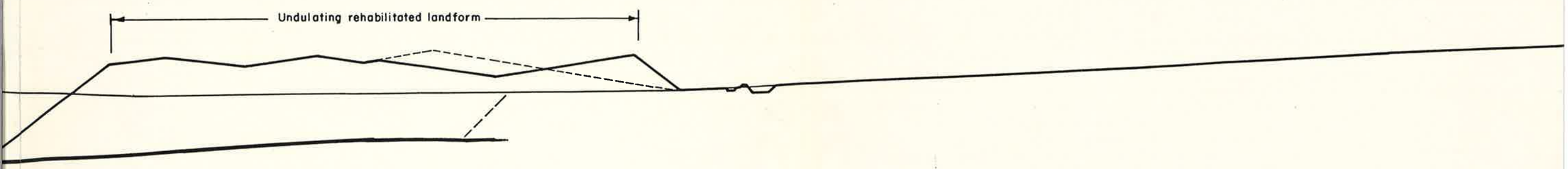

Fence
Natural Surface
Fence
PIT YC
Pollux Seam
0 100 200 300 400 5
Scale 1:
DISTURBED AREA
0 500
Scale 1: 3
MINE & SURROUND



500 1000m

1:1000

EA CROSS SECTION



00 1000m

3000

DS CROSS SECTION

TYPICAL REHABILITATION CROSS SECTION

Pre Rehabilitated Spoil Profile

ENSHAM COAL PROJECT- YONGALA MINE

HOLLINGSWORTH DAMES & MOORE

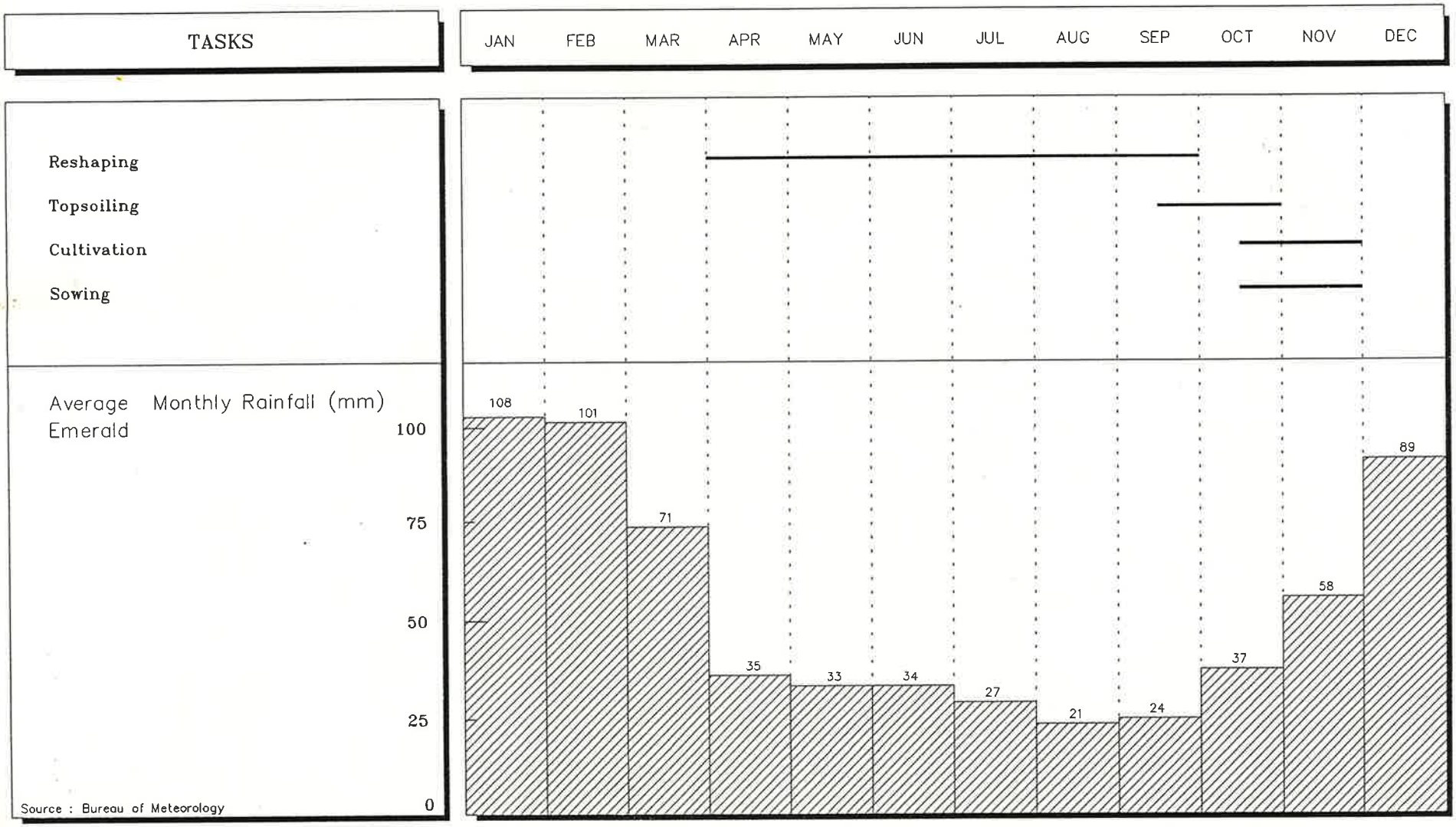
File Ref. HOF0345

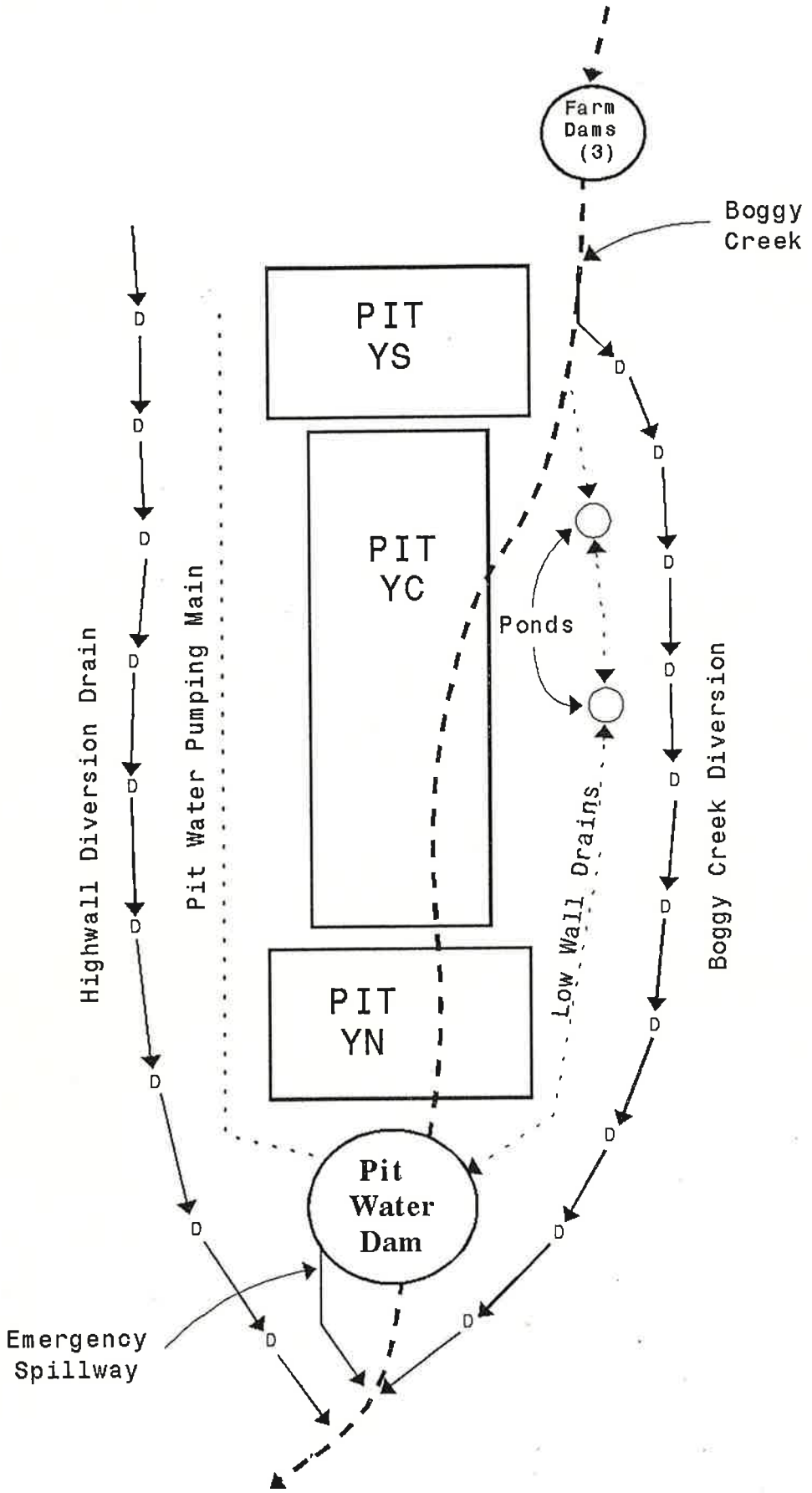
FIG. 8

HOLLINGSWORTH DAMES & MOORE

Figure 9

Ensham Coal Project – Yongala Mine
Annual Rehabilitation Schedule





ENSHAM COAL PROJECT - YONGALA MINE

WATER MANAGEMENT SCHEMATIC

HOLLINGSWORTH DAMES & MOORE

Not to Scale

File Ref. HOB0345

FIG. 10

SOLID GEOLOGY – CENTRAL BOWEN BASIN

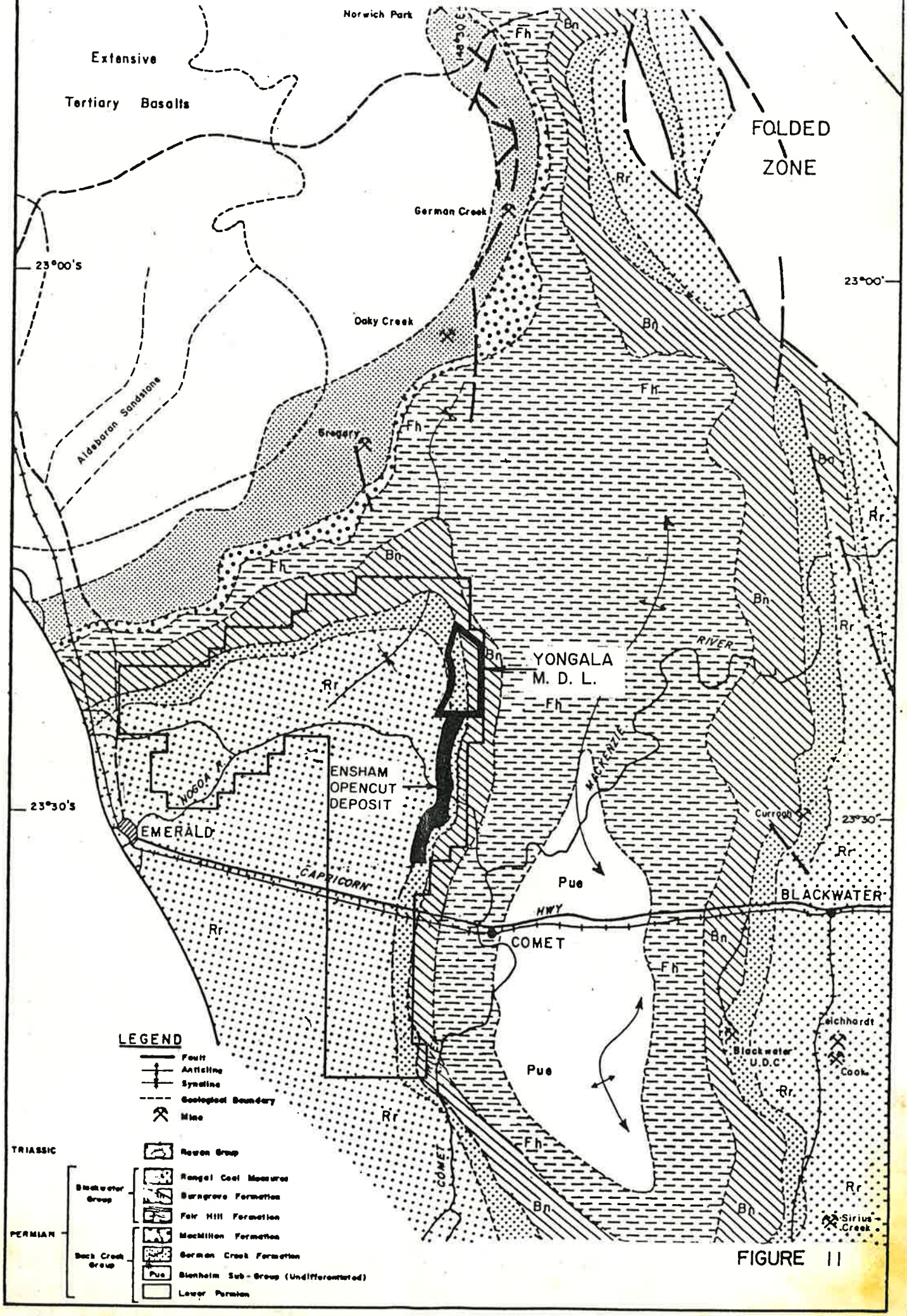


FIGURE 11

GENERAL LAYOUT

ENSHAM COAL PROJECT-YONGALA MINE

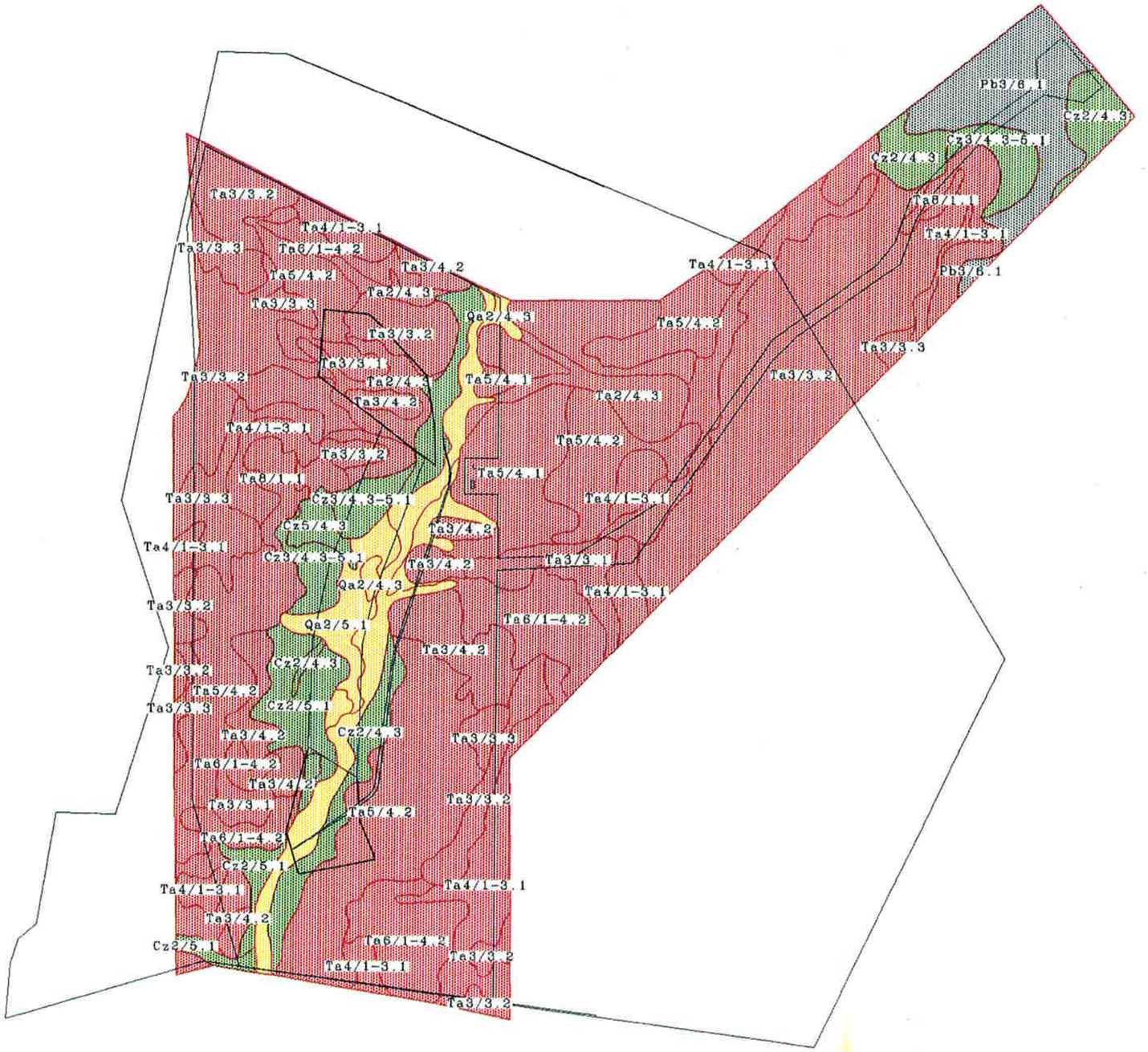
Scale - kms

0 1 2

HOLLINGSWORTH DAMES & MOORE

File Ref. HOB0345

FIG. 12



GEOLOGY & LAND UNITS

- (Qa) Alluvial Deposits
- (Cz) Cainozoic Soil Cover / Blackwater Group
- (Ta) Tertiary Sandstone, Siltstone, Claystone
- (Pb) Permian Blackwater Group

ENSHAM COAL PROJECT-YONGALA MINE

N

Scale - kms

0 1 2

HOLLINGSWORTH DAMES & MOORE

File Ref. HOB0345

FIG. 13

SITE INSPECTION/
SOIL SAMPLING LOCATIONS

ENSHAM COAL PROJECT-YONGALA MINE

N

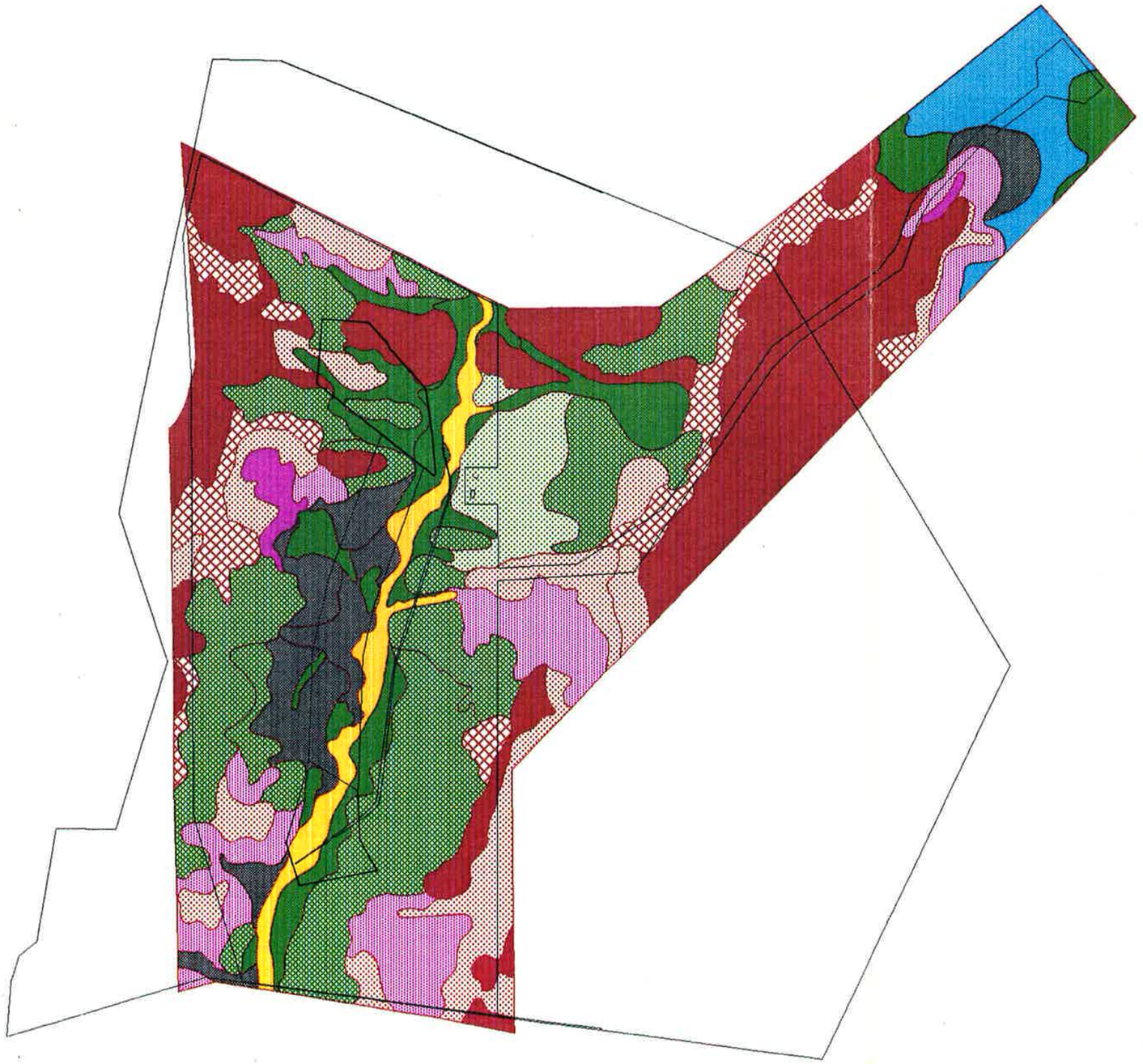
Scale - kms

0 1 2

HOLLINGSWORTH DAMES & MOORE

File Ref. H0B0345

FIG. 14



SOILS

	1.1	Shallow rocky sands and loams
	1–4.2	Mixed occurrences of soil types 1.1 and 4.2
	2.1	Deep uniform sands, earthy sands and loamy alluvial soils
	3.1	Gradational sandy (lateritic) yellow earths
	3.2	Gradational red earths
	3.3	Gradational lateritic red earths
	4.1	Moderately shallow acidic yellow-brown duplex soils over HW rock
	4.2	Moderately deep acidic to mildly alkaline brown or reddish brown duplex soils over HW rock
	4.3	Deep loamy surface duplex soils with yellowish brown or brown alkaline clay subsoils
	5.1	Deep uniforms dark brown – or reddish brown clay soils
	6.1	Shallow brown cracking clays over HW rock

ENSHAM COAL PROJECT-YONGALA MINE

N

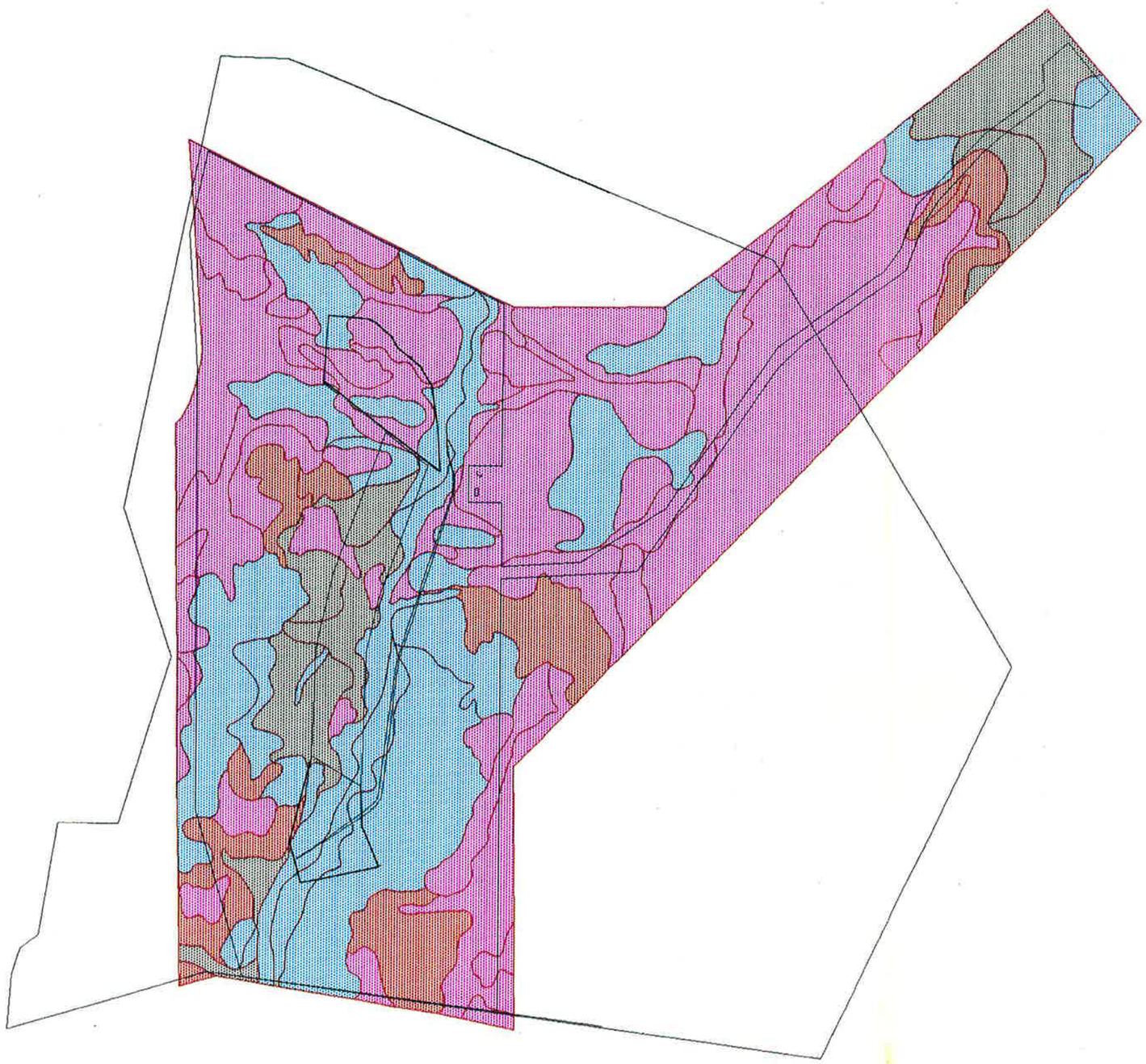
Scale - kms

0 1 2

HOLLINGSWORTH DAMES & MOORE

File Ref. HOB0345

FIG. 15



LAND SUITABILITY

- Suitable land with negligible limitations
- Suitable land with minor limitations
- Suitable land with moderate limitations
- Marginal land with severe limitations
- Unsuitable land with extreme limitations

ENSHAM COAL PROJECT-YONGALA MINE

N

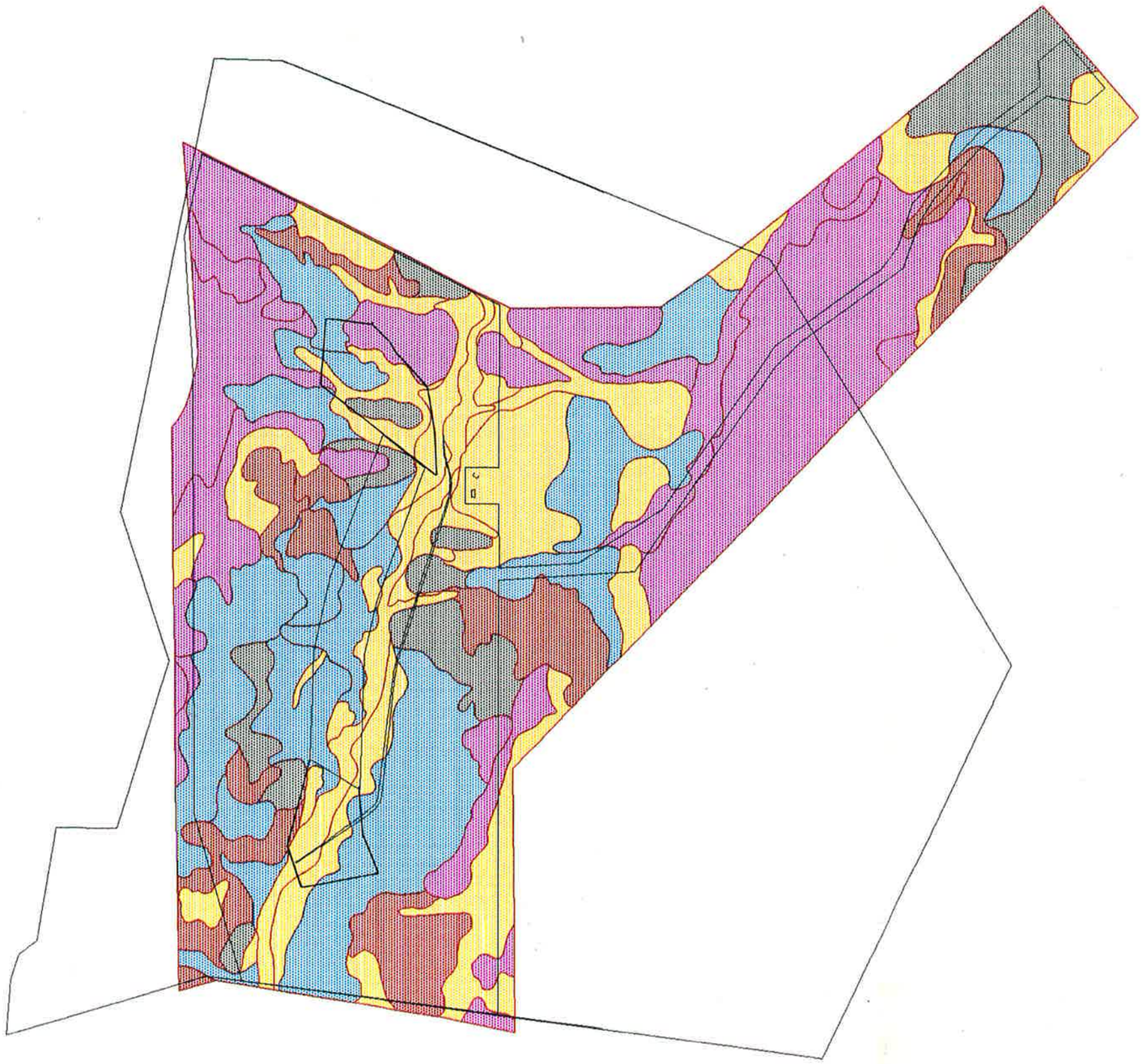
Scale - kms

0 1 2

HOLLINGSWORTH DAMES & MOORE

File Ref. HOB0345

FIG. 16



TOPSOIL STRIPPING DEPTHS

- 0 - 15cms (A1)
- 0 - 25cms (A1 + A2)
- 0 - 50cms (A + B1)
- 0 - 100cms (A + B)
- No Suitable Layers

ENSHAM COAL PROJECT-YONGALA MINE

N

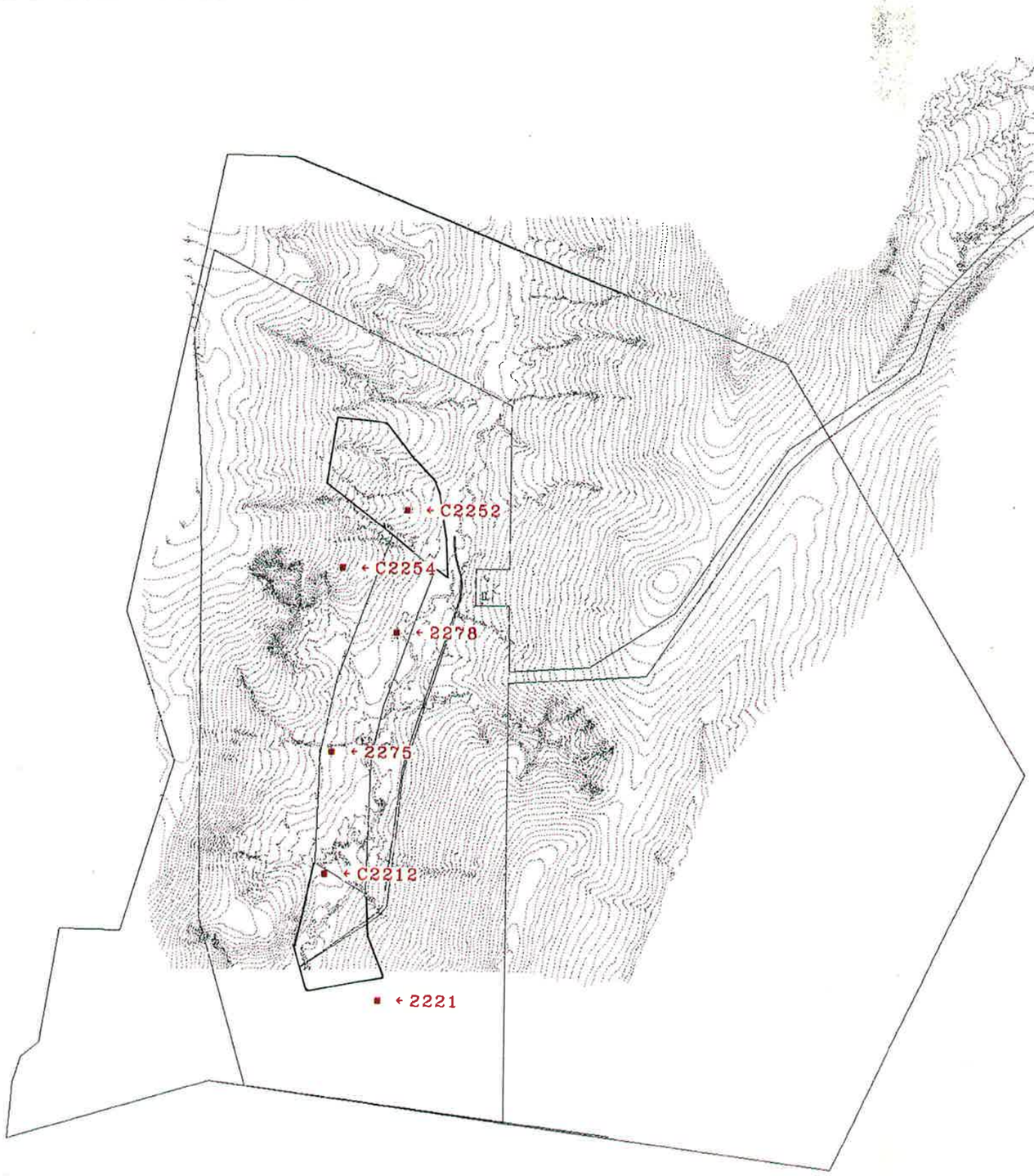
Scale - kms

0 1 2

HOLLINGSWORTH DAMES & MOORE

File Ref. HOB0345

FIG. 17



BOREHOLE LOCATIONS OF GEOCHEMICALLY SAMPLED CORES

ENSHAM COAL PROJECT-YONGALA MINE

Scale - kms

0 1 2

HOLLINGSWORTH DAMES & MOORE

File Ref. HOBO345

FIG. 18

LEGEND FOR SCREENING PHASE ANALYSES


SOIL


CLAY


SAND


GRAVEL

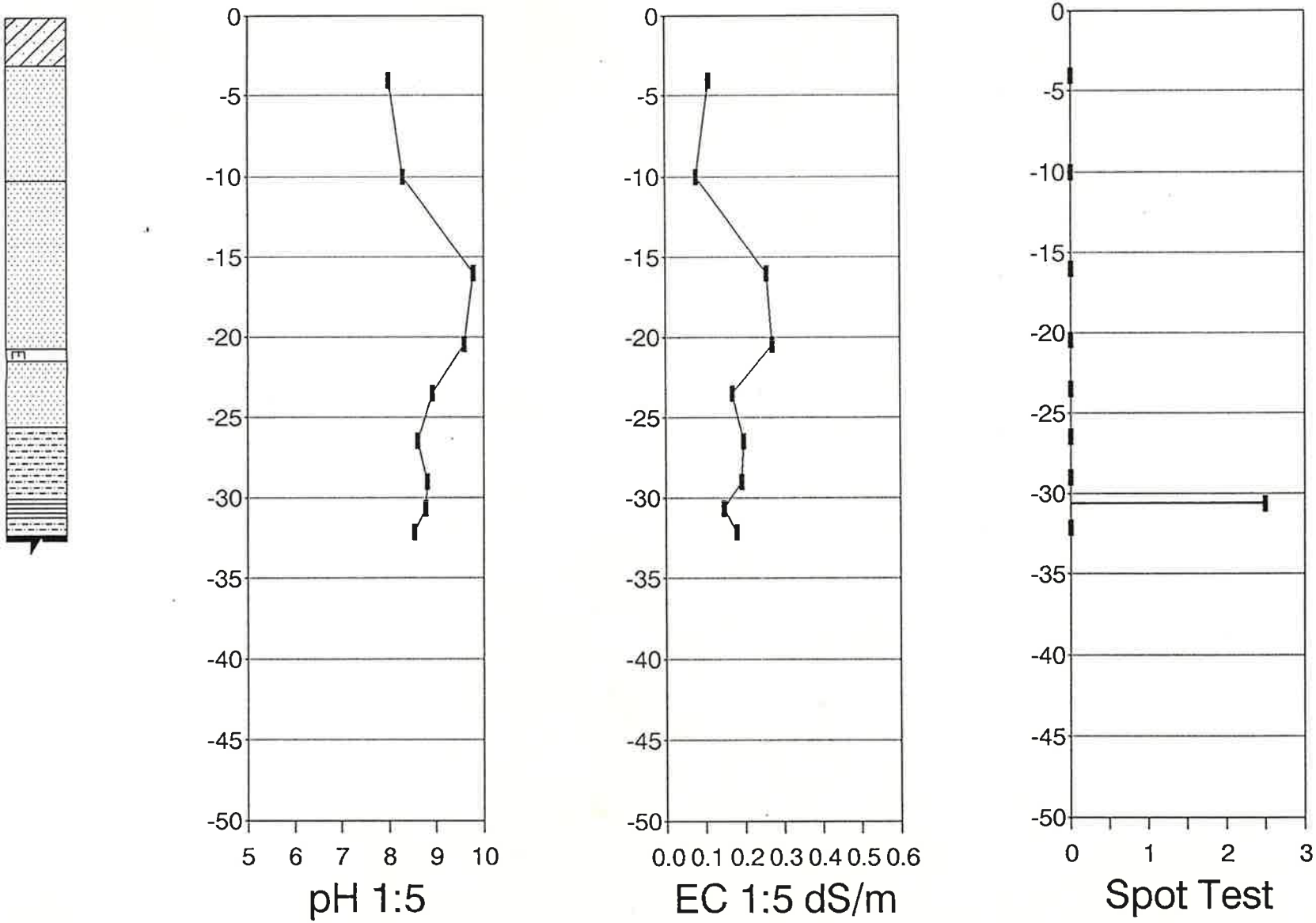

COAL


CLAYSTONE/MUDSTONE


SILTSTONE


SANDSTONE


IRONSTONE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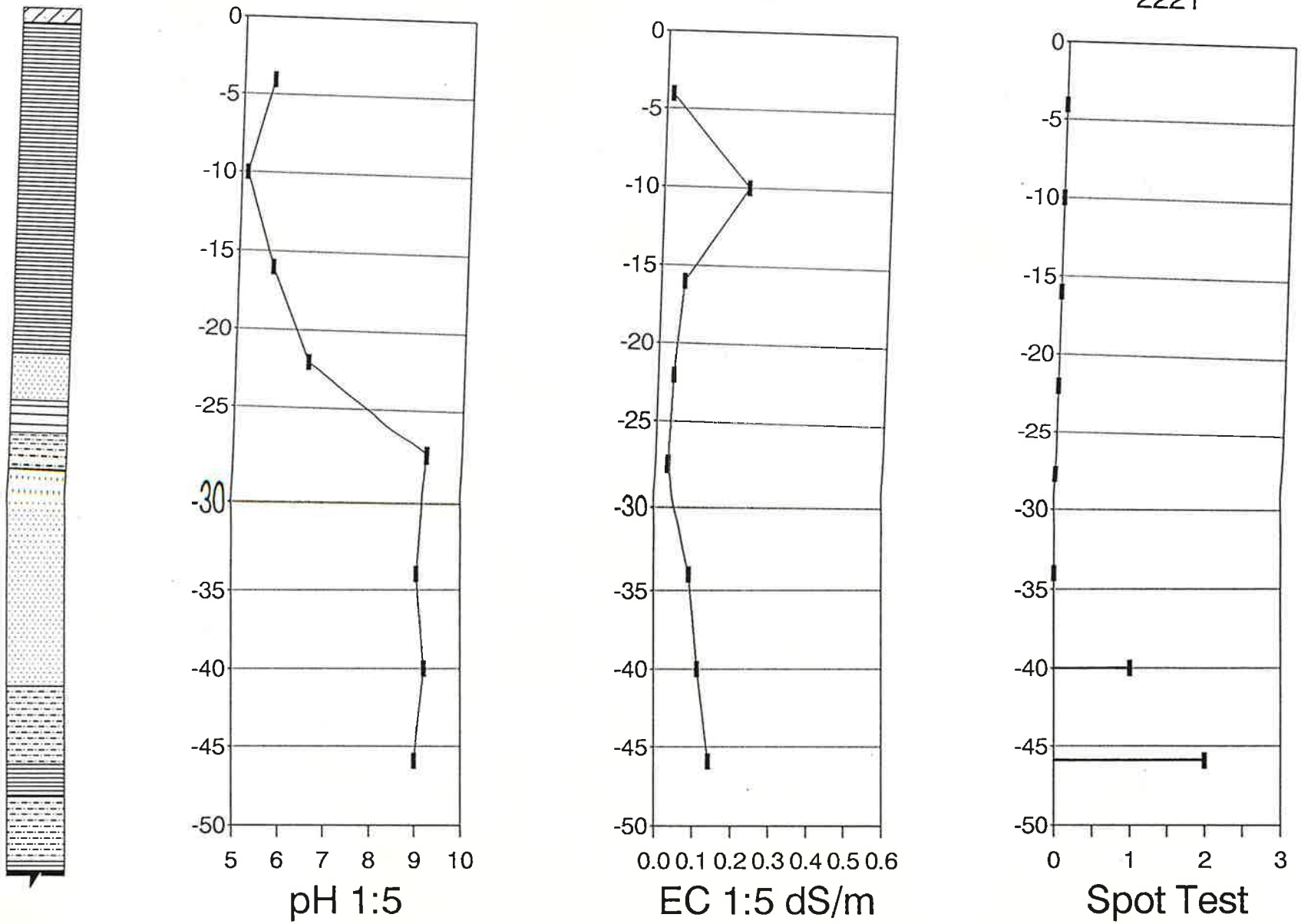
2212
Salinity
2212
Pyrite
2212
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
5 6 7 8 9 10
pH 1:5
0.0 0.1 0.2 0.3 0.4 0.5 0.6
EC 1:5 dS/m
0 1 2 3
Spot Test

FIGURE 19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-5
-10
-15
-20
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-30
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-40
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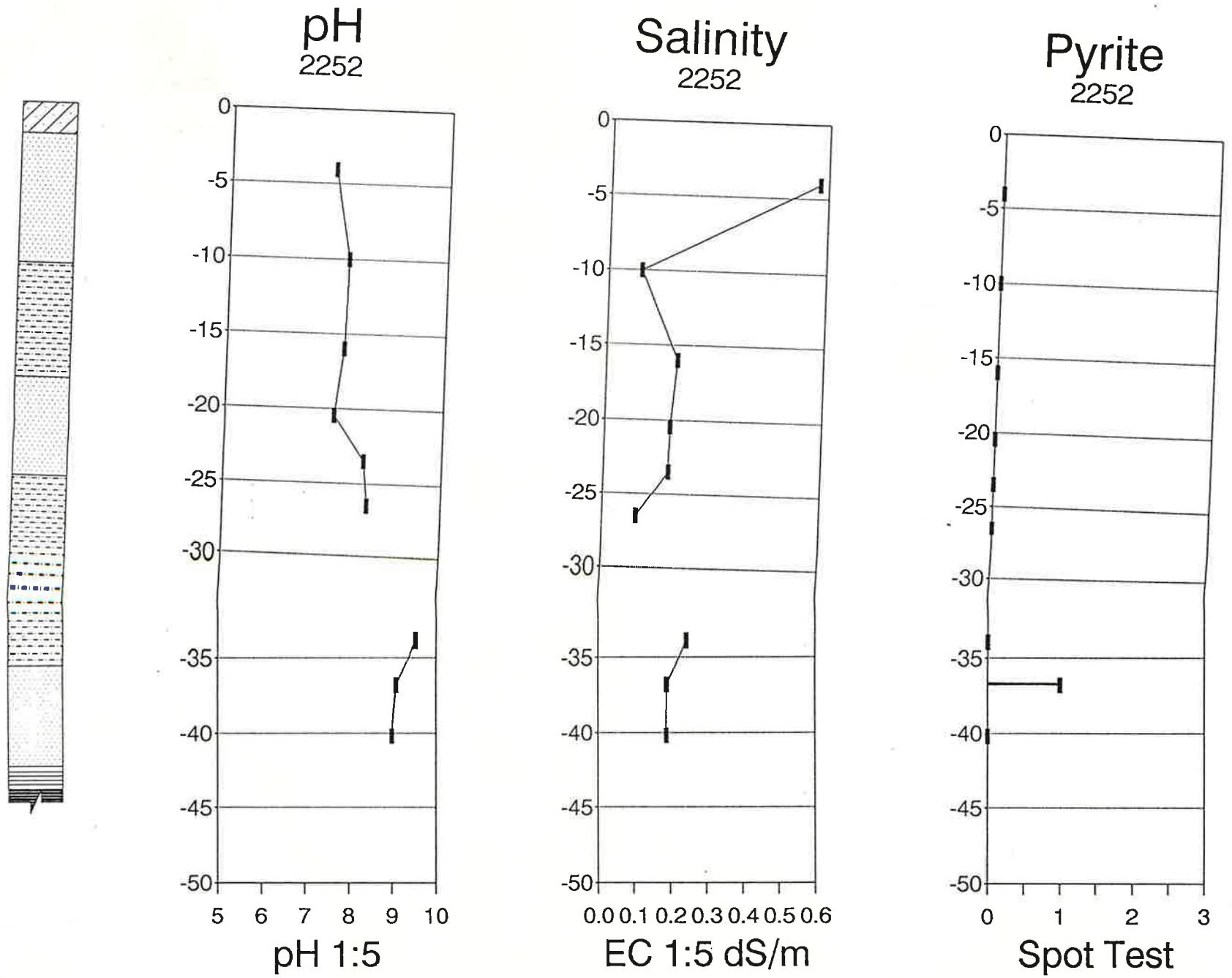
pH 1:5
Salinity
2221
0.0 0.1 0.2 0.3 0.4 0.5 0.6
EC 1:5 dS/m
Pyrite
2221
0 1 2 3
Spot Test

FIGURE 20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-5
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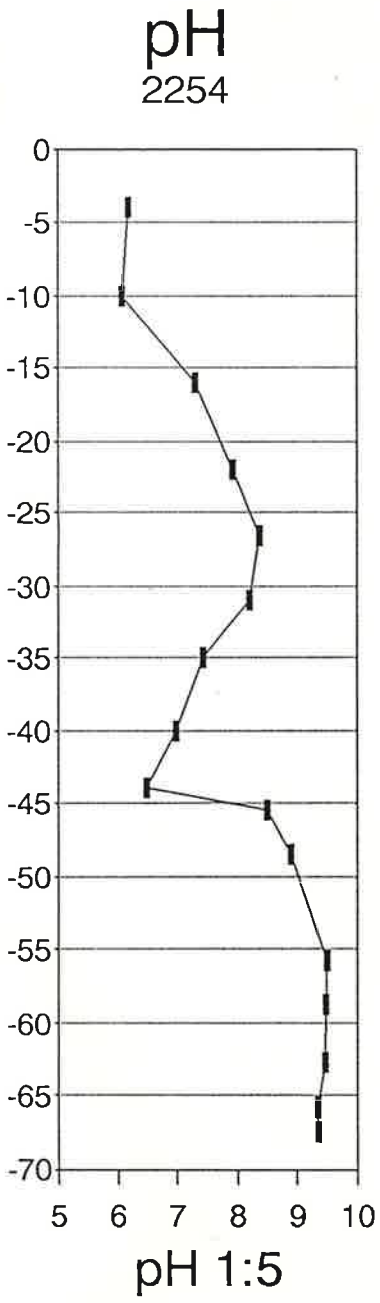
pH 1:5
Salinity
2252
0.0 0.1 0.2 0.3 0.4 0.5 0.6
EC 1:5 dS/m
Pyrite
2252
0 1 2 3
Spot Test

FIGURE 21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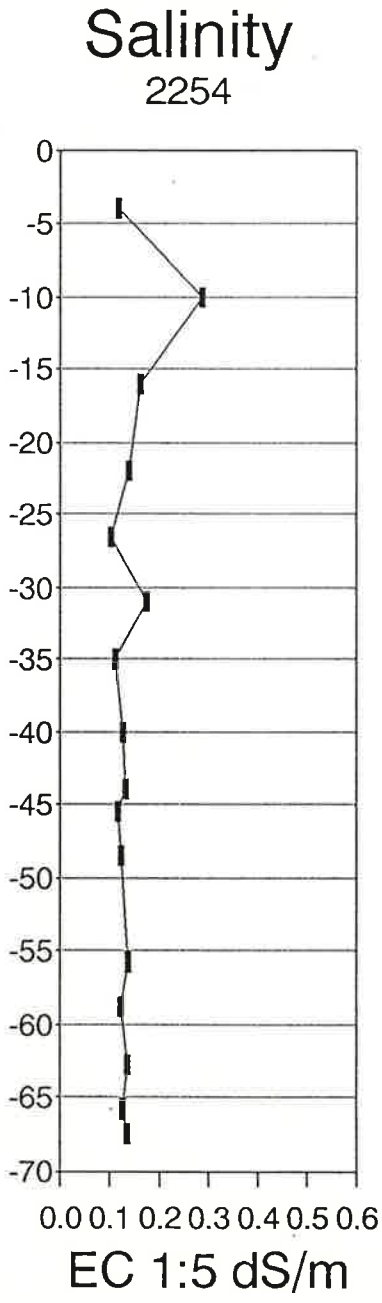
-70
5 6 7 8 9 10
pH 1:5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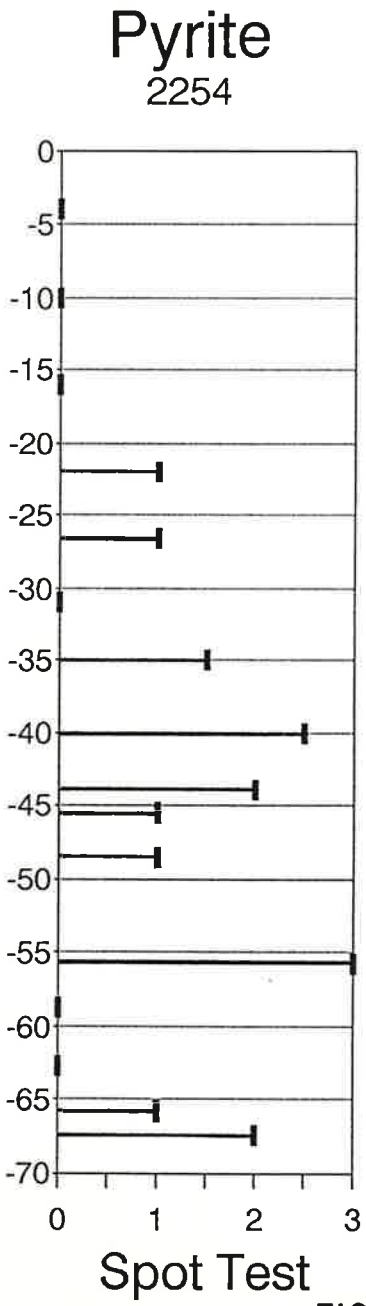
0.0 0.1 0.2 0.3 0.4 0.5 0.6
EC 1:5 dS/m


Pyrite
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-10
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-45
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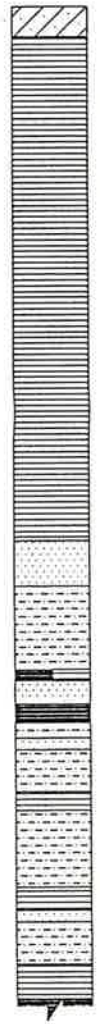
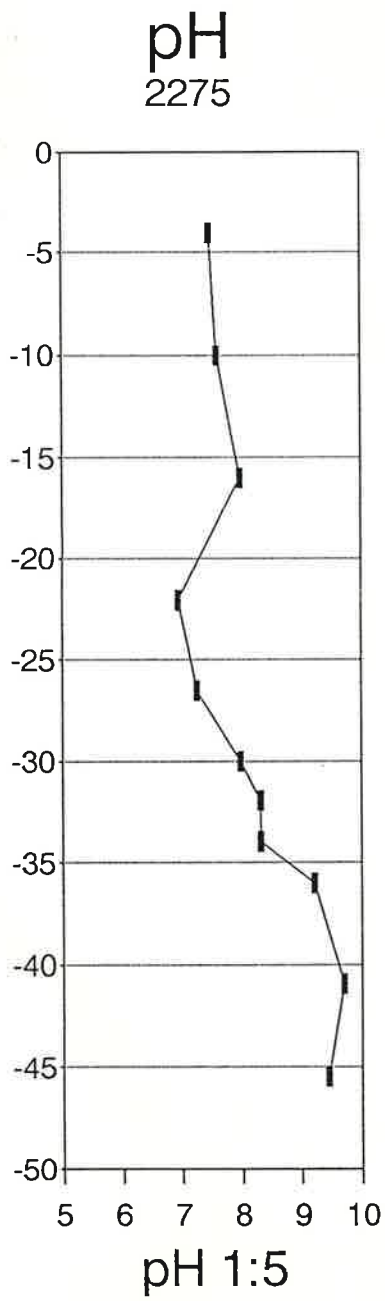
-60
-65
-70
0 1 2 3
Spot Test

FIGURE 22

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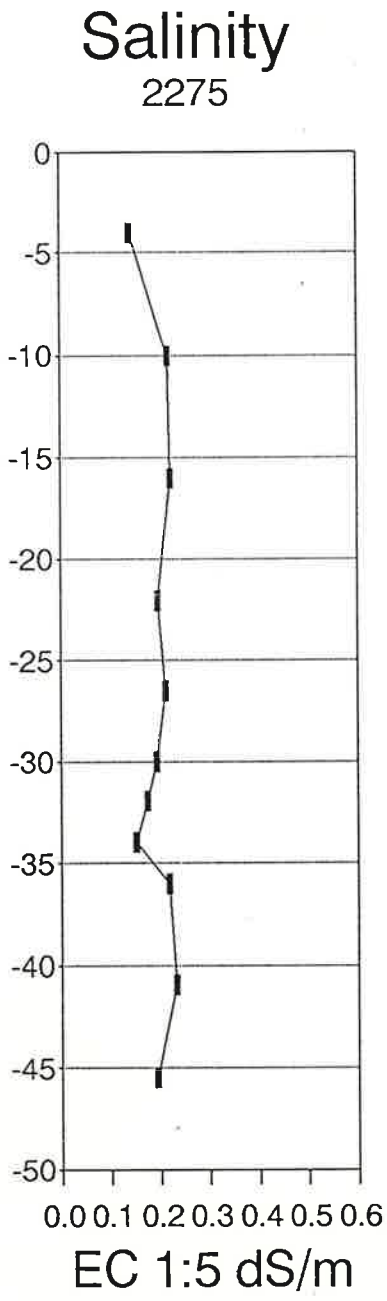
pH 1:5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-40
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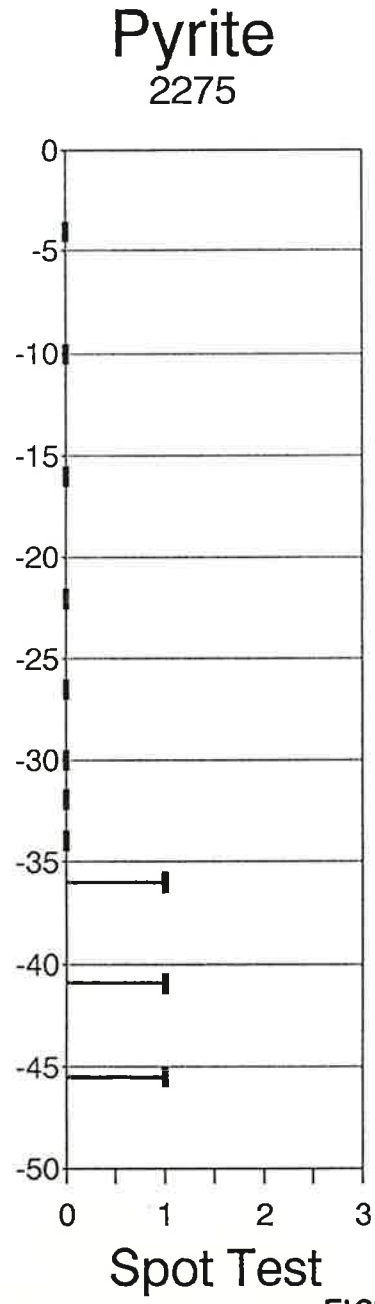
-50
0.0 0.1 0.2 0.3 0.4 0.5 0.6
EC 1:5 dS/m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-20
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-30
-35
-40
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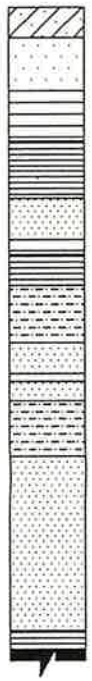
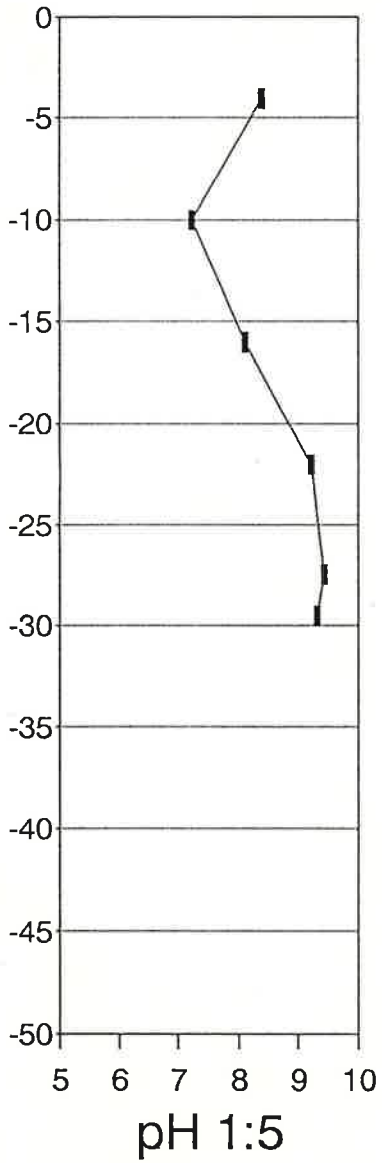
-50
0 1 2 3
Spot Test

FIGURE 23

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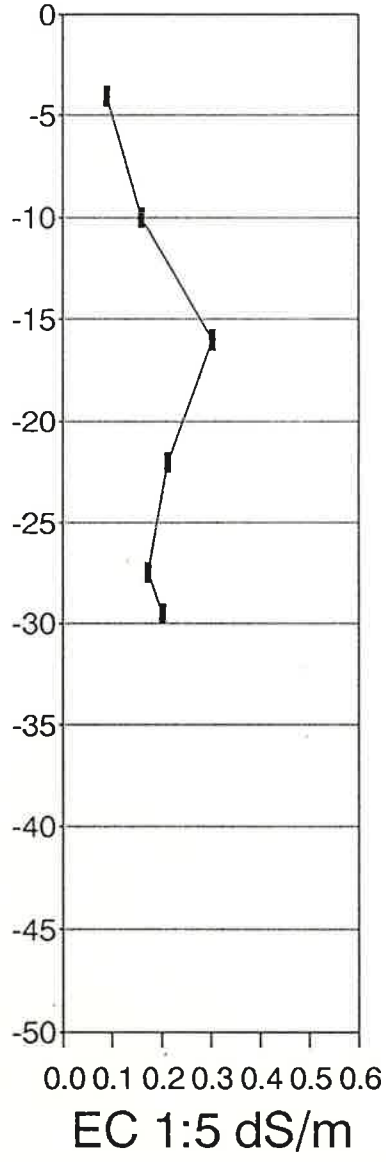
pH 1:5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EC 1:5 dS/m

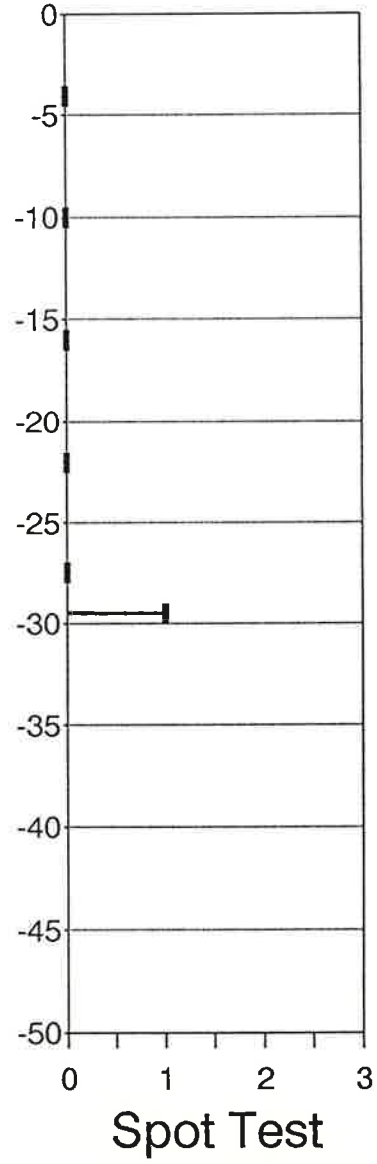
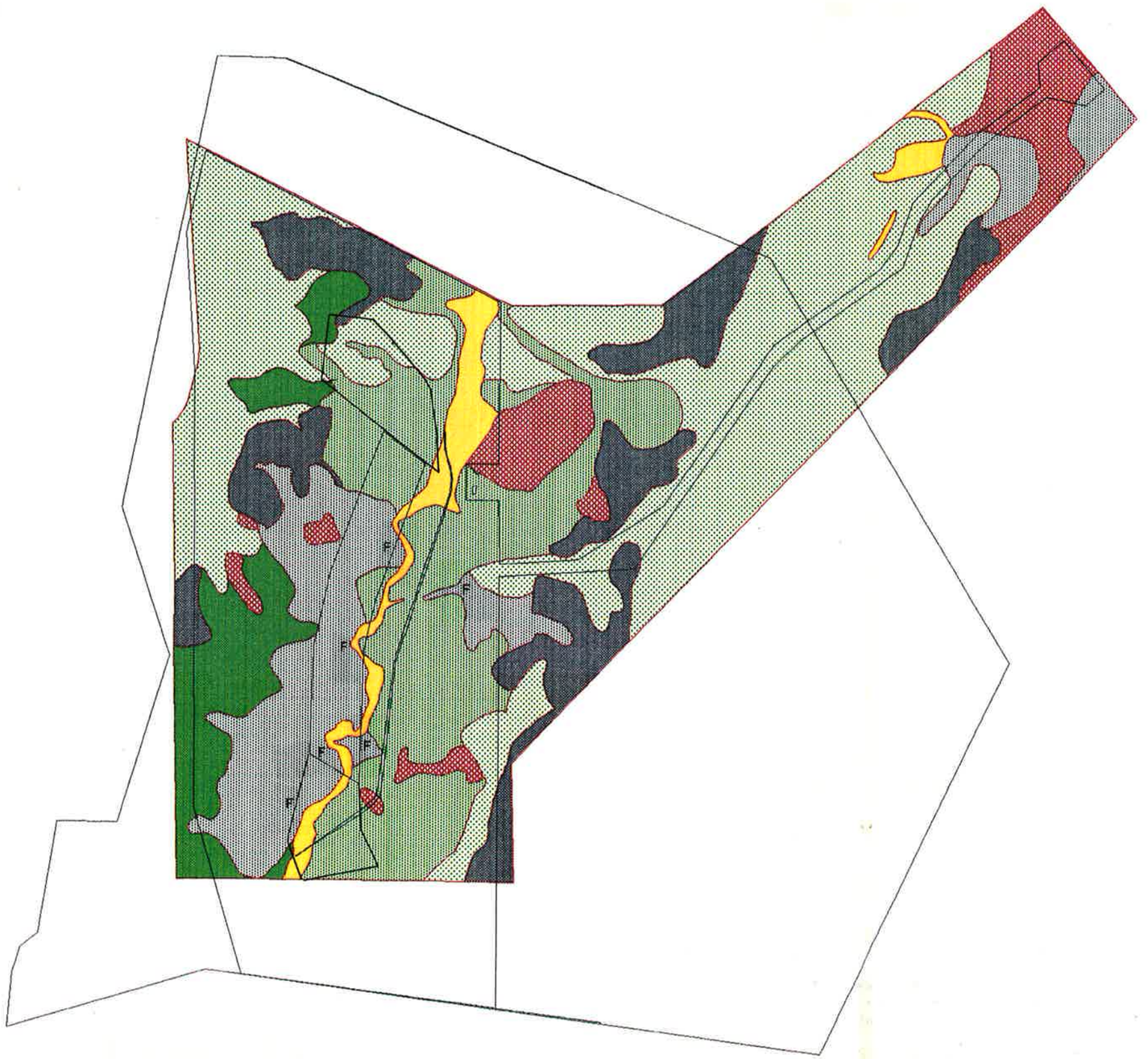

Pyrite
2278
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
0 1 2 3
Spot Test

FIGURE 24



VEGETATION

- Narrow Leaved Ironbark - Bloodwood Woodland
- Lancewood - Mountain Yapunyah Open Forest
- Brigalow - Mountain Yapunyah Open Forest
- Brigalow - Poplar Box Mixed Low Woodland
- Ironbark - Poplar Box Mixed Open Woodland
- Poplar Box Open Woodland
- Riverine
- Selectively Cleared - Highly Disturbed

ENSHAM COAL PROJECT-YONGALA MINE

N

Scale - kms

0 1 2

HOLLINGSWORTH DAMES & MOORE

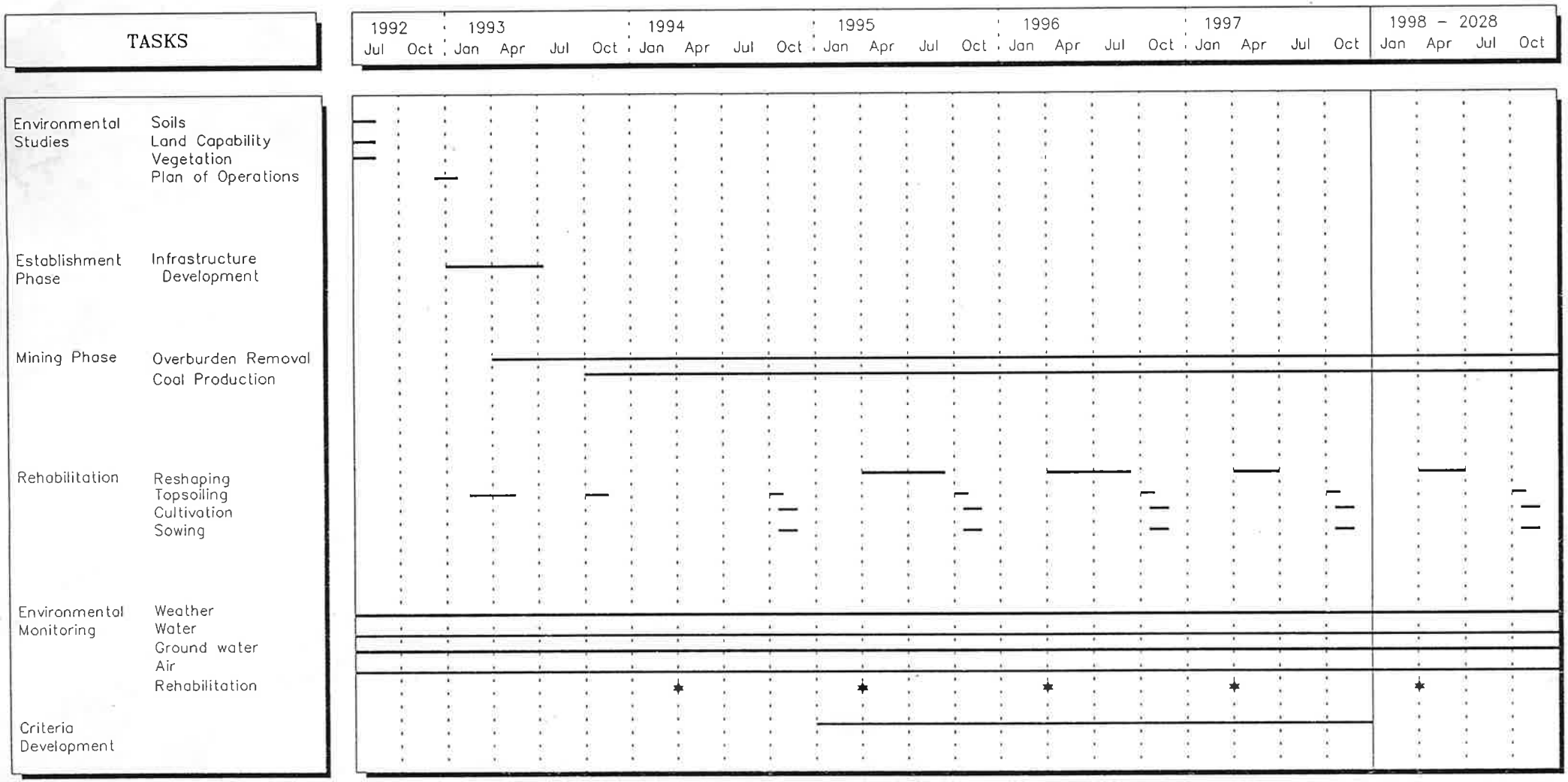
File Ref. HOB0345

FIG. 25

HOLLINGSWORTH DAMES & MOORE

Figure 26

Ensham Coal Project – Yongala Mine
Overview Schedule



B345FG26.DWG, ROTATION 90, FIT.

APPENDICES

APPENDIX 1

YONGALA MINE
SCOPE OF ENVIRONMENTAL WORK

YONGALA MINE
SCOPE OF ENVIRONMENTAL WORK

LAND RESOURCES

The land resources component of an EMOS requires a statement of post mine land use capability and the strategies proposed to achieve this. The derivation of the above is based on the findings of a variety of component studies including spoils characteristics, existing vegetation habitats and hydrology, details of which are provided below:

Spoil Characteristics

The proposal for this task is based on verifying that the results of work previously conducted for the Ensham Project are applicable to Yongala. It is assumed that exploratory drilling has been conducted from which samples can be obtained for testing. Samples will be prepared and then undergo a screen testing phase. If necessary, further testing will be conducted to quantify the extent of any potentially difficult materials.

Terrain and Soils

A terrain analysis is proposed which will provide an overview of the site area in terms of geology, existing landform and topsoil resources. This study will provide a firm basis for determining pre-mining land capability and post mining land use options.

A soils map covering the area to be disturbed by mining and infrastructure development as well as an indicative topsoil suitability assessment and stripping depth map.will be produced as part of this study.

Landform Development

Landform development will be based on mine schedules to be provided by Ensham Resources. Provision has been made for liaison between Hollingsworth Dames & Moore and Ensham Resources personnel as it is considered that an optimum landform can be achieved if development of the mine and rehabilitation plans occur concurrently.

Drainage and access considerations will be provided for within the landform design.

Rehabilitation Procedures

Rehabilitation procedures suited to the post mining land use will be derived based on existing technology and proposed research programmes where applicable. These will include topsoil management, reshaping of spoil emplacements, cultivation, sowing and post–establishment management.

WATER RESOURCES

Surface Water

The surface hydrological environment has previously been described for the Ensham Coal Project and should be applicable for the Yongala site. It is considered that the major hydrological issue for this project is the required diversion of Boggy Creek. It is proposed therefore to prepare a conceptual design for the necessary structure to achieve this diversion. It is assumed that hydrological studies conducted for the Ensham Coal Project will provide sufficient information for such a design. On the basis of this conceptual design the environmental implications of the diversion can be assessed.

Groundwater

It is understood that exploratory drilling for the project failed to detect any groundwater presence. It is proposed therefore to undertake a brief review of existing bore logs and provide a statement of the likely groundwater regime with reference to that existing in the vicinity of the Ensham Project.

In addition allowance has been made to check existing bore logs for any groundwater presence and if possible undertake limited sampling and analysis.

CONSERVATION VALUES

A vegetation map of the site will be prepared by air photo interpretation and field inspection. This will be tied into the vegetation mapping undertaken for the Ensham project and will be used as part of the Land Resources studies. Any identified conservation values will be noted.

HERITAGE

The files of the Department of Family Services and Aboriginal and Islander Affairs will be examined to see if there are any recorded archaeological sites in the area. Given the lack of sites in the north of the Ensham project area, it is note expected that an archaeological survey of the Yongala site is warranted.

SOCIAL

Given the relatively small workforce proposed, there is not likely to be a significant affect on the local social or community facilities. The general background socio-economic data in the Ensham EIS will be summarised and the likely effects of the project's workforce assessed in a brief desktop study.

RESEARCH

It is not envisaged that any research will be required for the preparation of this EMOS. However, the EMOS is likely to recommend that rehabilitation trials be undertaken once mining commences to refine the recommended rehabilitation strategies.

ENVIRONMENTAL MONITORING

The EMOS will include a programme for environmental monitoring to be implemented during the project's operational phase.

APPENDIX 2

YONGALA MINE
GEOLOGY AND COAL QUALITY

1.0 INTRODUCTION

The Ensham Exploration Permit (EP505C) covers an area of approximately 900km^2 (390 sub–blocks) and is located 200km west of Rockhampton within the Bowen Basin of Central Queensland.

Structurally the EP lies on the western flank of a broad anticlinorium known as the Comet Ridge and the main structure within the EP is a northeast trending syncline which has a shallow plunge to the southwest. Strata dips are generally less than 5° and major folding is not apparent.

The coal reserves at Ensham occur within the Late Permian Rangal Coal Measures which are traceable over a strike length of 80km within the EP (Figure 11). The main seams present are, in ascending stratigraphic order, the Pollux, the Castor and the Aries seams. Exploration has generally concentrated on a large opencut resource along the eastern boundary of the area where various splits of the Aries and Castor seams coalesce to form a 4–6 metre thick seam at shallow depth.

To date, over 89,000 metres of drilling (more than 1550 boreholes) has been undertaken to define the Ensham mine area with openholes drilled at a spacing of 250m and with coreholes drilled 500m apart.

The Ensham mine has in–situ reserves, in all seams greater than 1.5m thick to a depth of 100m, calculated as 168 million tonnes. Of these, 76 million tonnes occur at less than 60m overburden depth to the main seam horizon.

Reserve drilling undertaken in 1985 and again in 1986 indicated that the Pollux seam improves significantly in quality at the northern end of the Ensham opencut area, and in 1991 a drilling program was instigated to investigate the extent and quality of the improved Pollux seam within the Yongala area.

Drilling was conducted on a 250m x 250m grid with coreholes spaced 500m apart. A total of 5819 metres of drilling was completed in 103 boreholes including 118.25 metres of slim core in 14 slim coreholes and 10.43 metres of large core in 2 large diameter coreholes.

The 1991 drilling program verified an average Pollux seam thickness of 2.58 metres over a strike length of 5.5 kilometres and testing indicated that on a whole seam basis the Pollux seam is a by–pass quality steam coal with low ash (±10%) and high energy (±7100Kcal/kg) characteristics.

In 1992, 12 large diameter coreholes were drilled over a strike length of 2.5km in the proposed initial mining area. These cores, (composited into a 1 tonne sample), were dispatched to the Coal Research Laboratories of Idemitsu Kosan in Japan for detailed testwork.

2.0 YONGALA SITE DESCRIPTION

2.1 Location and Access

"Yongala" is the property name of Portion 3, Parish of Yan Yan, County of Talbot situated in the south central Bowen Basin of Queensland. The property covers an area of 4,797 hectares and lies immediately to the north of the "Ensham" property, approximately 40km northeast of Emerald.

The area is currently accessed via property tracks from the Wyuna Road or from the Ensham property to the south.

2.2 Topography, Vegetation and Drainage

Topographic elevation ranges generally from 180m to 230m above the Australian Height Datum (AHD). The ridge along the western edge of the area rises to a maximum 266m AHD.

The property is moderately to heavily treed and grass cover is sparse. The soil is very sandy in the vicinity of Boggy Creek and the hills and ridges are mostly covered by lateritic gravels. No crops are grown on the property and the only current use for the area is cattle grazing.

The main drainage of the area is via Boggy Creek which flows south through the centre of the area and joins the Nogoa River east of Ensham Hill. The catchment for Boggy Creek is limited and water flows are intermittent.

2.3 Stratigraphy

The generalised stratigraphy of the region is depicted on Figure 2. The uppermost significant seam encountered is the A21 seam which has a thickness ranging from 0.50m to 1.81m and averaging 1.33m. A thin (average thickness 0.44m) A22 seam is generally present about 1–2m below the A21 seam but it is not considered to be of economic significance in this area.

The interburden between the A22 seam and the underlying Castor seam varies from around 5 metres in the south of the area to 23 metres in the north in the region where the Castor seam coalesces with the underlying Pollux seam.

The Castor seam shows a considerable variation in thickness from an average 0.7m in the south of the area to around 1.7m in the north although the seam remains relatively high in ash content throughout the Yongala block. The interburden between the Castor seam and the underlying Pollux seam is about 25 metres in the south of the area and thins to the north. In the far north of the area the Castor and Pollux seams coalesce.

The Castor–Pollux seam was intersected in more than 20 holes but because of the obvious quality difference between the Castor and the Pollux sections, each was identified and labelled separately to assist in mining and reserve modelling. Where the coalesced seam has been cored, the Castor and the Pollux subseams have been sampled and analysed separately.

The Pollux seam is the lowermost significant seam intersected in the Yongala area and the primary mining target. The seam is characterised by a consistent thickness averaging 2.58m, a low raw coal ash content (average 10.61%), and high raw coal energy (7100 Kcal/kg) on an air dried basis.

The roof and floor to the Pollux seam are generally soft carbonaceous mudstones and siltstones and the floor often contains thin coal plies 1–2 metres below the seam.

The lowermost stratigraphic unit identified within the Yongala area comprises tuffaceous sediments of the Burngrove Formation which subcrop along the eastern side and in the far north and conformably underlie the Rangal Coal Measures.

Triassic sediments of the Rewan Group conformably overlie the Rangal Coal Measures and form the hills and ridges along the western edge of the Yongala property. Where lateritised, these sediments are quarried to provide gravel for road surfacing.

Tertiary sands and gravels were intersected in a number of boreholes, particularly in the north where multi–coloured sands were encountered to depths of ±30 metres.

2.4 Structure

The Yongala area is structurally positioned at the northern end of the eastern limb of the Ensham syncline, to the north of the Ensham mine area.

In this area the strata dip direction varies around the Ensham synclinal nose from northwesterly to southwesterly with apparent dips remaining relatively gentle at around 2°–5°. The fact that this region is close to the synclinal axis, however, may suggest that an increased density of faulting could be anticipated although drilling to date has not verified this assumption.

Direct evidence for faulting has been recognised in 4 holes drilled within the Yongala block and faults have been inferred based on this evidence and from an interpretation of the structural model for the Pollux seam.

Three faults have been interpreted as trending east–west to northwest–southeast across the deposit.

The northernmost fault is downthrown 9 metres to the north while the other two faults are downthrown approximately 10 metres to the south. In addition to these faults, two other faults of limited extent and unknown trend have also been identified. In the north, the structural elevation of the Castor–Pollux seam in hole C2286 was found to be approximately 30 metres higher than expected and an upthrown block is suspected. Hole R2192 in the southern part of the area is fault thinned.

The model of the structure roof of the Pollux seam indicates that the dip of the seam in the southern part of the Yongala area, south of the southernmost east–west trending fault, is steeper than that to the north of this fault. This may indicate some strike–slip component to the southern fault.

2.5 Seam Characteristics

Pollux Seam

In the Yongala area the Pollux seam is of consistent thickness averaging 2.58 metres and has a characteristic hard, dull stony coal band, generally 0.15m to 0.30m thick, about 0.40m to 0.70m from the base of the seam. The seam has been intersected in 99 boreholes including 13 in which the seam has been cored by slim core and 15 in which a large diameter (200mm) core was retrieved. The roof and floor of the seam are relatively sharp and generally soft mudstone or carbonaceous mudstone and there is often a thin coal ply 20cm or 30cm below the base of the seam.

Castor Seam

The Castor seam in the Yongala area ranges in thickness from 0.2m to 3.48m and averages 1.36 metres thick. The seam has been cored in 6 slim holes and 3 large cores and generally displays a gradational roof with interbedded mudstone, carbonaceous mudstone and thin coal plies over a thickness of 10cm–60cm. A number of thin siltstone and mudstone bands occur within the seam and together with the generally higher inherent ash content for the coal result in an overall high ash content (range 25%–35%).

A21 Seam

The A21 seam was intersected in 20 boreholes including two in which the seam was cored. It has an average thickness of 1.33 metres (range 0.5m–1.81m) and has an average raw coal ash content of around 15%. The roof of the seam appears sharp although the floor (interburden to the A22 seam) is gradational. The roof is comprised of mudstone while the floor is interbedded mudstone, carbonaceous mudstone, siltstone and thin coal plies.

Other Seams

The A22 seam was identified in 19 boreholes and cored together with the A21 seam in two. The seam occurs 1m–2m below the A21 seam and is comprised of dull and bright coal lithotypes. From the two cores available, the roofs and floors appear to be sharp and distinct but the material is variable.

A number of thin unidentified seams were noted above the A21 seam in 8 holes along the western margin of the block. These seams may be splits off the A21 seam, sub–seams of the A1 seam, or they may be some other seam introduced into the sequence in this part of the MDL.

2.6 Coal Quality

Pollux Seam

The Pollux seam in the Yongala area is of export quality in the raw state and analyses conducted during the 1991/92 exploration program concentrated on the production of a whole seam raw coal product.

The ash content is low averaging 10.61% (range 8.10–11.30%) and the specific energy is high averaging almost 7100 kcal/kg (range 7000–7300 kcal/kg) on an air dried basis, and 8300 kcal/kg on a dry, ash free basis. Inherent moisture is low (average 3.6%) and volatile matter content averages around 29%. Total sulphur content averages 0.57% but is known to be variable with higher values possibly reflecting a proximity to faulting. The ASTM classification for the Pollux seam on a raw coal basis is high volatile C bituminous.

On a whole seam raw coal basis, without any allowance for mining dilution, the air dried quality of the coal from the Pollux seam within the Yongala area could be expected to be:

Thickness	2.58m
Inherent Moisture	3.6%
Ash Content	10.6%
Volatile Matter	28.7% (approximately 29.7% ASTM)
Fixed Carbon	57%
Total Sulphur	0.6%
Specific Energy	7100 Kcal/kg
CSN	3

Dry sizing tests were undertaken on two large (200mm) cores and the results from the detailed analyses indicate that by dry sizing of the coal, a 9.8% ash steam coal with a CSN of between 1 and 4 (average 2) can be produced from the coarser fraction (+16mm, approximately 66% of the seam), while a coking coal with an ash content averaging 8% and a CSN of 6–7 can be produced from the finer fraction (–16mm +0.5mm, approximately 30% of the seam). The –0.5mm fraction (approximately 3% of the seam) could be added to the steam coal fraction.

Where the Castor seam and the Pollux seam are coalesced, at the northern end of the Yongala block, analyses were usually undertaken on the individual seam components. In one core however (C2252), analyses were undertaken on the total 4.52m thick combined seam. The results of the raw coal analysis of this seam show an ash content of 14.8%, specific energy of just over 6700kcal/kg, sulphur content of 0.49% and volatiles of 26.0 on an air dried basis.

The increased thickness of this seam is off-set by the generally deeper weathering profile in the north but the quality is such that the full seam section could be blended with the cleaner Pollux seam coal immediately to the south.

Castor Seam

On a raw coal basis the Castor seam has an ash content that ranges from 25.3% to 59.8%. Float/sink analyses have been previously undertaken on three cores and it is apparent from the results that a product with ash content of <10% can be produced, but at low yields.

A21 Seam

Raw coal analyses of the A21 seam indicate that the coal has an ash content of around 15% with specific energy of approximately 6700 kcal/kg. It is anticipated that the coal could be blended with the Pollux seam and it is estimated that the blend would have a 12% ash content with specific energy of around 6900 kcal/kg and a CSN of 1½.

2.7 Reserves

Reserves have been calculated for the Pollux seam, the Castor seam and the A21 seam within the MDL area using the results of the 1991 drilling. The overburden limit has been calculated using the combined thickness of coal in all three seams and reserves have been calculated to the 12:1 overburden ratio (12 cubic metres overburden : 1 tonne coal).

Because of the higher ash nature of the Castor seam, it has not been included in the calculation of estimated raw coal product tonnes. The yield of the Pollux and A21 seams is assumed to be 100%. The relative densities derived from the drilling have been used in the tonnage calculations, (ie Castor seam 1.43, A21 seam 1.43, Pollux seam 1.38).

In-situ opencut reserves for the three seams, from the LOX line down to the 12:1 overburden limit, have been calculated as approximately 32 million tonnes with an average overburden ratio of approximately 10:1. In-situ tonnes raw coal suitable for direct export (Aries 21 and Pollux seams) totals almost 25 million tonnes.

Additional drilling will be required to confirm and refine the interpretation, particularly in the LOX zone, and there is scope for a further increase in reserves to the north and further to the west of the currently defined area.

2.8 Geotechnical Considerations

The roof and floor material of the Pollux seam is commonly a soft, plastic mudstone. It is unlikely that this material will require blasting prior to excavation but careful consideration will need to be given to the location and configuration of the spoil piles.

Groundwater is not considered to be a problem as significant groundwater was not encountered in any of the holes drilled into the Rangal Coal Measures. Some small flows were recorded in a number of the deeper holes but most of the holes were found to be dry.

YONGALA RESERVES

IN-SITU RESERVES

SEAM	AVERAGE THICKNESS	TONNES
A21	1.33m	4,883,000
CASTOR	1.36m	7,226,000
POLLUX	2.58m	19,880,000
		31,989,000

DIRECT SHIPPING COAL

SEAM	TONNES
A21	4,883,000
POLLUX	19,880,000
	24,763,000

APPENDIX 3

YONGALA MINE
LAND RESOURCES

TABLE OF CONTENTS

LAND RESOURCES

YONGALA MINE

LAND RESOURCES

1.0 INTRODUCTION

This section of the report considers various aspects of the physical environment which will be affected to varying degrees due to development of the Yongala mine. Specifically, those aspects include an evaluation of:

- surface geology,
- landform and related soil type,
- soil physical and chemical properties and soil erodibility,
- existing land use and current condition,
- land suitability for agricultural/pastoral purposes,
- characterisation and handling of overburden materials,
- various aspects of land care and rehabilitation.

Consideration of these attributes provides the basis for assessing the extent and controlling the effects of any perceived environmental impacts to an acceptable level.

2.0 DESCRIPTION OF THE PHYSICAL ENVIRONMENT

2.1 Geology

The main geological formations which occur within the Yongala study area include:

- Quaternary Alluvium: including gravel, sand, silt and clay.
- Cainozoic Soil Cover: including sand, soil, gravel, ferruginous gravel and reworked laterite.
- Tertiary Sediments: including argillaceous sandstone, siltstone, claystone and laterite.
- Triassic, Rewan Group: mudstone with lithic sandstone interbeds.
- Upper Permian, (Blackwater Group) Rangal Coal Measures: carbonaceous mudstone, siltstone, feldspathic and lithic sandstone, calcareous sandstone, tuff and coal seams.
- Upper Permian, (Blackwater Group) Burngrove Formation: carbonaceous mudstone, thinly interbedded mudstone and fine sandstone, calcareous, lithic and feldspathic sandstone.

The coal seams of interest for the Yongala Project occur in the Rangal Coal Measures; they generally have a low angle dip in a westerly direction and in descending order they comprise the Aries I, Aries II, Castor, Pollux and Orion seams.

A detailed geological description, including stratigraphy, structure, and coal seam characteristics, is given in Appendix 2. In the interests of compatibility with previous studies in the Ensham exploration area (HDM,1991) which is contiguous to the south with the Yongala area, the geological formations as mapped by the Geological Survey of Queensland (GSQ) on the Australia 1:250,000 Geological Series –Duaringa and Emerald sheets, have been adopted as the basis for terrain mapping in this present study.

It is noted that the extensive areas of Tertiary Sediments mapped by the GSQ which occur as lateritised undulating to hilly areas and dissected plateau remnants are probably lateritised outcrops of the Triassic Rewan Formation in the western part of the Yongala area, and lateritised Upper Permian Burngrove Formation sediments in the eastern sector. The Upper Permian Rangal Coal Measures lie conformably above the Burngrove Formation and occurs along the central sector of the study area where they are covered by a veneer of Cainozoic alluvial/colluvial deposits and recent alluvium adjacent to Boggy Creek.

A generalised description and occurrence of the geological units mapped is as follows:

- Quaternary Alluvium (Qa): comprising coarse (sandy) and finer–textured alluvial deposits associated with Boggy Creek and some minor tributary streams.

- Cainozoic Soil Cover (Cz): comprising undulating plains and interfluves with surficial weathered soils overlying older colluvium/alluvium, Tertiary sediments or older lithologies.

- Tertiary Sediments (Ta): these occur mainly as dissected plateau remnants and dissection slope interfluves, comprising lateritised argillaceous quartz sandstone, pebbly sandstone and conglomerate, siltstone or claystone, possibly of Triassic or Late Permian age.

- Upper Permian Blackwater Group, Burngrove Formation (Pb): as mapped occurring as dissection slopes below the Tertiary land surface in the north eastern sector of the area of interest, comprising carbonaceous mudstone, thinly interbedded mudstone and fine lithic sandstone, siliceous siltstone, lithic and feldspathic sandstone.

The occurrence and distribution of the geological units mapped is shown in Figure 13. (A general mine layout plan is provided in Figure 12).

2.2 Topography and Drainage

The terrain within the Yongala study area comprises mildly dissected undulating to low hilly lands, with internal slopes mostly less than 5–10%, occurring as crestal plains and gently sloping plateau remnants with moderately steep locally benched slopes (up to 25%) and low scarps (25–60%) in some more deeply dissected erosion gullies and around the margins of the area. Internally, the site comprises broadly rounded gently to moderately inclined (3–5%) dissection slope interfluves generally trending in an EW direction, with outwash slopes and plains flanking Boggy Creek. Boggy Creek flows in a SSW direction through the centre of the area and joins the Nogoa River approximately 10 kms to the south in the Ensham property. Upstream of the mine site Boggy Creek has a limited catchment area and stream flows are intermittent. When inspected in early June 1992, the creek was dry.

Land units have been identified within the study area from airphoto interpretation and field survey. They have been described in terms of geology, surface slope and form, and associated soil type. The occurrence of land units within the site is shown on Figure 13 and detailed descriptions are given in Table A3.1.

2.3 Soils

2.3.1 Soil Classification

The soils within the study area have been described and data recorded according to the guidelines in the Australian Soil and Land Survey Handbook – McDonald et al (1990). Soils have been classified in terms of Australian Great Soil Groups (Stace et al, 1968). Soil types within each soil group have also been classified in terms of Principal Profile Form (PPF) (Northcote, 1979), and individual soil layers which occur within each typical profile have been rated in terms of the Unified Soil Classification (USC), (AS1726 – 1981)) to indicate engineering soil properties.

Soil and land unit characteristics were recorded throughout the area of interest, details of which are included in Annexure A. A total of 39 sites were inspected, the locations of which are shown on Figure 14. Soil profiles were described and sampled from backhoe pits. As is usual practice in carrying out a reconnaissance soil/site survey, numerous additional observations were made en–route between sites, noting vegetation types, surface conditions (soil colour, rockiness, colour of termite mounds etc.) all of which are reasonable indicators of soil type.

The occurrence and distribution of the major soil groups within the study area are shown on Figure 15. A generalised description of each soil mapping unit is given in the map reference. More detailed descriptions are included in Table A3.1.

The soils of the area have been classified into 6 major groups with a total of 10 soil types or soil variants, as shown in Table A3.2. The main soil groups and soil types have, wherever possible, been made compatible with the soils nomenclature used in the Ensham Project study (HDM 1992). However whilst the 6 major soil groups are essentially similar, individual soil types within a group may differ to some extent due to differing geological and terrain conditions between the Yongala and Ensham areas.

TABLE A3.1

DESCRIPTION OF LAND UNITS

Land Unit No.	Landform Description	Soil Type	Erosion[1] Condition	Land[2] Suitability Class	Comments
(Qa) Quaternary Alluvium : alluvial clay, silt, sand and gravel					
Qa1/2.1	Stream terraces and levees including banks and channel of Boggy Creek and its tributaries, subject to regular overflow flooding and erosive flood flows.	Deep (>1.5 m) uniform or weakly gradational fine sands, silty sands and sandy loam alluvial soils (Soil type 2.1 – Uc1.43, Uc5.31)	M–S	3	Local bank instability due to undercutting and scour during flood flows; Moreton Bay ash, blue gum and popular box woodland common.
Qa2/4.3	Alluvial flats and terraces adjacent to Boggy Creek; near level or very gently inclined slopes, mostly <1%	Deep (>1.5 m) thin loamy surface duplex soils with brown, reddish brown or yellowish brown alkaline medium to heavy clay sub–soils (Db1.33, Dr2.23)	M–S	4	The subsoil clays are mod. sodic and highly dispersive; popular box woodland.
Qa2/5.1	Near level or very gently inclined alluvial plain; slopes 1–2%	Deep (>1.5 m) dark brown – reddish brown uniform or weakly gradational clay soils with moderately to strongly alkaline medium to heavy clay subsoils (Soil Type 5.1, Uf5.31, Uf6.31, Gn3.13)	L–M	2	Vegetation is dominantly brigalow scrub with softwood understorey locally; moderate gullying on approaches to drainage.
(Cz) – Cainozoic Soil Cover: Clay, sand, gravel and reworked laterite					
Cz2/4.3	Gently inclined footslopes and locally near level remnant older alluvial terraces, slopes up to 2%.	Mostly deep (>1.5 m) loamy surface duplex soils with brown or reddish brown alkaline medium – heavy clay sub–soils (Soil Type 4.3 – Db1.33, Dr2.23)	M	3	The subsoils have increasing sodicity with depth and are moderately dispersive, vegetation is mainly poplar box.
Cz2/5.1	Near level or very gently inclined alluvial flats, infrequently floodprone; slopes <2%	Deep (>1.5 m) uniform or weakly gradational dark brown or reddish brown clay soils; with moderately to strongly alkaline medium to heavy clay subsoils; (soil type 5.1 – Uf6.31)	M	2	Vegetation is mainly brigalow scrub; surface soils have a very thin fine self–mulching surface veneer.

Table A3.1 (Cont'd)

Land Unit No.	Landform Description	Soil Type	Erosion[1] Condition	Land[2] Suitability Class	Comments
Gz3/5.1–4.3	Gently inclined, broadly rounded dissection slope interfluves; slopes mostly in the range 2–5%	Mixed occurrences of deep (>1.5 m) uniform brown – reddish brown clay soils (soil type 5.1 – Uf5.31, Uf6.31) and thin loamy surface duplex soils commonly with a gravelly and thin bleached A2 horizon, with alkaline medium to heavy brown or reddish–brown clay subsoils (soil types 4.3–Db1.43)	L	2	Mixed blackbutt – brigalow communities; the clayey subsoils are dispersive and become increasingly sodic and saline with depth.
Cz5/4.3	Gently to moderately sloping, dissected and highly eroded footslopes and overflow outwash plains; slopes mostly around 5% overall	Deep (?) loamy surface duplex soil with extremely tough diffusely mottled medium or heavy clay subsoil (soil type 4.3 – Db2)	S	4	Heavily sheet and gully eroded overflow outwash slope mainly devoid of vegetation but fringed by brigalow scrub
(ta) Tertiary Sediments and Laterite; laterite or lateritic sediments, claystone, siltstone, sandstone, pebbly sandstone					
Ta2/4.3	Lower footslopes and broadly depressional gently inclined valley flats and drainage–ways, slopes up to 2% but generally with a single sharply incised erosion gully with sub–vertical banks (1.5 – 3.0 m) high	Moderate to deep (0.8 – 1.2 m) mainly yellowish brown to dull brown loamy surface duplex soils in places with a bleached A2 horizon underlain by slightly acidic to alkaline medium to heavy mottled clay subsoils, underlain by indurated mottled zone (soil type 4.3 – Db2.42, Db2.43)	S	4	Locally very deep (0.8–1.2 m) incised erosion gullies occur along the drainageways between the gently inclined dissection slope interfluves; subsoils may be highly sodic and dispersive; mostly ironbark tending to poplar box woodland down slope.
Ta3/3.1	Gently inclined broadly rounded dissection slope interfluves with slopes mostly around 2–3% but locally to 5% on slopes to dissection gullies	Moderately shallow (0.3–0.6 m) sandy gradational lateritic yellow–brown earth soils underlain by weathered indurated hard and brittle claystone (soil type 3.1 – Ks–Gn2.21)	L	4	The near surface soils are very gravelly and have low PAWC; moderately severe areas of sheet erosion occur locally

Table A3.1 (Cont'd)

Land Unit No.	Landform Description	Soil Type	Erosion[1] Condition	Land[2] Suitability Class	Comments
Ta3/3.2	Near level to gently inclined crestal plains on the plateau surface and dissected plateau remnants, slopes are broadly rounded to planar mostly in the range 1–3% occasionally up to 5% on slopes to broadly depressional dissection gullies.	Mostly deep (>1.0 m) sandy loam to loamy surface gradational red earths with slightly acidic to neutral fine sandy clay loam to light clayey subsoils (soil type 3.2–Gn2.12, Gn2.11)	L–M	4	The unit is locally prone to development of surface scalds which are prone to surface sheet erosion; locally there is a moderate to high potential for woody regrowth which inhibits improved pasture establishment; nutrient levels are low.
Ta3/3.3	Gently inclined marginal slopes and near level areas associated with unit Ta3/3.2. Slopes mostly in the range 1–2%, locally to 5% in steeper parts.	Moderately shallow (0.3–0.6 m) gradational red earth soils with varying amounts of lateritic gravel included, underlain by lateritic gravelly loams to light clay subsoils, or they may be lateritic gravelly throughout the profile (soil type 3.3–Gn2.11, KS–Gn2.11)	L–M	4	The unit supports narrow–leaved ironbark woodland with locally dense shrubby understorey of woody acacia regrowth.
Ta3/4.2	Gently inclined broadly rounded dissection slope interfluves mainly in the mid to lower slope sectors of the dissected Tertiary land surface; slopes in the range 3–5%.	Moderately deep (0.6 – 1.0 m) brown or reddish brown sandy loam to loamy surface duplex soils often with a bleached A2 horizon over acidic to mildly alkaline medium to heavy clay subsoils underlain by weathered siltstone, claystone (soil type 4.2–Db1.41, Dr3.32)	M	3	The clayey subsoils may be dispersive; characteristic vegetation is poplar box woodland with some narrow – leaved ironbark associated in places; some bare scalded areas included.
Ta4/1–3.1	Low rocky rises, eroded plateau crestal areas with locally moderately inclined, benched slope margins mostly about 3–5% but locally steeper up to 12%	Shallow, gradational sandy brown and yellowish brown lateritic sandy earth soils some crestal areas; shallow rocky sandy to sandy loam soils underlain by weathered rock on the steeper slope margins (soil types 1 and 3.1 – KS–Gn2.21)	M–S	4	Copious ferruginous, siliceous and quartz gravel occurs as a surficial lag gravel accumulation; surface sheet erosion is common, with some bare heavily eroded areas evident.

Table A3.1 (Cont'd)

Land Unit No.	Landform Description	Soil Type	Erosion[1] Condition	Land[2] Suitability Class	Comments
Ta5/4.1	Gently to moderately inclined mainly planar middle and lower erosional slopes mostly around 3–5%, locally steeper.	Mostly shallow (<0.5 m) thin silty to loamy surface duplex soils with neutral to strongly acidic, mottled yellowish brown, grey and reddish brown, medium to heavy clay sub–soils underlain by weathered indurated claystone sandstone sequences. (Soil type 4.1 – Dy3.32)	M–S	4	Local areas of severe sheet and shallow gully erosion occur; surface soils are locally extremely hard set (almost rock–like) subsoils may be slightly to moderately dispersive.
Ta5/4.2	Gently to moderately inclined mainly planar middle to upper erosional slopes mostly in the range 3–7%	Moderately deep (0.6 – 1.0 m) thin loamy surface duplex soils with mainly red, reddish brown or brown acidic to slightly alkaline medium clay subsoils underlain by ferruginous gravelly clay transitional to weathered rock which may have a high proportion of cherty cobbles and broken rock boulders (soil type 4.2 – Dr2.11, Db1.33); some gradational lateritic gravelly red earths (Gn2.12) may also occur.	M–S	3	Local areas mostly towards the upper parts of the slope are prone to severe sheet and shallow but intensive gullying; the surface soils are hard–setting which promotes rapid runoff and the subsoils may be dispersive in places.
Ta6/1–4.2	Moderately steep, irregular benched slopes and dissected middle and lower parts of steeper gully and escarpment slopes; slopes mostly within the range 12–25%	Shallow rocky sandy to loamy soils and shallow gravelly reddish brown and brown duplex soils, as for unit (Ta5/4.2) underlain by lateritised/ferruginised siltstone, claystone sequences (soil type 4.2 – Db4.11, Db1.33, Dr2.11)	M	5	The unit supports fairly dense lancewood, ironbark and softwood vegetation association; rock outcrop and ironstone is commonly exposed; the unit is vulnerable to clearing.
Ta8/1.1	Low escarpment slopes irregular to steep and locally benched slopes, with local sub–vertical rocky outcrops; overall slopes mostly in the range 33–66%	Exposures of cemented laterite or lateritised sedimentary rock with areas of shallow rocky to gravelly sandy loams or shallow uniform red loamy soils.	M	5	Comments as for unit T6/1–4.2 apply – the unit should not be cleared for grazing purposes.

Table A3.1 (Cont'd)

Land Unit No.	Landform Description	Soil Type	Erosion[1] Condition	Land[2] Suitability Class	Comments
(Pb) Upper Permian – (Blackwater Group) Burngrove Formation; comprising carbonaceous mudstone, feldspathic and lithic sandstone and coal.					
Pb3/6.1	Gently to moderately strongly undulating lowlands with occasional low rocky rises included; slopes mostly 1–3% locally steeper (5%) on the approaches to erosion gullies.	Mostly shallow (0.3 – 0.5 m) stony or gravelly surface uniform brown or reddish brown cracking clay soil underlain by highly weathered sedimentary rock (soil type 6.1 – Ug 5.12); some shallow brown or reddish brown thin loamy surface duplex soils (soil type 4.1 – Dr2.12) occur locally	M	2	Unit occurs in the extreme north–eastern sector where the proposed haul road approaches the railway line; the subsoils may be somewhat dispersive; some poorly drained gilgai, depressions may occur where deeper cracking clay soils are present.

Note: (1) Erosion Condition Rated L–Low, M–Moderate, S–Severe (refer text Section 3.3 for explanation of terms).
(2) Land Suitability Class for beef cattle grazing/improved pasture (refer text Appendix 3 for explanation of class ratings).

Table A3.2

Soil Mapping Unit Reference

Major Soil Group	Dominant Soil Type		Common Group Name	Classification	
	No.	Brief Description		P.P.F.	U.C.S.
Shallow Rocky Soils	1.1	Shallow uniform fine, medium and coarse textured very rocky soils; rock outcrop common.	Skeletal Soils, Lithosols	K–Um 1, K–Uc1.2	GP, GM, GC
Uniform Coarse to Medium Textured Soils	2.1	Deep uniform or weakly gradational sands, earthy sands and loamy alluvial soils.	Alluvial Soils	Uc1.43 Um1.21	SP, SM–SC
Gradational Red Yellow and Brown Earths	3.1	Shallow loamy sand over clayey sand soils; lateritic sandy yellow or brown earths.	Sandy (lateritic) Yellow/ Brown Earth	KSGn2.21	SM/SC–GC
	3.2	Sandy loam to loamy surface soils grading to reddish brown sandy to silty clay loam, sandy clay or light to medium clay subsoils.	Loamy Red Earth	Gn2.11 Gn2.12	SC–CL/CL or SC–ML/CL–CH
	3.3	Deep lateritic red earths with sandy to silt loam surface soils and lateritic clayey gravel subsoils.	Lateritic Red Earth	KS–Gn2.11	SC–ML/GC
Texture Contrast (Duplex) Soils	4.1	Mod. shallow yellowish brown to brown duplex soils with acidic med. – heavy clay subsoils over weathered rock.	Solod	Dy3.32 Dr3.31	SC–CL/CH
	4.2	Mostly deep sandy to loamy surface duplex soils with brown or reddish brown acidic to mildly alkaline medium clay subsoils	Solod/Solodic	Dr2.13 Db1.13 Dr2.11	CL–ML/CL–CH
	4.3	Deep loamy surface duplex soils with dark brown, yellow brown or reddish brown alkaline med. to heavy clay subsoils	Solodic, Solodized Solonetz	Db1.13 Dr2.13 Db1.33	CL–ML/CH
Dark Brown and Grey Brown Clay Soils	5.1	Mod. deep mostly uniform dark brown or reddish brown medium clay soils, with some gravelly lenses included.	Alluvial Soils	Uf6.31 Uf6.12 Uf5.31	CL–CH/CH
Grey and Brown (Cracking) Clay Soils	6.1	Mod. shallow mostly dark brown med. to heavy clay soils over weathered rock; considerable surficial stone may be present.	Brown Soils of Heavy Texture, Black Earth	Ug5.32 Ug5.12	CH

A generalised description of each of the major soil groups and soil type variants is as follows:

Soil Group (1) – Shallow Rocky Soils

These comprise shallow rocky soils (lithosols) which occur mainly on the steep and hilly lands, generally in association with prominent rocky outcrops. The soils are generally less than 0.3 m deep (but small deeper pockets may occur) and they exhibit little or no profile development apart from some slight darkening near the surface due to the influence of organic matter. One general soil type has been described:

Soil Type 1.1: these soils are shallow and generally slightly acidic to neutral and have mainly uniform medium and coarse textures. They generally contain gravel or rock fragments derived from Permo–Triassic sedimentary rocks as well as siliceous and ferruginous gravels derived from erosion of the Tertiary weathered zone materials.

Soil Group (2) – Uniform Coarse to Medium–Textured Soils

The soils in this group occur on recent alluvial deposits and show very limited profile development apart from some accumulation of organic matter at the surface. Only one soil type has been mapped:

Soil type 2.1: these comprise deep uniform sand, loamy sand or sandy loam textures, dominantly brown yellowish brown or dull reddish brown in colour. Soil reaction is generally slightly acid throughout and they may be underlain by weakly cemented clayey sand with ferruginous gravel included. They generally occur on levees and stream terraces (Qa1/2.1) and support silver–leaved ironbark, Moreton Bay ash and blue gum woodland, and are reasonably fertile soils due to fairly frequent flooding.

Soil Group (3) – Gradational Red and Yellow Earths

These soils occur on the elevated gently inclined and dissected plateau surface (Ta3/3.1, Ta3/3.2 and Ta3/3.3) on broadly undulating dissection slope interfluves and colluvial aprons. As shown in Table A3.2, three soil variants have been mapped distinguished by colour, texture and presence of lateritic gravel.

Soil type 3.1: these comprise shallow to moderately deep (<0.6 m) loamy sand to sandy loam surface soils grading to sandy clay loam in the subsoils. They are moderately acidic throughout the profile and have up to high (>60%) amounts of lateritic gravel included. They may be underlain by weathered rock or laterite below about 0.6 m. They occur on gently inclined ridge crests and interfluves, mainly with lancewood and ironbark woodland.

Soil type 3.2: these comprise moderate to deep sandy to loamy surface soils grading to red fine sandy clay loam or light to medium clay subsoils. Soil reaction is slightly acidic throughout the profile. They may be underlain by lateritic gravelly clay at depths of about 0.6 – 0.8 m. They occur on broadly rounded low rises and interfluves with mainly bloodwood and ironbark woodland associated.

Soil Type 3.3: these are similar to soil type 3.2 but comprise deep lateritic red earth soils with sandy to silt loam surface soils and light clayey subsoils with up to high amounts (>60%) lateritic gravel included. They occur in association with but mainly along upper slope margins of soil type 3.2.

Soil Group (4) – Texture Contrast (Duplex) Soils

These soils are characterised by a clear or abrupt change in texture between a generally sandy silt or loamy surface soil and clayey subsoil horizon. They are generally formed by clay illuviation, often under the influence of sodium salts, resulting in the development of a "tough" low permeability massive or coarse columnar–structured clay subsoil horizon.

The soils have formed on a variety of parent materials derived from the Permo–Triassic sedimentary rocks, the lower zones of the Tertiary deeply weathered zone, on broad outwash deposits and on alluvium.

Three soil variants have been mapped within the study area:

Soil type 4.1: these comprise shallow sandy to loamy surface soils underlain by mildly alkaline to strongly acid sandy clay or heavy clay subsoils over weathered rock generally above 0.5 m depth. Surface soils are generally gravelly and hard set and a pale or bleached subsurface (A2) horizon is common. They occur on gently inclined plains mainly with silver–leaved ironbark and poplar box low open woodland.

Soil Type 4.2: these are moderately deep soils underlain by weathered rock generally between about 0.6 – 1.0 m. They have sandy to loamy (often gravelly) surface soils overlying brown or reddish–brown slightly acidic to alkaline medium to heavy structured clay subsoils. They occur on gently inclined interfluve slopes, with ironbark, poplar box and/or blackbutt woodland.

Soil Type 4.3: these are deep (>1.0 m) yellow–brown, brown occasionally reddish brown sandy to loamy surface soils with slightly acid to neutral or strongly alkaline heavy clay subsoils. Soft carbonate segregations occur in the deeper subsoils. A thin sporadically bleached or pale subsurface (A2) horizon commonly occurs. The vegetation is typically poplar box, blackbutt or silver–leaved ironbark woodland with patches of brigalow scrub included locally. In places where associated with the blackbutt–brigalow communities, a ferruginous gravelly layer may be present between the A and upper B horizons.

Soil Group (5) – Dark Brown and Grey Brown Clay Soils

These soils have uniform or weakly gradational texture profiles in which the clay content increases slightly with depth. They occur mainly on gentle colluvial outwash slopes and on alluvial terraces associated with the local stream system. The characteristic vegetation is brigalow in places with an understorey of softwood scrub. One soil type has been identified within the study area. However in places, the soils of this group occur in association with deep loamy surface duplex soils (soil type 4.3) where the characteristic vegetation type is mixed brigalow and blackbutt woodland.

Soil type 5.1: these are deep soils with mainly uniform but occasionally weakly gradational texture profiles. The immediate surface soil is dark brown or dark reddish brown and tends (in places) to be slightly to moderately subplastic with fine granular to weak fine subangular blocky structure. There is a gradual slight increase in clay fines with depth and the soil colour changes to slightly paler brown, red brown or yellowish red in the subsoils. Soil reaction at the surface is generally slightly acid and becomes moderately to strongly alkaline with depth (>0.5 m) where some soft carbonate segregations or ferruginous concretions may occur. Texture at the surface is usually medium to heavy clay loam or silty clay of medium plasticity becoming medium to heavy clay with depth. Soil structure is weak to moderate subangular blocky in the upper 0.4 – 0.5 m where both smooth and rough ped faces are evident, but tends to become more massive below in the free carbonate zone where the soils tend to become strongly sodic and dispersive with increasing salinity levels with depth.

Soil Group (6) – Grey and Brown (Cracking) Clay Soils

The main characteristics of these soils are their uniform medium to high clay contents and pronounced swelling and shrinkage properties on wetting and drying. Gilgai micro–relief is common where associated with some deeper soil occurrences. They are thought to be of limited occurrence in the extreme northeastern sector on the dissected undulating plains below the Tertiary land surface escarpment where the proposed mine haul road approaches the existing railway line. Vegetation is probably low open eucalypt woodland of broadleaf ironbark and other eucalypt species. Only one soil type is likely to occur within the area.

Soil type 6.1: these are shallow to moderately deep dark brown medium to heavy cracking clay soils overlying weathered rock. They are mainly developed on Permian shales and mudstone. Soil colours range from dark brown to dark reddish brown and soil reaction is normally slightly acid at the surface becoming strongly alkaline with depth. When dry, the soils crack and a thin weak granular self–mulching layer forms at the surface.

3.0 SOIL PHYSICAL AND CHEMICAL CHARACTERISATION

3.1 Soil Salinity, pH and Dispersion Characteristics

In addition to the field soil identification procedures, a limited soil testing programme was carried out to determine soil acidity/alkalinity and salinity characteristics for typical soils in the area. Soil pH and EC levels were determined in 1:5 soil water solutions. In addition indicative testing was undertaken to determine the dispersive characteristics of the soil using a modified version of the soil aggregate stability test developed by Emerson and Seedsman (1981). The modified test gives an indication of the potential for soil dispersion and breakdown of soil aggregates in water, both in their natural state and in a remoulded or reworked condition – e.g. following stripping and handling during the topsoil or overburden removal process.

The results of the testing carried out are summarised in Table A3.3. The location of the sampling sites is shown in Figure 14.

3.1.1 Interpretation of Test Results

Soil pH values indicate strongly acidic conditions in soil type 4.2 (Ta5/4.2) at location 19 and in the surficial layer in soil type 4.2 (Ta 4/1–4.2) at location 24. Both of those locations exhibited some quite extensive scalded (bare) areas with extremely hard set surface conditions. Elsewhere pH levels were within the normal range (pH 5.0 to pH 8.5) but rose to very high levels (pH >8.5) in the deeper (>0.6 m) subsoil horizons of soil type 4.3 in terrain units Qa 2/4.3 – locations 12 and 25, and Cz 2/4.3 at location 37. Quite high values were also recorded in the deeper subsoils of soil type 4.3 in Cz3/5.1–4.3 – location 26 and soil type 5.1 in Qa 2/5.1.

EC values indicate moderate salinity levels in the deeper subsoils of soil type 4.3 in terrain units Qa 2/4.3 – location 25, Cz 3/5.1–4.3 – location 26 and Cz 2/4.3 – location 37, and in soil type 5.1 in terrain units Cz 3/5.1–4.3 – location 27 and Qa 2/5.1 – location 30. High to very high salinity levels were recorded in soil type 4.3 in terrain unit Ta 2/4.3 – location 39. Potentially moderately to highly dispersive soil layers occur in a majority of the clayey subsoils of soil types 4.2 and 4.3 and also in soil type 5.1.

Care will need to be exercised in the handling and management of those dispersive soil types to minimise their erosion potential and reduce the potential for excess sediment generation due to runoff from within those areas, particularly where earthworks activities are proposed.

3.2 Soil Chemical and Fertility Status

Seven profiles (comprising 21 samples) considered to be representative of the generally deeper and potentially useable topsoil resources in the mine site and surrounding areas were submitted for full profile analysis by SGS Australia Pty Ltd.

TABLE A3.3

Soil pH, EC and Dispersion Characteristics

Site	Map Unit	PPF (Soil Type)	Depth (mm)	pH (1:5)	EC (1:5) dS/m	Dispersion Class (a)	Comments
9	Ta3/3.2	Gn2.11	0–100	6.26	0.0084	3M	Fine sandy clay loam
			300–600	6.70	0.0092	4/7M	Sandy clay loam
			800–1000	5.82	0.0196	4/7M	Lateritic gravelly sandy clay
10	Ta3/3.1	Ks/Gn2.41	0–150	5.60	0.0080	3M	Lateritic sandy loam
			400–600	5.50	0.0098	4/7M	Clayey ferruginous gravel
			800–900	6.90	0.025	4/7M	Mottled clay ferruginous
			1500+	6.80	0.045	4/7M	Lateritic ferruginous zone
11	Ta3/4.2	Db1.41	0–100	6.20	0.0142	3M	Sandy Loam
			400–500	7.00	0.140	1M	Brown heavy clay
			600–700	7.10	0.252	1M	Sandy clay–EW sandstone
12	Qa2/4.3	Dy3.83	0–100	6.40	0.0164	3M	Silt loam
			200–300	6.53	0.0118	3M	Sandy loam
			500–600	6.90	0.0110	3M	Clay loam
			900–1000	8.80	0.0720	1M	Medium clay, mottled
13	Ta3/3.1	KS–Gn2.21	0–100	6.20	0.0180	3M	Sandy gravel
			200–300	6.00	0.0070	3M	Clayey gravel
			400–500	6.80	0.0086	3M	EW brittle claystone
15	Ta5/4.1	Dy3.22	0–100	5.72	0.0098	3M	Loamy sand–gravelly
			700–800	7.50	0.0485	1M	Medium clay – mottled
			900–1000	7.00	0.0097	2M	Indurated claystone
16	Ta3/3.2	Gn2.11	0–100	5.60	0.0095	3M	Silt loam
			500–600	4.90	0.0120	4/7M	Silty clay loam – red
			1500–1600	5.50	0.0123	4/7M	Silty clay loam – red
18	Ta3/3.3	K5–Gn2.11	0–500	6.00	0.0228	4/7M	Lateritic clayey gravel
19	Ta5/4.2	Dr3.31	0–100	4.30	0.146	4/7M	Silty clay loam
			100–200	4.10	0.145	4/7M	Silty medium clay
20	Ta5/4.1	Dy3.32	0–100	6.20	0.0083	3M	Fine sandy loam
			300–400	6.90	0.0228	3M	Fine sandy medium clay
24	Ta4/1–4.2	Db1.12	0–200	4.90	0.175	3M	Brown silt loam
			400–600	6.70	0.154	4/7M	Silty light clay
25	Qa2/4.3	Db1.33	0–100	6.10	0.0106	3M	Clay loam, dark brown
			300–400	7.40	0.224	1M	Brown medium clay
			600–700	8.80	0.756	1M	Medium – heavy clay
			800–900	9.40	0.784	1M	As above with carbonate
26	Cz3/5.1–4.3	Db1.43	0–100	6.00	0.0157	3M	Fine sandy silt loam
			600–700	8.30	0.525	1M	Dark brown heavy clay

TABLE A3.3 (cont)

Soil pH, EC and Dispersion Characteristics

Site	Map Unit	PPF (Soil Type)	Depth (mm)	pH (1:5)	EC (1:5) dS/m	Dispersion Class (1)	Comments
27	Cz3/5.1–4.3	Uf6.12	0–100	5.70	0.0590	3M	Self–mulching sandy clay
			300–400	6.80	0.150	1M	Red–brown medium clay
			500–600	8.30	0.550	1M	Medium clay diffuse mottling
			1000–1100	8.00	0.849	1M	Red–brown med.–heavy clay
29			0–100	6.40	0.0079	3M	Sandy loam
			600–700	6.30	0.081	1M	Medium – heavy clay
30	Qa2/5.1	Uf5.31	0–100	5.40	0.0487	4/7M	Subplastic silty clay
			300–400	7.20	0.236	1M	Med. – heavy red–brown clay
			600–700	7.80	0.393	1M	Med. – heavy structured clay
			900–1000	8.40	0.445	1M	heavy clay free from carbonate
32	Ta5/4.2	Db1.12	0–100	6.40	0.0106	3M	Fine sandy silt loam
			300–400	7.10	0.0150	3M	Fine Sandy clay loam
			900–1000	7.40	0.0236	3M	Gravelly medium clay
33	Qa1/2.1	Uc1.43	0–100	6.60	0.0089	3M	Fine sand – loose
			700–800	6.50	0.0059	3M	Fine sand – dense
36	Cz2/5.1	Uf6.31	0–100	5.80	0.0129	4/7M	Silty clay
			300–400	7.20	0.0438	2M	Gravelly clay
			1000–1200	6.80	0.271	1M	Med.–heavy clay mottled
37	Cz2/4.3	Dr2.43	0–100	6.40	0.0130	3M	Brown silt loam
			400–500	7.10	0.0329	3M	Med. – heavy red–brown clay
			800–1000	9.20	0.313	2M	Ferruginous gravelly clay
38	Ta5/4.2	Dr2.11	0–100	6.20	0.0215	3M	Silty clay loam
			300–400	6.60	0.0245	4/7M	Silty medium clay
			800–900	5.50	0.0470	4/7M	Ferruginous gravelly clay
39	Ta2/4.3	Db2.42	0–100	6.00	0.00523	4/7M	Sandy loam
			200–350	6.30	0.0056	2M	Silty fine sandy loam
			500–600	7.60	1.44	4/7M	Light–medium clay
			900–1000	6.80	2.35	3M	Med.–heavy brown clay

NOTE: Electrical Conductivity (EC) values have been reported as (dS/m). An indicative potential salinity severity rating is:

Nil	:	E.C. <0.05
Slight	:	E.C. 0.05 – 0.30
Moderate	:	E.C. >0.30 – 0.80
High	:	E.C. >0.8 – 2.0
Severe	:	E.C. >2.0

Soil Acidity/Alkalinity levels (pH) are:

Strongly acidic	:	pH <5.0
Acidic	:	pH 5.0 – 6.5
Neutral	:	pH 6.6 – 7.3
Alkaline	:	pH 7.4 – 8.5
Strongly alkaline	:	pH >8.5

TABLE A3.3 (cont)

Soil dispersion characteristics were determined using the modified Emerson aggregate stability test (Emerson and Seedsman Tech. Memo 15, 1981). Interpretation of the rating classes recorded in Table 4.5.2 is as follows:

Class 1M	–	materials are highly dispersive and will be prone to erode severely when exposed and in contact with water.
Class 2M	–	materials are moderately dispersive and will erode but probably less severely than Class 1M materials.
Class 3M	–	materials exhibit slight to moderate dispersion and may be subject to erosion particularly in a remoulded or reworked state.
Class 4/7M	–	materials are essentially non–dispersive or only very slightly dispersive.
Class 8M	–	materials are not dispersive and cannot be remoulded.

It should be noted that dispersion characteristics relate both to the chemical/physical attributes of the soil material and on the chemistry of the water which comes in contact with the soil. The test procedure adopted utilises distilled or deionised water which is the condition most likely to create dispersion. However, other combinations of soil and water chemistry may give rise to dispersion which may not be apparent for the "indicative" level of testing adopted.

The testing procedure included determinations of:

- pH, EC, and chloride levels
- levels of major elements
- levels of trace elements
- organic matter
- cation exchange capacity (CEC)

The results of the soil chemical/fertility tests carried out are summarised in Table A3.4. The full range of analyses undertaken and the test methods used are included as Annexure B.

3.2.1 Comments on Test Results

pH, EC and available Aluminium

pH values in Table A3.4 generally appear somewhat lower than the equivalent sample test results in Table A3.3. This is due to the different test methods utilised. The pH values recorded in Table A3.3 have been determined using a 1:5 soil/water mix. Those recorded in Table A3.4 were determined using 1:5 soil/0.01 M $CaCl_2$ solution mix. When an appropriate correlation factor is applied to the results of the two test methods, the respective pH values are reasonably compatible. Nevertheless, the surface soils at each of the seven sites tested are acidic to highly acidic. In addition available aluminium levels are undesirably high in some soils where the value is below pH 5.1.

Salts, Sodium and Chloride

Of the seven sites where full tests were undertaken, none show excessively high salinity (indicated by total soluble salt levels). Sodium and chloride are marginally higher than desirable in the 300 – 400 mm depth at sites 25, 27 and 30, although problems are not expected for plants excepting those that are salt sensitive.

At depth, salinity, sodium and chloride are higher than desirable at sites 25, 27 and 30.

Soil Structure, Exchangeable Sodium and Calcium Magnesium Ratio

A high exchangeable sodium (ESP) (above 6 and especially above 15) and low calcium magnesium ratio (below 2.0 and especially below 1.0) indicate that soil structure may be a problem in reducing soil aeration, root penetration and water drainage. High ESP levels in many instances correlates with dispersion characteristics.

Sites 25, 27 and 30 show possible soil structural problems below about 300 – 500 mm.

TABLE A3.4

SOIL CHEMICAL/ FERTILITY TESTING

Location	Soil Mapping Unit	PPF	Depth	Test Results																Calculations							
				pH	EC	Al	N	P	K	S	Ca	Mg	Cu	Zn	Mn	Fe	B	OM	Na	Cl	TSS	CEC	ESP	EPP	ECP	EMP	CAMG	EAP
			mm		dS/m	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	meq%	%	%	%	%	%	%
9	Ta3/3.2	Gn2.11	0-100	5.0	0.01	20	3	11	180	3	740	180	1.9	0.1	78	20	0.3	1.5	10	10	40	5.8	0.7	7.8	62.6	25.1	2.5	3.8
			300-600	6.2	0.02				120		430	270							20	10	60	4.7	1.8	6.4	45.1	46.6	1.0	
			800-1000	5.1	0.03				100		130	280							20	10	80	3.2	2.6	7.8	19.7	69.9	0.3	
15	Ta2/4.1	Dy3.22	0-100	4.4	0.01	8	2	16	80	5	230	60	0.6	0.2	26	40	0.3	1.1	10	10	40	1.9	2.2	10.3	58.1	24.9	2.3	4.5
			700-800	7.0	0.11				20		400	830							310	50	350	9.6	13.2	0.5	19.6	66.8	0.3	
25	Qa2/4.3	Db1.33	0-100	4.6	0.02	6	2	17	170	4	580	220	1.4	0.6	210	140	0.4	1.6	20	10	50	5.2	1.6	8.2	54.7	34.2	1.6	1.3
			300-400	6.6	0.26		3	5	20	8	1080	830	1.4	0.1	223	70	1.4	0.8	770	380	830	14.2	21.4	0.3	34.6	43.7	0.8	
			600-700	8.1	0.76				10		1240	1160							1320	1050	2430	17.4	26.7	0.1	28.8	44.4	0.6	
			800-900	8.3	0.78				10		10850	1460							1320	910	2480	67.8	8.0	0.1	75.3	16.7	4.5	
27	Cz3/5.1-4.3	Uf6.12	0-100	4.6	0.07	16	7	12	170	15	800	380	1.8	1.2	90	110	1.0	2.3	100	40	230	7.8	5.3	5.3	48.9	38.2	1.3	2.2
			300-400	6.0	0.19		3	10	80	20	710	730	2.6	0.5	83	70	1.4	1.2	420	210	610	10.5	15.8	1.8	30.6	51.8	0.6	
			500-600	7.6	0.56				10		490	980							1170	870	1800	12.5	32.6	0.2	15.7	51.6	0.3	
			1000-1100	7.4	0.86				40		220	1170							1750	1380	2720	13.8	41.3	0.6	6.0	52.2	0.1	
30	Qa2/5.1	Uf5.31	0-100	4.5	0.06	5	14	33	160	17	930	120	1.9	1.4	293	140	0.4	2.8	10	10	190	5.8	0.7	6.7	75.7	16.1	4.7	0.9
			300-400	6.7	0.28		2	7	20	24	900	600	1.5	0.2	112	50	1.1	0.5	450	380	880	9.9	17.1	0.4	39.3	43.1	0.9	
			600-700	7.3	0.40				10		750	790							650	560	1290	10.9	21.6	0.2	28.6	49.6	0.6	
			900-1000	7.5	0.46				10		470	710							820	700	1480	9.2	30.3	0.2	19.9	49.6	0.4	
33	Qa1/2.1	Uc1.43	0-100	5.4	0.01		2	4	70	2	360	110	0.9	0.4	108	70	0.2	1.0	10	10	40	2.9	1.5	6.1	61.5	30.9	2.0	
37	Cz2/4.3	Dr2.43	0-100	5.2	0.02		3	8	140	2	650	180	1.2	0.2	84	70	0.4	1.5	10	10	60	5.0	0.8	7.0	63.3	28.8	2.2	
			400-500	5.9	0.04				40		880	600							160	30	130	9.9	6.9	1.0	43.4	48.7	0.9	
			800-1000	8.3	0.34				10		4310	1140							610	240	1100	31.7	7.9	0.1	64.1	27.9	2.3	

Organic Matter

Organic matter is generally lower than normally preferred levels in the surficial soils at all seven sites. Organic matter benefits soil structure, nutrient holding and water holding capacity and therefore a high level (above about 4%) is desirable.

Major Nutrients

Nitrogen and phosphorus are low in all samples except for site 30 (0–100 mm). Applications of both nutrients at all sites is desirable for the successful establishment of most plants. The rate of application will depend on the plants to be grown.

Potassium is at reasonable levels in the 0–100 mm samples at all sites and sulphur varies from good e.g. site 27 and 30 to low, in sites 33 and 37.

Trace Elements

The levels of copper, zinc, iron, manganese and boron are generally low. Most organic fertilisers have useful levels of trace elements.

3.3 Soil Erosion

The lands of the general region are prone to erosion due to the high intensity rainfall events mainly during the summer period, and also due to the inherent erodibility of some of the soils/landforms which occur. Runoff control structures (contour banks, grassed waterways and diversion banks) are generally required to control erosion on sloping lands, particularly in areas to be disturbed or where the ground is left bare of some form of protective surface cover i.e. either vegetative or stone cover.

The extent to which soil erodes depends on a number of factors including its texture, structure, physical and chemical properties, and the overall steepness and form of the ground surface. The nature of the ground surface cover, particularly good vegetative cover, can limit the susceptibility to erosion.

The forms of erosion which are of concern to clearing and earthworks operations for mine construction sites are sheet erosion, gullying and tunnel erosion. Sheet erosion is the disappearance of topsoil in a thin layer of widely spread water runoff. Gullying is caused by larger concentrations of runoff water in defined channels. Tunnel erosion is caused by localised infiltration of water in certain soils containing dispersible clays.

In Table A3.1, ratings have been assessed on a land unit basis which classifies the status of erosion both in terms of the current condition as well as the potential for erosion of soils when exposed and unprotected due to for example overgrazing, clearing and/or disturbance due to construction activities. The assessments have been made based on air photo and field observations and consideration of the physical and chemical properties, permeability and structural stability of the soil profile layers.

The following criteria have been applied in deriving the ratings:

- **Rating L – Low Mainly Stable**

  The soil profile horizons are considered to be resistant to natural disturbing forces of wind or water and contain no layers which might be dispersive. Generally the surface material may be gravelly or medium to coarse–grained material which contains a sufficiently high proportion of fines and/or organic matter to act as a binding agent. Infiltration of surface water is moderate to rapid. Overall ground slopes are mostly gentle, long, smooth, even slopes, generally less than 5%; surface runoff is generally fairly low.

  Areas are mainly stable in their present condition but disturbance or removal of the natural surface vegetation may give rise to minor surface sheet erosion and shallow gullying. The soils are non–dispersive.

- **Rating M – Moderate**

  The materials often lack some binding agent, they have low organic content and may have a significant proportion of silt and/or fine sand, particularly in the topsoil layer. They are mainly stable in the subsoil layers, i.e. the subsoils are either non–dispersive or exhibit very low dispersion. They are moderately susceptible to surface sheet and gully erosion due to relatively low infiltration and moderate to high runoff. Overall ground slopes are generally short and moderately inclined, mostly 5–12% and occur mainly along the margins of more gently sloping terrain and on approaches to drainage.

  These areas show some evidence of sheet and/or shallow gully erosion and/or removal of the natural vegetation (scalded areas).

- **Rating S – Severe**

  The surface soils may be shallow to moderately deep, low in organic matter with a high proportion of fine sand and/or silt. They may be susceptible to wind and sheet–wash erosion, or the surface soils are hard–setting with low infiltration and prone to rapid surface water runoff with consequent moderate to severe erosion. The profile may contain highly dispersive subsoil layers which are prone to severe tunnelling and gully erosion. Ground slopes may be very low (<2%) where dispersive soils occur, or moderate to steep (>12%).

  In their existing state these areas exhibit locally severe sheet and/or gully erosion requiring intensive soil conservation works for control.

The assessment of the erodibility ratings on the above criteria is largely qualitative and is included to provide a guideline for site planning and development purposes.

Dispersive Soils and Erosion

Some soils are prone to slake and disperse in the presence of relatively pure water and may be highly susceptible to gully erosion and piping failures. The extent to which a soil may be dispersive depends on its mineralogy, chemistry, and levels of exchangeable sodium and dissolved salts in the percolating water.

In most cases soil dispersion is highly undesirable in that the deflocculated soil particles are readily transported by water. This facilitates erosion particularly where the soil has been stripped of vegetation, or where the protective topsoil layer is removed or disturbed.

A test procedure has been devised (Emerson, Seedsman, Tech Memo 15–1981) to predict the behaviour of overburden materials as a result of disturbance by mining. This test has been used to determine indicative aggregate stability ratings for the samples obtained within the project area. The results of these tests are included in Table A3.3.

The significance of the modified class ratings determined by the test are as follows:

- Materials classified 1M or 2M exhibit slaking with high to moderate dispersion and will give rise to problems where exposed during the mining process or when they occur in cuttings or embankments without adequate surface protection.

- Materials classified 3M also slake and are considered to be slightly to moderately dispersive and may give rise to problems. Accordingly care should be exercised to minimise the amount of reworking applied to them, and to limit the ingress of water when exposed as in the case of the Class 1M and 2M materials.

- Classes 4/7M and 8M may slake but are essentially non–dispersive and problems arising from these soils are expected to be less than for Classes 1M to 3M.

4.0 LAND CAPABILITY

The purpose of a land capability rating is to indicate which lands have the capacity to sustain the impact of agricultural and/or pastoral use. There is a need to assess pre-mining land capability in order to identify appropriate rural land uses and rehabilitation techniques and strategies.

Agricultural use implies broadacre rainfed cropping and related infrastructure, including land clearing and cultivation.

Pastoral use implies the upgrading of land with limited clearing and occasional cultivation for the introduction of improved pasture species. The requirement for the use of fertilisers, additional watering points, access tracks and fencing is also implied.

4.1 Existing Land Use

The only current land use within the study area is beef cattle grazing on predominantly native pasture of low to moderate productivity with some small areas of introduced pasture species – mainly buffel grass.

4.2 Current Condition

Overall, the Yongala property, which comprises the major part of the study area, is currently in a moderately to in places severely degraded condition. The rating of "Erosion Status" in Table A3.1 largely reflects the current condition of the land, in that those areas which are potentially susceptible to degradation due to landform, soil type and drainage conditions, already reflect a substantial level of degradation.

In places, very deep erosion gullies have developed in many of the depressional drainageways within the property (e.g. Land Units Qa2/4.3, Cz2/4.3 and Ta2/4.3). The size and severity of gullying (see Plate 1) is attributable to the generally dispersive nature of the soils and substrate materials within those land units and uncontrolled surface water runoff. Once initiated these "badlands" type erosion gullies are very difficult and costly to control or eliminate without substantial engineering effort being employed.

Elsewhere, in particular on the gently inclined land units mapped on Figure 13 as Ta5/4.1, Ta5/4.2, Cz5/4.3, frequent small to fairly extensive occurrences of surface scalding (bare areas) are evident. It is unclear what has caused the surface scalding effects. However, it is possible that those areas represent zones of downslope drainage concentration with possibly higher levels of soluble salt concentrations in those areas. Alternatively, it may just reflect areas of "sweeter" pasture due to increased moisture conditions which are preferentially grazed by cattle to the extent that over time the areas become totally eaten out and not able to respond to normal regrowth conditions during drier periods. Irrespective of the origin, once those areas become devoid of surface vegetative cover, they are susceptible initially to sheet erosion and subsequently to increasing levels of gully erosion.

Other areas which are currently exhibiting patches of quite severe sheet erosion are some crestal areas and marginal gully slopes within the Tertiary land surface (land units Ta4/1.3.1 and Ta6/1.4.2). Typically these areas support lancewood and ironbark vegetation with poor quality native pasture developed, largely due to the occurrence of poor quality soils and generally quite shallow depth to bedrock.

4.3 Land Suitability Classification

4.3.1 Pre-Mining Land Suitability

Based on the land use history of the site and its limited potential for other agricultural uses, the land suitability classification for beef cattle grazing on improved pastures only has been assessed. In deriving the land suitability classes for cattle grazing on improved pastures, the approach outlined by Shields and Williams (1991) for a land resource survey and evaluation of the Kilcummin area Queensland, has been adopted.

The suitability assessment process includes an evaluation of factors which may constitute varying levels of hazard in terms of land degradation. The factors considered include:

- soil and site drainage condition
- soil moisture holding capacity
- soil physical conditions
- soil chemical conditions
- soil erosion hazard
- adverse site factors – (rockiness, steep rugged topography, etc).

The specific land resource attributes considered in deriving the land suitability class ratings are explained in Annexure C1. The impact of each limitation assessed has been allocated into one of five levels of severity of constraint with respect to the land use enterprise being considered. The levels of limitations assessed are:

Rating 1	Nil or negligible limitation
Rating 2	Minor limitation
Rating 3	Moderate limitation
Rating 4	Severe limitation
Rating 5	Extreme limitation

Land is considered less suitable as the severity of the limitation increases. The combined effects of the limitations assessed may reflect (a) reduced potential for production and/or (b) increased inputs to achieve acceptable levels of productivity and/or (c) increased inputs and land management practices to prevent land degradation, consideration of which permits the appropriate land suitability class rating to be determined.

Table A3.5 summarises the process and limitations considered in deriving the land suitability class rating and provides an additional evaluation of potential grazing management options specific to the classes of land identified.

TABLE A3.5
LAND SUITABILITY FOR CATTLE GRAZING

Land Unit No.	Land Unit Description	Land Suitability Rating and Assessed Levels of Limitations												Potential Grazing Management Options			
		m	n	p	sa	r	g	w	e	f	t	v	Class	Option	Stocking Rate (Est.) Unimproved (beast/ha)	Stocking Rate (Est.) Improved (beast/ha)	Comment
Qa1/2.1	Stream flats with Uc–Um, soils and mixed shrubby woodland (*E. tess, E. ter*)	3	1	2	1	1	1	1	2	3	2	3	3	E	1/10	–	Should not be cleared
Qa2/4.3	Alluvial plain with Dy soils and mixed shrubby woodland (*E. pop*)	2	3	3	2	1	1	1	4	2	4	3	4	D	1/12–16	1/6–8	Limited chemical clearing preferred
Qa2/5.1	Alluvial plain with brown (Uf) clay soils, brigalow woodland	1	1	1	2	1	2	2	2	2	2	2	2	A	1/16–20	1/3–4	Buffel
Cz2/4.3	Inclined plains with Db. soils and mixed eucalypt woodland (*E. pop*)	2	3	3	2	1	1	1	3	2	3	3	3	D	1/12–16	1/6–8	Limited chemical clearing preferred
Cz2/5.1	Plains with brown (Uf) clay soils; brigalow woodland	1	1	1	2	1	2	2	2	2	2	2	2	A	1/16–20	1/3–4	Buffel
Cz3/5.1–4.3	Plains with Db and Uf soils and mixed brigalow – eucalypt woodland	2	1	2	2	1	1	2	2	1	1	2	2	A	1/12–14	1/4	Buffel and stylos
Cz5/4.3	Eroded outwash slopes – bare	3	3	4	2	1	1	1	4	2	4	3	4	B	–	1/6–8	Highly eroded bare area, requires remediation
Ta2/4.3	Footslopes/gully floors, Db soils with *Eucalypt* shrubby woodland (*E. pop*)	3	3	3	2	1	1	1	4	2	4	3	4	D	1/12–16	1/6–8	Limited chemical clearing preferred
Ta3/3.1	Crestal plain – lat. yellow earths and mixed eucalypt woodland (ironbark)	4	3	2	1	2	1	1	2	1	1	2	4	D	1/20	1/12	Limited chemical clearing only; low P levels
Ta3/3.2	Crestal plain; red earth soils and mixed ironbark/bloodwood woodland	2	4	2	1	1	1	1	2	1	1	3	4	D	1/20	1/12	Limited chemical clearing only; low P levels
Ta3/3.3	As above, with lat. red earths and ironbark shrubby woodland	2	4	2	1	2	1	1	2	1	1	4	4	D	1/20	1/12	Limited chemical clearing only. low P levels
Ta3/4.2	Dissected plain with Dr–Db soils and mixed ironbark/box woodland	3	2	3	1	1	1	1	2	1	1	2	3	E	1/6–8	1/5–6	Buffel and stylos – light cultivation only
Ta4/1–3.1	Ridge crests with rocky Dr–Db soils and lancewood woodland	4	3	3	1	1	1	1	3	1	3	3	4	F	1/20–25	–	Should not be cleared
Ta5/4.1	Inclined plain with shallow Dy soils and sparse box woodland with regrowth	4	3	4	1	1	1	1	4	1	2	1	4	D	1/12–16	1/6–8	Heavily overgrazed area requires remediation
Ta5/4.2	Inclined plain; with Dr–Gn soils and mixed ironbark woodland	3	3	3	1	2	1	1	3	1	2	2	3	E	1/6–8	1/5–6	Buffel and stylos – light cultivation – stick rake only
Ta6/1–4.2	Dissected slopes; with shallow rocky soils and lancewood woodland	3	2	3	1	4	1	1	4	1	5	2	5	F	1/20–25	–	Should not be cleared
Ta8/1.1	Low escarpments, with shallow rocky soils and lancewood–ironbark woodland	4	2	4	1	5	1	1	4	1	5	3	5	F	1/20–25	–	Should not be cleared
Pb3/6.1	Undulating plains; shallow Ug soils and open eucalypt woodland	2	1	2	1	2	2	2	2	1	2	1	2	C	1/6–8	1/5–6	Limited chemical clearing only

Land Suitability Classification
(for Beef Cattle Grazing/Pastoral Improvement)

Class 1 **Suitable land with negligible limitations** and is highly productive requiring only simple management practices to maintain economic production

Class 2 **Suitable land with minor limitations** which either reduce production or require more than simple management practices of Class 1 to maintain economic production

Class 3 **Suitable land with moderate limitations** which either further lower production or require more than those management practices of Class 2 land to maintain economic production

Class 4 **Marginal land with severe limitations** which make it doubtful whether the inputs required to achieve and maintain production outweigh the benefits in the long-term

Class 5 **Unsuitable land with extreme limitations** which preclude its use

Classification for Grazing Management Options

A Suitable land for grazing a range of sown pastures; pasture establishment by either sowing into ashbed or with cultivation; minor to moderate woody weed regrowth hazard, native pastures of low productivity.

B Suitable or marginal land for grazing a range of sown pastures; successful pasture establishment into ashbed, but difficult if cultivation necessary; long term productivity may be doubtful; minor woody weed regrowth hazard, native pastures of low productivity.

C Suitable land for grazing on a limited number of sown pastures; cultivation necessary for pasture establishment; negligible woody weed regrowth hazard, highly productive native pastures.

D Suitable land for grazing low quality native pastures oversewn with shrubby stylos; moderate to severe woody weed regrowth hazard.

E Suitable land for grazing highly productive native pastures; marginal land for grazing sown pastures; cultivation necessary for pasture establishment but long term productivity doubtful.

F Suitable land only for grazing native pastures of low productivity.

The assessments have been made on a land unit basis and the various suitability classes determined are shown on Figure 16. Analyses of land suitability classes within both the mine lease area and the area to be disturbed are given in Annexures C2 and C3 respectively.

The levels of limitations assessed and the suitability class ratings determined are largely qualitative and have been derived from an analysis of the soil physical and chemical data obtained and from previous experience of similar landform/soil types in the general vicinity (HDM 1991, 1992). Table A3.5 also includes indicative stocking rates for typical occurrences of the soil/landscape units identified in terms of unimproved and improved pasture conditions. Those stocking rates have been determined in consultation with the Queensland Department of Primary Industries (pers. com. G. Bourne).

4.3.2 Post–Mining Land Suitability

The post–mining reshaped landform will comprise an undulating land surface with gently rounded crestal areas and broadly depressional internal shallow troughs and valleys. Internal slopes will generally be 15%, but they will be gentler on the upper marginal slopes and the concave lower slopes. Some slopes around the perimeter of the rehabilitated area will be at angle of repose, with overall slopes of 60% to 70%.

An average thickness of 150 mm of topsoil will be spread over the conventional recontoured surface, about 25% of which will have been derived from the higher quality brigalow soil areas. the balance of the topsoil will be derived from the somewhat lighter textured sandy alluvial soils and the surficial horizons of duplex soil occurrences which overall, have a lower water holding capacity compared to the brigalow soils. Consequently the potential suitability for improved pasture establishment will vary within the area to be rehabilitated due to the slope of the surface, the soil moisture regime and the general landform surface hydrology. For example, the lower depressional parts of the landform will generally be moister for longer periods than the higher crestal areas.

Accordingly an overall suitability rating of Class 3–4 has been allocated for conventional areas of improved pasture establishment with increasing productivity anticipated over time provided carefully controlled stocking rates are maintained during the early stages of the rehabilitation process.

The narrow and deeply elongated margins of the angle of repose rehabilitated lands are rated Class 5 primarily due to the steepness of the surface slopes and the associated potential for erosion and land degradation. To maintain the long term stability within that zone it is proposed to fence the area to restrict access to a minimum.

5.0 TOPSOIL RESOURCES

5.1 Topsoil Suitability

Spreading a layer of topsoil over surfaces to be rehabilitated will improve the chances of successful revegetation.

In order to assess the suitability of soils within the area of interest for rehabilitation purposes, representative samples of each of the main soil type profile layers were submitted for routine chemical testing and physical characterisation. The test results are included in Tables A3.3 and A3.4.

Based on an analysis of the results of the physical and chemical testing undertaken, together with field observations and previous experience with similar soils in a similar environment, a topsoil suitability assessment and estimated resource depth for each of the land units and soil types identified has been determined. The results of this are summarised in Table A3.6. The physical and chemical criteria used in deriving the assessment are explained in Table A3.7.

5.2 Useable Soil Depth

The term topsoil generally refers to the surficial (A horizon) soil layer which is usually darker in colour than the underlying soil due to the accumulation of organic matter. Topsoil also contains seeds and micro-organisms which will assist in the rapid re-establishment of plant growth. However in certain soil types, the immediate subsoil layer below the topsoil may provide a useful supplementary soil resource, especially if that material is required to be removed due to the mining operations. Accordingly, the assessment of topsoil suitability in Table A3.6 also includes an assessment of the additional useable subsoil resources which may be useful in the rehabilitation process. The criteria used to determine the subsoil suitability are somewhat less stringent than those used for the topsoil assessment. Those criteria are also given in Table A3.7.

As a general rule the upper 10-30 cm of the material described as topsoil in Table A3.6 will be recovered from all areas to be disturbed. However, as shown in Table A3.6 this depth will vary with soil type. Where subsoil resources are indicated, these will be stripped and stockpiled separately from the topsoil materials.

5.3 Topsoil Stripping Depths

Based on the topsoil suitability ratings given in Table A3.6, Figure 17 has been prepared which shows the indicative stripping depth classes within the study area.

Figure 17 also provides the basis for determining the depth of stripping and likely volume of material available from each of the areas which will be disturbed during the mine development, and ongoing mining operations phase.

TABLE A3.6

TOPSOIL RESOURCES ASSESSMENT

Land Unit No.	Land Unit Description	P.P.F.	Depth of Topsoil	Useable (cm) Subsoil	Comments
Qa1/2.1	Stream flats with Uc–Um, soils and mixed shrubby woodland (*E. tess, E. ter*)	Uc1.43 Um1.21	0–15	–	Mainly sandy coarse–textured subsoils – subsurface horizons tend to form bulldust
Qa2/4.3	Alluvial plain with Dg soils and mixed shrubby woodland (*E. pop*)	Db1.33 Dy3.83	0–15	–	A2 horizons tend to be pulverulent and form bulldust
Qa2/5.1	Alluvial plain with brown (Uf) clay soils, brigalow woodland	Uf5.31 Uf6.31	0–25	25–50	Sodic and dispersive deeper subsoils
Cz2/4.3	Inclined plains with Db. soils and mixed eucalypt woodland (*E. pop*)	Db1.33 Dr2.43	0–15	–	Sodic and dispersive subsoils
Cz2/5.1	Plains with brown (Uf) clay soils; brigalow woodland	Uf5.31 Uf6.31	0–25	25–50	Sodic and dispersive deeper subsoils
Cz3/5.1–4.3	Plains with Db and Uf soils and mixed brigalow – eucalypt woodland	Uf6.31 Db1.43	0–25	25–50–	Sodic and dispersive deeper subsoils
Cz5/4.3	Eroded outwash slopes – bare	Db2.33	0	–	None suitable due to poor soil physical properties
Ta2/4.3	Footslopes/gully floors, Db soils with *Eucalypt* shrubby woodland (*E. pop*)	Db2.42 Db2.43	0–15	–	Sodic and dispersive subsoils. A2 horizons tend to form bulldust when reworked
Ta3/3.1	Crestal plain – lat. yellow earths and mixed eucalypt woodland (ironbark)	Ks–Gn2.21	0–15	15–50	Lateritic gravel throughout the profile, low nutrient levels but will resist erosion
Ta3/3.2	Crestal plain; red earth soils and mixed ironbark/bloodwood woodland	Gn2.11 Gn2.12	0–50	50–100	Suitable textural properties but generally low nutrient levels, esp. N and P
Ta3/3.3	As above, with lat. red earths and ironbark shrubby woodland	Ks–Gn2.11	0–25	25–100	Lateritic gravel throughout the profile; now nutrient levels but will resist erosion
Ta3/4.2	Dissected plain with Dr–Db soils and mixed ironbark/box woodland	Db1.41 Dr3.32	0–25	–	Sodic and dispersive subsoils
Ta4/1–3.1	Ridge crests with rocky Dr–Db soils and lancewood woodland	Ks–Gn2.21	0–15	–	Where possible never surficial soil for seek stock and organic material
Ta5/4.1	Inclined plain with shallow Dy soils and sparse box woodland with regrowth	Dy3.32 Dy3.31	0–15	–	Shallow soils with poor physical properties. Topsoils tend to be hardsetting, subsoils dispersive
Ta5/4.2	Inclined plain; with Dr–Gn soils and mixed ironbark woodland	Dr2.11 Gn2.12	0–25	25–50	Mixed occurrences of gradational red earths locally tending to red duplex soils
Ta6/1–4.2	Dissected slopes; with shallow rocky soils and lancewood woodland	Dr2.11 Db1.33	0	–	None suitable due to rockiness
Ta8/1.1	Low escarpments, with shallow rocky soils and lancewood–ironbark woodland	K–Um1 K–Uc1	0	–	None suitable due to rockiness
Pb3/6.1	Undulating plains; shallow Ug soils and open eucalypt woodland	Ug5.32 Ug5.12	0–25	–	Shallow cracking clays over weathered rock

Table A3.7

Topsoil Suitability Assessment Criteria

Limitations	Topsoil		Useable Subsoil	
	Suitable	Unsuitable	Suitable	Unsuitable
Salinity (1)	$EC_{(1:5)}$ <0.7 dS/m	$EC_{(1:5)}$ >0.7 dS/m	$EC_{(1:5)}$ >1.2 dS/m	$EC_{1:5)}$ >1.2 dS/m
pH (2)	pH >5.0 to <7.8	pH <5.0 or >7.8	pH >4.5 to <8.5	pH <4.5 to >8.5
Sodicity (3)	ESP <6–10	ESP >10	ESP <15	ESP >15
Soil Physical Properties (soil texture, hard setting, properties, poor soil structure, rockiness etc. – from field observations)	Nil or minor to moderate limitation	Moderate to high limitation	Moderate limitations	High limitations
Potential for (4) Dispersion	Nil to slight (Class 4/7)	Moderate or higher (Class 1 or 2)	Slight – moderate (Class 3 or 4/7)	Moderate or higher (Class 1 or 2)

Note
(1) Determined by electrical conductivity (EC) in 1:5 soil/water suspension
(2) pH – (1:5 soil water)
(3) ESP – Exchangeable Sodium Percentage and estimates of ESP based on observed soil properties
(4) Modified Emerson Aggregate Stability Class (Emerson – 1981)

6.0 SPOIL CHARACTERISATION

6.1 Introduction

Studies were undertaken to assess the properties of the overburden in the proposed mine area, and to interpret the influence of those properties on the rehabilitation programme.

The overburden assessment involved two distinct phases, an initial screening phase to define the variation in overburden properties, followed by a more detailed assessment of the properties of composite strata samples. Selection of subsamples for the composite strata samples was based on information derived from stratigraphic information as well as the results from the screening phase.

Initial testing was done on 60 samples taken from six boreholes (Figure 18). Relatively simple, indicative tests were used in this screening phase to maximise the number of samples analysed and enable determination of the spatial variation of overburden properties. The properties measured in this phase provided an indication of pH, salinity and pyrite content.

More detailed testing was then undertaken to quantify the chemical characteristics of the spoil.

6.2 Sample Collection and Preparation

Subsamples were taken from chip and core samples which had been collected during a recent drilling programme and stored in a storage shed on site. Six boreholes located across the proposed mine area were selected for analysis to provide data on overburden throughout the mine area. The boreholes selected comprised C2212, C2221, C2252, C2254, C2275 and C2278.

Chip samples were available at metre intervals down the profile to a variable depth above the coal seam, with continuous core then being available down to the coal seam. Subsamples from chip samples were taken at every third metre down the profile, except near the main coal seam or any floating seams where subsamples were taken at every metre.

Cores were subsampled by taking a 0.05 m section of the core at 0.5 m intervals

To minimise the number of analyses, some of these samples were then combined prior to analysis. Samples were only combined when the borehole descriptions suggested them to be of similar origin and weathering state.

All samples were dried and ground to 200 mesh using a ring mill prior to analysis.

Samples were again selectively combined for detailed analysis following the initial screening testing. Selection of depth ranges for the samples analysed in the second phase was based upon both stratigraphic information and the results of the initial testing. Further testing was done on a total of ten composite samples.

6.3 Comments on Analytical Methods

6.3.1 pH

Except in extreme cases, pH generally does not directly affect plant growth, but it does affect plant growth indirectly through its influence on nutrient availability and toxicity. It can also be used to indicate the general chemistry of the overburden.

pH was determined from a 1:5 overburden:water solution in both the screening phase and the more detailed testing performed on composite strata samples.

6.3.2 Acid–Base Account

Acidic conditions may develop in overburden that contains elevated levels of pyrite when exposed to oxidising conditions after mining. Such changes are normally predicted from the maximum potential acid production calculated from the pyrite content of the material and the acid neutralising capacity. Material where potential acid production exceeds neutralising capacity by more than 5 t $CaCO_3$ equiv. / 1000t material is considered to constitute a potential acid problem (Sobek et al 1978). This value approximately corresponds to a sulphur content of 0.2% (assuming that pyritic sulphur constitutes approximately 80% of total sulphur in unweathered overburden).

A qualitative test (pyrite spot test) that accurately identifies samples where the pyrite content is below 0.15% was performed on all samples. Sulphur levels were then determined using a Leco Furnace for those samples where this test indicated the possibility of higher pyrite contents.

Only one sample showed any significant indication of pyrite (viz. where the pyrite spot test rating equalled 3), and no further testing was considered necessary.

6.3.3 Salinity

High levels of salinity can affect plant growth through induced water stress. Salinity levels were assessed from measurement of electrical conductivity in a 1:5 overburden:water solution ($EC_{1:5}$) for both the screening phase and the analyses of composite samples. Plant growth is generally related to the electrical conductivity of a saturated soil paste (EC_{se}), although this measurement is rarely assessed in most testing programs owing to the difficulty in the preparation and measurement of electrical conductivity in the saturated paste. Instead, correlations between $EC_{1:5}$ and EC_{se} have been developed to relate measurements of $EC_{1:5}$ to EC_{se} and thus to plant growth.

Correlations between $EC_{1:5}$ and EC_{se} commonly used for soils (eg. Talsma 1968) have been shown to underestimate EC_{se} for overburden, and the following relationship has been used in their place:

$$EC_{se} = 11.5 \times EC_{1:5} - 0.29 \quad (r^2 = 0.95) \quad \text{(Crossley 1990).}$$

TABLE A3.8

DETAILED CHEMICAL/ FERTILITY TESTING FOR SELECTED COMPOSITE OVERBURDEN SAMPLES

Location	Depth	Test Results								Calculations							
		pH	EC	Al	K	Ca	Mg	Na	Cl	TSS	CEC	ESP	EPP	ECP	EMP	CAM G	EAP
	m		dS/m	ppm	ppm	ppm	ppm	ppm	ppm	ppm	meq%	%	%	%	%	%	%
C2212	2.0–12.0	7.0	0.58		250	640	960	1530	760	1850	15.2	36.2	3.5	17.4	42.9	0.4	
	28.0–32.7	7.6	0.57		590	780	1090	1360	620	1820	17.2	29.1	7.4	19.2	44.2	0.4	
C2221	2.0–6.0	4.3	0.04	7	10	40	110	60	40	140	1.2	17.8	1.7	13.6	61.6	0.2	5.3
	8.0–24.0	4.5	0.10	26	130	350	290	110	40	330	4.7	9.1	6.4	33.4	45.6	0.7	5.5
	26.0–48.0	8.0	0.28		460	7140	1250	320	60	910	47.0	2.9	2.4	73.5	21.2	3.5	
C2254	2.0–12.0	4.8	0.72	7	300	70	400	730	2250	2300	3.7	41.4	10.0	4.6	43.0	0.1	1.0
	14.0–46.0	6.6	0.48		440	460	910	550	460	1530	10.7	18.0	8.5	17.3	56.3	0.3	
	46.0–68.0	8.2	0.33		500	12140	1190	1510	110	1060	72.2	3.0	1.7	82.0	13.2	6.2	
C2278	2.0–18.0	6.7	0.62		180	430	690	1230	920	1990	10.2	39.2	3.4	15.8	41.6	0.4	
	20.0–30.0	8.3	0.60		500	2110	1880	1590	570	1930	30.9	20.2	3.7	30.8	45.2	0.7	

This relationship is consistent with that described by Shaw et al (1986) for soils with a clay content of about 30%, as would be expected in ground unweathered overburden samples.

The effect of salinity on plant growth was then developed based on the relationships between plant yield and EC_{se} from Shaw (1986).

6.3.4 Sodicity

Sodicity is a measure of the proportion of sodium compared to other cations in the soil, with Exchangeable Sodium Percentage (ESP) the accepted measurement of this property. A low Ca:Mg ratio can also indicate potential structural problems. Overburden containing a high proportion of sodium or a low Ca:Mg ratio is prone to dispersion, surface crusting and poor root penetration. This condition is normally the most severe limitation to plant re-establishment in the Bowen Basin. Sodic spoil is more prone to gully erosion or piping than non-sodic spoil, and may also be more prone to slope or dam failure as a consequence.

The ESP of the composite strata samples was calculated from the concentrations of extracted elements by SGS standard procedures (Annexure B). While this may not be an accurate measure of ESP, it can be used to indicate potential problems.

6.4 Test Results

The results of the analyses for individual samples is shown in Figures 19 to 24, along with the general stratigraphy of the overburden. The results of the more detailed testing of composite samples are shown in Table A3.8.

6.4.1 Acid Mine Drainage

The results indicate that there will be no problems with acid mine drainage emanating from the overburden spoil areas. Results from the pyrite spot tests indicated that only one sample (C2254 55 - 56 m) was above 0.2%. As this material represents only a very small percentage of the overburden (less than 2%), it is unlikely that this material will cause any significant concern for rehabilitation.

6.4.2 Salinity

The salinity levels in the overburden were generally low compared to most overburden in the Bowen Basin. Some discrepancy was noted between salinity levels measured for samples in the screening phase and for the corresponding composite samples in the subsequent detailed analysis. The cause of this discrepancy is unknown, however the salinity levels were not found to be very high in either set of results.

The salinity levels were rated as low to high and would only limit growth of salt sensitive species. Growth of pasture species should not be affected, but any legumes used in the pasture mix should be moderately salt tolerant.

6.4.3 Sodicity

The most significant limitation to rehabilitation is expected to be associated with the structure of the overburden. The overburden was generally found to be highly sodic in the surface strata, but less sodic at depth. This decreased sodicity at depth may reflect high levels of partially soluble calcium and magnesium carbonates in these samples. Where these compounds are present in a sample, the enhanced dissolution of calcium and magnesium in the ammonium acetate extraction solution can yield low values of sodicity (as the levels of calcium and magnesium are overestimated).

Plant establishment will be affected by soil crusting and root penetration will be limited by the lack of structure of the overburden. Erosion from bare spoil may be moderately high until a vegetative cover can be established as the overburden will tend to disperse.

A thin layer of topsoil will improve soil conditions for pasture establishment as will deep ripping after topsoil spreading to improve rooting conditions.

for **HOLLINGSWORTH DAMES & MOORE**

G.J. RENFREY
Consultant–in–Charge – Terrain Analysis

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ANNEXURE A

SOIL/SITE DESCRIPTIONS

ANNEXURE A

SOIL/SITE DESCRIPTIONS

Terms and Abbreviations used in Soil/Site Descriptions

Drainage Status

"Runon"

Low – Nil or minimal upslope local catchment area – upper slopes and crestal areas

Mod. – Moderate runon from adjacent upslope areas – mid to lower slopes.

High – High runon from upslope areas; – surface overflow on lower slopes

F/prone – Floodprone from overbank flow, local runon/overland flow.

"Runoff"

Slow – Nil or very slow runoff–surface ponding for lengthy periods

Mod. – Short–term surface ponding only, and/or surface water infiltrates rapidly; mostly gentle slopes.

Rapid – Rapid runoff, low infiltration, generally moderate to steep slopes, or gently to moderately inclined very hard set (bare) surfaces.

V/rapid – Very rapid runoff, minimal infiltration, generally steep to very steep slopes.

"Profile"

WD – Well–drained: soils transmit water freely both vertically and horizontally

MD – Moderately well–drained: soils may remain wet for limited periods, some structural variation may be evident

ID – Impeded drainage: strong structural variation, periodic water–logging likely

S – Slow: vertical transmissivity slow; soils remain wet for lengthy periods

PD – Poorly drained: water logged, periodically, seasonally high perched water.

NA – Not apparent

NR – Not recorded

NHS – Not hard set

s/a – Subangular

s/r – Subrounded

YONGALA – SITE DESCRIPTIONS

Site No: 6
AMG Ref: S 23°21'.005
E 148°33'.089
Soil Type: 3.2
Great Soil Group: Red Earth
Principal Profile Form: Gn2.12
Substrate Material: Lateritic clay
Geological Ref: Ta
Drainage Status: Runon Runoff Profile
Low Mod. WD

Survey: Yongala
Landform Unit: Ta3/3.2

Landform Element: Mid slope
Slope (%): 2
Microrelief: NA
Surface Coarse Fragments: NA
Surface Condition: Hard set
Erosion: Scalds (small)

Date: 10/6/92

Vegetation: Ironbark, lancewood, other mixed species, some buffel grass

Profile Morphology:
Horizon Depth (m)

Described by: Reng
Description

			Field pH Depth (m)	: pH
A	0–0.25	Clay Loam (fine sandy) (SC–CL) dark reddish brown massive friable earthy	0	6.0
			0.2	6.0
B	0.2–0.65(+)	Light Clay (CL) 10R3/4 massive earthy friable, some fine ironstone gravel	0.4	6.0
			0.6	6.5

Comments: OK for reliable topsoil use but low in nutrients. Photo 1/3

Site No: 9
AMG Ref: S 23°21'.103
E 148°29'.939
Soil Type: 3.2
Great Soil Group: Red Earth
Principal Profile Form: Gn2.11
Substrate Material: Lateritic gravelly clay
Geological Ref: Ta
Drainage Status: Runon Runoff Profile
Low Mod. WD

Survey: Yongala
Landform Unit: Ta3/3.2

Landform Element: Crestal Plain
Slope (%): <1
Microrelief: NA
Surface Coarse Fragments: NA
Surface Condition: Hard set
Erosion: Some small scalded areas

Date: 11/6/92

Vegetation: Buffel grass (good) ironbark and acacia woodland

Profile Morphology:
Horizon Depth (m)

Described by: Reng
Description

			Field pH Depth (m)	: pH
A	0–0.3	Fine Sandy Clay Loam (SC–CL) (2.5YR3/6) massive earthy fabric friable to powdery when dry	0	6.0
			0.2	6.0
B	0.3–0.6	Sandy Clay Loam to Light Clay (CL) (2.5YR4/6) massive earthy friable	0.4	6.0
			0.6	6.0
	0.6–1.3(t)	Gravelly Sandy Clay (CG–CL) becoming Sandy Clay Gravel (GC) low plasticity, gravel is subrounded ironstone gravel (>60%) beyond 1.0 m	0.8	6.0
			1.0	6.0
			1.2	6.0

Comments: Gravel is low plasticity and could be good source of construction material

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YONGALA – SITE DESCRIPTIONS

Site No: 10
AMG Ref: S 23°21'.390
E 148°30'.315
Soil Type: 3.1
Great Soil Group: Lateritic Yellow Earth
Principal Profile Form: KS-Gn2.41
Substrate Material: Lateritic mottled zone
Geological Ref: Ta
Drainage Status: Runon Runoff Profile
Mod. Mod. WD

Survey: Yongala Date: 11/6/92
Landform Unit: Ta3/3.1
Landform Element: Gentle marginal slope
Slope (%): 1–2
Microrelief: NA
Surface Coarse Fragments: NA
Surface Condition: Hard set
Erosion: na

Vegetation: Ironbark/acacia (regrowth) association; good ground cover of kangaroo grass

Profile Morphology:
Horizon Depth (m)

Described by: Reng
Description

Horizon	Depth (m)	Description	Field pH Depth (m)	pH
A	0–0.3	Sandy Loam (SC) (7–5YR4/6) <15% fine laterite gravel massive apedal structure	0	6.0
			0.2	6.0
B	0.3–0.7	Clayey Gravel (GC) brown 60–70% rounded ferruginous gravel up to 5 cm ϕ mostly 1–2 cm with sandy clay matrix of low plasticity – massive dry powdery	0.4	6.0
			0.6	6.0
			1.0	7.0
C	0.7–1.5+	Desiccated lateritic mottled clay, massive apedal red, orange and grey mottled (ferruginous claystone) with ironstone nodules decreasing with depth	1.5	7.0

Comments: Photo 1/10

Site No: 11
AMG Ref: S 23°21'.640
E 148°30'.8
Soil Type: 4.2
Great Soil Group: Solod
Principal Profile Form: Db1.42
Substrate Material: Fine sandstone
Geological Ref: Ta
Drainage Status: Runon Runoff Profile
Mod. Rapid ID

Survey: Yongala Date: 11/6/92
Landform Unit: Ta3/4.2
Landform Element: Gentle slope
Slope (%): 3–4%
Microrelief: NA
Surface Coarse Fragments: Sparse fine siliceous gravel
Surface Condition: Hard set
Erosion: Local mod. severe gullying

Vegetation: Mod.–poor groundcover of kangaroo grass and leaf mulch otherwise predominantly poplar box open woodland

Profile Morphology:
Horizon Depth (m)

Described by: Reng
Description

Horizon	Depth (m)	Description	Field pH Depth (m)	pH
A1	0–0.15	Sandy Loam (SM–SC) dark brown massive pulverulent	0	6.0
A2	0.15–0.3	Sandy Loam (SM–SC) bleached horizon, massive, pulverulent	0.2	6.0
B	0.3–0.6	Heavy Clay (CH) (10YR4/6) massive v. stiff moist – tending to weak blocky (2–5 cm) structure	0.4	7.5
			0.7	8.0
B–C	0.6–0.8	Sandy Clay (CL) – whitish grey EW sandstone	0.9	8.0
C	0.8–1.25+	Weathered Sandstone		

Comments: Abrupt change from bleached A2 to B horizon

YONGALA – SITE DESCRIPTIONS

Site No: 12
AMG Ref: S 23°21'.915
E 148°31'.330
Soil Type: 4.3
Great Soil Group: Solodic
Principal Profile Form: Dy3.83
Substrate Material: Buried (Ta) residual soil
Geological Ref: Qa
Drainage Status: Runon F/prone Runoff Slow Profile ID
Vegetation:

Survey: Yongala
Landform Unit: Qa2/4.3
Date: 11/6/92

Landform Element: Upper terrace level
Slope (%): 1 (towards creek)
Microrelief: NA
Surface Coarse Fragments: NA
Surface Condition: Hard set
Erosion: Minor scalding

Profile Morphology:
Horizon Depth (m)

Described by: Reng
Description

Horizon	Depth (m)	Description	Field pH Depth (m)	pH
A11	0–0.1	Silt Loam (SM–SC)	0	6.5
A12	0.1–0.3	Sandy Loam (SM–SC) 7.5YR3/4	0.2	6.5
			0.4	6.5
A13(b)	0.3–0.7	Light Clay Loam to Clay Loam (CL)	0.6	6.5
			0.8	6.5
A2(b)	0.7–0.9	Sandy Loam (bleached horizon–relict) (CL–ML) massive	1.0	8.5
B	0.9–1.2	Medium Clay (CH) (2.5YR6/2) mottled orange and dull grey brown, massive v. stiff moist between 0.9–1.2 becoming weak s/a blocky below	1.2	8.5

Comments: This appears to be a buried soil profile overlain by about 0.5 m of recent alluvial deposits

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Site No: 13
AMG Ref: S 23°22'.345
E 148°31'.445
Soil Type: 3.1
Great Soil Group: Lateritic Yellow Earth
Principal Profile Form: KS–Gn2.21
Substrate Material: Claystone

Geological Ref: Ta
Drainage Status: Runon Low Runoff Mod. Profile MD
Vegetation: Ironbark, grey box (gum)/poor to mod. kangaroo grass

Survey: Yongala
Landform Unit: Ta3/3.1
Date: 12/6/92

Landform Element: Gently inclined plain
Slope (%): 2–3
Microrelief: NA
Surface Coarse Fragments: Fe. sandstone mod. mostly <1 cm some 5–10 cm
Surface Condition: Not hard set
Erosion: Low sheet erosion

Profile Morphology:
Horizon Depth (m)

Described by: Reng
Description

Horizon	Depth (m)	Description	Field pH Depth (m)	pH
A	0–0.3	Sandy Gravel (GM) gravel size 1–2 cm mostly (>60%) ferruginous gravel concretions in loamy sand matrix	0	6.5
			0.2	6.5
B	0.3–0.5	Clayey Gravel (GC) gravel subrounded (1–2 cm) ironstone concretions; 30% clayey fines of medium plasticity (7.5YR5/8)	0.5	6.5
B–C	0.5–0.6	E.W. Claystone, brittle very hard, orange and grey mottled		
C	0.6–0.7+	Indurated Claystone, siliceous, v. hard		

Comments: Proposed workshop site area: – Sampled

YONGALA – SITE DESCRIPTIONS

Site No: 14
AMG Ref: S 23°22'.350
E148°31'.340
Soil Type: 3.1
Great Soil Group: Lateritic Yellow Earth
Principal Profile Form: KS–Gn2.21
Substrate Material: Claystone
Geological Ref: Ta
Drainage Status: Runon Runoff Profile
Low Mod. MD
Vegetation: As per Site 13 with spindly acacia regrowth

Survey: Yongala
Landform Unit: Ta3/3.1
Landform Element: Gently inclined plain
Slope (%): 2
Microrelief: NA
Surface Coarse Fragments: Fe. sandstone
Surface Condition: Not hard set
Erosion: Low sheet erosion

Date: 12/6/92

Profile Morphology:
Horizon Depth (m)

Described by: Reng
Description

Field pH
Depth : pH
(m)

A11	0–0.1	Loamy Sand (SM) massive apedal some ironstone gravel (<1cm) variable gravel percentage 20–50%
A12	0.1–0.3	Sandy Loam, (GM–GC) (5YR4/6) massive apedal >50% ferruginous gravel, subrounded and rounded 1–2 cm
B	0.3–0.3	Gravelly Clay (GC), (7.5YR5/6) >60% s/a–s/r – ferruginous gravel, 2–5 cm, with clayey fines, low–med. plasticity, considerable silt
C	>0.6	Ferruginised Claystone, partly silicified, v. hard

Comments: Proposed workshop area

Site No: 15
AMG Ref: S 23°22'.350
E 148°31'.340
Soil Type: 4.1
Great Soil Group: Solod
Principal Profile Form: Dy3.22
Substrate Material: Claystone
Geological Ref: Ta
Drainage Status: Runon Runoff Profile
Mod. Rapid ID
Vegetation: As per Site 13 but with spindly acacia regrowth

Survey: Yongala
Landform Unit: Ta5/4.1
Landform Element: Gentle slope
Slope (%): 1–2
Microrelief: NA
Surface Coarse Fragments: NA
Surface Condition: Hard set
Erosion: NA

Date: 12/6/92

Profile Morphology:
Horizon Depth (m)

Described by: Reng
Description

			Field pH Depth (m)	pH
A1	0–0.15	Loamy Sand, (SP–SM) dark brown, massive, crumbly dry (pulverulent) 20% rounded Fe. gravel 1 cmϕ Sandy Gravel	0 2.0	6.0 6.0
A2	0.15–0.6	Sandy Ground >60% Fe. gravel mostly <1 cm, massive, earthy fabric	4.0 6.0	6.5 7.0
B	0.6–0.9	Medium/heavy Clay (CH) (10YR5/6) yellowish brown with grey mottles moderate angular blocky → prismatic 5–10, 2–5 cm	8.0	7.0
	0.9–1.0	Indurated Grey Claystone ferruginised in part		

Comments: Proposed workshop area

YONGALA – SITE DESCRIPTIONS

Site No: 16
AMG Ref: S 23°22'.290
E 148°32'.110
Soil Type: 3.2
Great Soil Group: Red Earth
Principal Profile Form: Gn2
Substrate Material: –
Geological Ref: Ta
Drainage Status: Runon Runoff Profile
Low Mod. WD

Survey: Yongala
Landform Unit: Ta3/3.2
Landform Element: Crestal plain
Slope (%): 1
Microrelief: NA
Surface Coarse Fragments: NA
Surface Condition: Hard set
Erosion: NA

Date: 12/6/92

Vegetation: Some brigalow, bloodwood ironbark with mod. shrub understorey

Profile Morphology:
Horizon Depth (m)

Described by: Reng
Description

Horizon	Depth (m)	Description	Field pH Depth (m)	pH
A	0–0.4	Silt Loam (ML) red massive friable earthy dry	0.2	5.5–6.0
B	0.4–1.8	Silty Clay (CL–ML) (10YR4/8) red. massive earthy friable just moist <10% fine gravel (<1 cm) lateritic gravel increasing below 1.8 m	0.6	5.5
			1.2	6.0

Comments: Haul road location – Note 2nd hole dug approx. 50 m east – same profile encountered to 1.5 m

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Site No: 17
AMG Ref: S 23°22'.216
E 148°32'.109
Soil Type: 3.3
Great Soil Group: Lateritic Red Earth
Principal Profile Form: KS–Gn2.11
Substrate Material: NR
Geological Ref: Ta
Drainage Status: Runon Runoff Profile
Low Mod. WD

Survey: Yongala
Landform Unit: Ta3/3.3
Landform Element: Crestal plain
Slope (%): <1
Microrelief: NA
Surface Coarse Fragments: NA – sparse fine ironstone gravel
Surface Condition: Hard set
Erosion: NA

Date: 12/6/92

Vegetation: Spindly acacia (regrowth), ironbark emergents

Profile Morphology:
Horizon Depth (m)

Described by: Reng
Description

Horizon	Depth (m)	Description	Field pH Depth (m)	pH
A11	0–0.1	Fine Sandy Silt Loam (SM–ML) (7.5YR3/4) dark red low plasticity, massive friable <10% fine lateritic gravel	0	6.0
			0.2	5.5
A12	0.1–0.2	Sandy Clay Loam (SC) (2.5YR3/6) dark reddish brown, massive friable	0.4	6.0
			0.6	6.0
B1	0.2–1.1	Clay Gravel (GC) (2.5YR4/8) 60% ironstone gravel mostly <1 cm some to 2 cm; the clayey matrix is of low to medium plasticity	1.0	6.0
			1.2	6.0
B2	1.1–1.4+	Silty Light Clay (CL) low plasticity (10YR4/8) some fine ironstone gravel (10%) well developed lenticular (platey) breaking to fine nutty structure <1 cm – shiny ped paces – crumbly brittle dry consistence		

Comments: Haul road alignment

YONGALA – SITE DESCRIPTIONS

Site No: 18
AMG Ref: S 23°22'.191
E 148°32'.127
Soil Type: 3.3
Great Soil Group: Lateritic Red Earth
Principal Profile Form: KS–Gn2.11
Substrate Material: NR
Geological Ref: Ta
Drainage Status: Runon Runoff Profile
Low Mod. WD
Vegetation:

Survey: Yongala Date: 12/6/92
Landform Unit: Ta3/3.2

Landform Element: Marginal slope
Slope (%): 1–2
Microrelief: NA
Surface Coarse Fragments: Fe. fine gravel
Surface Condition: NR
Erosion: NA

Profile Morphology:
Horizon Depth (m)

Described by: Reng
Description

Field pH
Depth : pH
(m)

A1	0–0.2	Silty Loam (ML) becoming Gravelly Clay Loam (GC–CL) dark red brown, massive earthy, up to 10% rounded ironstone gravel
B	0.2–0.9	Clayey Gravel (GC) dense subrounded ironstone, mainly 1–2 cm with about 35% clayey fines of low to medium plasticity becoming slightly less clayey with depth
B–C	0.9–1.5	Ironstone Clayey Gravel (GC) (2.5YR4/8) dense subrounded 5–10 cm max. size, but mostly 2–5 cm, with clay fines of medium–high plasticity (CH)

Comments: Two gravel samples 1 of clayey gravel material, 1 of ironstone gravel (composite) (0.9–1.5)
(sample of top 0.2 m) photo 1/21

Site No: 19
AMG Ref: S 23°22'.090
E 148°31'.891
Soil Type: 4.2
Great Soil Group:
Principal Profile Form: Dr3.31
Substrate Material: HW claystone
Geological Ref: Ta
Drainage Status: Runon Runoff Profile
Mod. Rapid ID
Vegetation: Scalded area

Survey: Yongala Date: 12/6/92
Landform Unit: Ta5/4.2

Landform Element: Upper marginal slope
Slope (%): 3–5 (towards gully)
Microrelief: Erosion pillars (30 cm)
Surface Coarse Fragments: V. sparse ironstone gravel
Surface Condition: V. hard set
Erosion: Severe sheet and shallow gullying

Profile Morphology:
Horizon Depth (m)

Described by: Reng
Description

Field pH
Depth : pH
(m)

A2	0–0.1	Silty Clay Loam (5YR4/6) – sporadic bleach	0	5–5.5
	0.1–0.3	Silty Medium Clay (CL–CH) (5YR4/6) mottled grey yellow orange and red fine blocky s/a to nutty structure, mostly <1 cm	0.2	4.5
	0.3–1.0+	Ferruginous and weakly silicified Claystone, highly weathered to 0.6 mm then moderately weathered below; breaks down to angular well–graded gravel up to 5–10 cm		

Comments: Scalded and heavily sheet–eroded area – A1 horizon removed by sheet erosion.
Gravel sample of weathered rock zone

YONGALA – SITE DESCRIPTIONS

Site No: 20
AMG Ref: S 23°21'.890
E 148°31'.191
Soil Type: 4.1
Great Soil Group: Yellow Podzolic
Principal Profile Form: Dy3.31
Substrate Material: Weathered sandstone
Geological Ref: Ta
Drainage Status: Runon Runoff Profile
Mod. Rapid ID

Survey: Yongala
Landform Unit: Ta5/4.1

Landform Element: Inclined plain
Slope (%): 3–4
Microrelief: NA
Surface Coarse Fragments: NA
Surface Condition: Hard set
Erosion: Weak surface sheet erosion

Date: 12/6/92

Vegetation: Scattered poplar box over sparse mid high grass

Profile Morphology:
Horizon Depth (m)

Described by: Reng
Description

Field pH
Depth : pH
(m)

A1	0–0.1	Fine Sandy Loam (SC) (10YR3/3) apedal massive dry pulverulent	0	6.0
A2(1)	0.1–0.25	Loamy Sand (SM) with coarse subrounded stone 2–5 cm, massive, apedal, pulverulent	0.4	6.0
A2(2)	0.25–0.3	As above but with sporadic bleach		
B	0.3–0.5	Fine Sandy Medium Clay (CH) brown (2.5Y5/6–2.5Y4/3 mottled) mod. well structured, prismatic 2–5 cm; weak coarse columnar structure, very stiff moist consistence		
C	0.5–0.85	EW Clayey Sandstone, moderately strong – not able penetrate with backhoe beyond 1 m		

Comments: One line of diversion channel – 2 samples topsoil and top of B

Site No: 21
AMG Ref: S 23°21'.448
E 148°30'.788
Soil Type: 3.1
Great Soil Group: Lateritic (Sandy) Brown Earth
Principal Profile Form: KS–Gn2.21
Substrate Material: Weathered silicified C/stone
Geological Ref: Ta
Drainage Status: Runon Runoff Profile
Low Mod. WD

Survey: Yongala
Landform Unit: Ta3/3.1

Landform Element: Crestal slope
Slope (%): 3–4%
Microrelief: NA
Surface Coarse Fragments: Mod. Fe. gravel cover 1–2 cm
Surface Condition: Hard set
Erosion: NA but severe gullying between interfluves

Date: 12/6/92

Vegetation: Ironbark woodland and spindly acacia regrowth

Profile Morphology:
Horizon Depth (m)

Described by: Reng
Description

Field pH
Depth : pH
(m)

0–0.3	Sandy Gravel (GM) 60% s/r ferruginous gravel (7.5YR5/6)
0.3–0.5	Sandy Gravel (GM) 80% ferruginous gravel <1 cm, loamy sand
0.5–0.85	Clayey fine Gravel – Gravelly Clay (GC–CL) red ferruginous gravel, mostly <1 cm approx. 40–50% gravel
0.85+	Weathered silicified claystone

Comments:

YONGALA - SITE DESCRIPTIONS

Site No: 22
AMG Ref: S 23°21'.291
E148°30'.923
Soil Type: 3.2
Great Soil Group: Red Earth
Principal Profile Form: Gn2.11
Substrate Material: NR
Geological Ref: Ta
Drainage Status: Runon Runoff Profile
Low Mod. WD

Survey: Yongala Date: 12/6/92
Landform Unit: Ta3/3.2

Landform Element: Interfluve
Slope (%): 2
Microrelief: NA some termite mounds (low)
Surface Coarse Fragments: NA
Surface Condition: Mod. hard set
Erosion: NA minor surface scalding

Vegetation: Broad-leaf ironbark, bloodwood association over sparse mid high grasses - some yellow-wood

Profile Morphology:
Horizon Depth (m)

Described by: Reng
Description

			Field pH Depth (m)	pH
A	0-0.1	Fine Sandy Loam (SM) massive, friable, pulverulent (powdery) dry consistence	0	5.0
			0.5	5.5
B	0.4	Silty Clay Loam (SM-SC) (10YR4/6) massive, earthy, firm to stiff dry consistence	1.0	6.0
B	0.6	Silty Clay Loam (CL) weak dry consistence massive		
B	0.9	Silty Loam (CL-ML) massive friable		

Comments: Note Red Earths on crests; duplex yellow and brown soils in intervening gullies

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Site No: 23
AMG Ref: S 23°21'.054
E 148°30'.852
Soil Type: 4.2 (gravelly)
Great Soil Group: Brown Podzolic
Principal Profile Form: Db4.11
Substrate Material: Claystone
Geological Ref: Ta
Drainage Status: Runon Runoff Profile
Mod. Rapid ID
Vegetation: Lancewood woodland

Survey: Yongala Date: 12/6/92
Landform Unit: Ta6/1-4.2

Landform Element: Mid-upper slope
Slope (%): 9-10
Microrelief: NA
Surface Coarse Fragments: Sparse Fe. gravel and stone
Surface Condition: Not hard set
Erosion: Some sheet

Profile Morphology:
Horizon Depth (m)

Described by: Reng
Description

		Field pH Depth (m)	pH
0-0.2	Sandy Gravel (GM)	0.1	5.5-6.0
0.2-0.6	Gravelly Clay (CH) high plasticity (10YR3/4) diffusely mottled red, weak blocky, breaking to fine nutty structure	0.5	5.0
0.6-0.8	Clayey Gravel (GC)		
0.8	EW Rock - Whitish Claystone ferruginised in part		

Comments: The gravelly soil is prone to bulldust development.

YONGALA – SITE DESCRIPTIONS

Site No: 25
AMG Ref: S 23°21'.939
E 148°31'.038
Soil Type: 4.3
Great Soil Group: Solodic Soil
Principal Profile Form: Db1.33
Substrate Material: Alluvium
Geological Ref: Qa
Drainage Status: Runon F/prone Runoff Slow Profile ID

Survey: Yongala
Landform Unit: Qa2/4.3
Landform Element: Floodplain
Slope (%): <1
Microrelief: NA
Surface Coarse Fragments: NA
Surface Condition: Hard set
Erosion: Surface scald

Date: 12/6/92

Vegetation: Poplar box bauhinia open woodland, over very sparse mid high grass

Profile Morphology:
Horizon Depth (m)

Described by: Reng
Description

Horizon	Depth (m)	Description	Field pH Depth (m)	pH
A1	0–0.2	Clay Loam (CL) dark brown (10YR4/3) weak platey structure	0	6.5
A2	0.2–0.25	Silt Loam brown (CL–ML) with sporadic bleach massive friable weak dry consistence	0.2	6.0
			0.4	8.5
B1	0.25–0.40	Medium Clay (CL–CH) (10YR4/4) mod. well developed s/a prismatic structure (2–5, 1–2 cm) just moist v. hard consistence	0.6	9.5
			0.8	9.5
B2	0.4–0.8	Medium–heavy Clay (CH) (10YR4/6) mod., angular blocky to prismatic structure (2–5, 1–2 cm) v. hard moist consistence, shiny smooth peds	1.0	9.5
	0.8+	As above but with soft carbonate segregations, weak angular blocky (5–10, 2–5 cm), shiny peds		

Comments: 4 x samples

Site No: 24
AMG Ref: S 23°21'.021
E 148°30'.403
Soil Type: 1–4.2
Great Soil Group: Soloth
Principal Profile Form: Db1.12
Substrate Material: Weathered siltstone
Geological Ref: Ta
Drainage Status: Runon Mod. Runoff Rapid Profile MD

Survey: Yongala
Landform Unit: Ta4/1–4.2
Landform Element: Interfluve (midslope)
Slope (%): 3–5
Microrelief:
Surface Coarse Fragments:
Surface Condition: Hardset
Erosion: Severe sheet erosion

Date: 12/6/92

Vegetation: Mainly narrow leaved ironbark over patchy sparse mid–high grass; bare in scald areas

Profile Morphology:
Horizon Depth (m)

Described by: Reng
Description

Depth (m)	Description	Field pH Depth (m)	pH
0–0.3	Silt loam brown	0.2	4.9
0.3–0.6	Silty Light Clay (CL) yellow brown weak prismatic tending to massive structure	0.5	6.7
0.6+	HW silicified siltstone, v. hard, not able to penetrate with backhoe		

Comments: Bare scalded area

YONGALA – SITE DESCRIPTIONS

Site No: 26
AMG Ref: S 23°22'.213
E 148°30'.806
Soil Type: 4.3
Great Soil Group: Solodic Soil
Principal Profile Form: Db1.43
Substrate Material: NR
Geological Ref: Ta
Drainage Status: Runon Runoff Profile
Mod. Mod. S

Survey: Yongala Date: 13/6/92
Landform Unit: Gently inclined dissection slope interfluves

Landform Element: Cz3/5.1–4.3
Slope (%): 5
Microrelief: NA
Surface Coarse Fragments: Sparse stone
Surface Condition: Hard set
Erosion: NA

Vegetation: *E tesselaris* tall open woodland with elements of brigalow included

Profile Morphology:
Horizon Depth (m)

Described by: Reng
Description

Field pH
Depth : pH
(m)

A11	0–0.15	Fine Sandy Silt Loam (SC–CL) dark brown	0	6.0
A21	0.15–0.3	Clayey Gravel (GC) 80% s/a 1–2 cm ferruginous gravel with conspicuous bleach in the low 10 cm where the gravel is more	0.2	6.0
			0.4	6.0
A22	0.3–0.4	rounded – 2/r mostly <1cm	0.6	8.5
B1	0.4–0.55	Gravelly Medium Clay (CH) with 20–30% fine ferruginous gravel – massive	0.8	8.5
B2	0.6–1.0+	Heavy Clay (CH) (10YR4/6) weak coarse blocky to prismatic structure (10+, 5–10–2–5 cm) hard just moist.		

Comments:

Site No: 27
AMG Ref: S23°22'.213
E 148°30.806
Soil Type: 5.1
Great Soil Group: NR
Principal Profile Form: Uf6.12
Substrate Material: NR
Geological Ref: Ez
Drainage Status: Runon Runoff Profile
Mod. Rapid S
Vegetation: Brigalow woodland

Survey: Yongala Date: 13/6/92
Landform Unit: Dissection slope interfluve

Landform Element: Mid–slope
Slope (%): 5
Microrelief: Mainly gilgai (diffuse) 20–30 cm deep
Surface Coarse Fragments: NR
Surface Condition: NH/S
Erosion: NA

Profile Morphology:
Horizon Depth (m)

Described by: Reng
Description

Field pH
Depth : pH
(m)

A	0–0.25	Sandy clay (CL), dark brown, grading to light–med. clay. Mod. strongly developed structure	0	5½–6
			0.2	6½
B1	0.25–0.6	Reddish brown med. clay (CH); v. fine ironstone gravel (<5%) through B to dull reddish brown – diffusely mottled (5YR4/6–4/4)	0.4	8½
			0.6	9½–10
B2	0.6–1.5+	Med–heavy clay (colour as above) weakly developed, angular, prismatic, 1–2 cm fine ironstone angular throughout. Extremely hard, just moist.	0.8	9½–10
			1.0	9½–10

Comments: This hole is 10 m downslope of Site 26; mod. strongly developed structure becomes more massive below; Strip upper 300–350 just into B.

YONGALA – SITE DESCRIPTIONS

Site No: 29
AMG Ref: (R2271) E 23°21'.914
S 148°30'.907
Soil Type: 4.2
Great Soil Group: Red Podzolic
Principal Profile Form: Dr
Substrate Material: Weathered siltstone
Geological Ref: Ta
Drainage Status: Runon Runoff Profile
Mod. Mod. ID
Vegetation: Poplar box, native grasses

Survey: Yongala Date: 13/6/
Landform Unit: Ta3/4.2

Landform Element: Mid. slope
Slope (%): 3–4
Microrelief: NA
Surface Coarse Fragments: V. fine ironstone gravel
Surface Condition: Hard set
Erosion: NA

Profile Morphology:
Horizon Depth (m)

Described by: Reng
Description

Horizon	Depth (m)	Description	Field pH Depth (m)	pH
A1	0–.15	Sandy Loam (SM–SC), dark brown massive apedal fine dry consistence	0	6.5
			0.2	7.0
A21	.15–.30	Fine Sandy Silt Loam (SM/SC) (10YR6/3, 10YR3/4), sporadic bleach massive apedal weak dry consistence	0.4	6.0
			0.6	6.0
A22	.30–.55	Sandy Gravel (GR–GC) in (>70% Fe. gravel) sr 1–2 cm silty sand matrix – non plastic conspicuous bleached horizon	0.8	6.5
			1.0	6.0
B	.55–.90	Med.–heavy clay (CH), diffusely mottled (yellowish grey), (25YR4/6), weak subangular blocky → prismatic structure 5–10% & 2–5 cm hard dry consistence in rough ped faces		
C	.90–1.0(+)	Weathered Siltstone partly silicified		

Comments: Strip 0–0.2 marginal quality

Site No: 30
AMG Ref: S 23°22'.322
E 148°30'.712 Z=330 m
Soil Type: 5.1
Great Soil Group: Grey–Brown Clay
Principal Profile Form: Uf 5.31
Substrate Material: NR
Geological Ref: Ta
Drainage Status: Runon Runoff Profile
Mod. Mod. S
Vegetation: Brigalow woodland

Survey: Yongala Date: 13/6/92
Landform Unit: Qa2/5.1

Landform Element: Upper slope
Slope (%): 2
Microrelief: NA
Surface Coarse Fragments: NA
Surface Condition: Hard set – surface crust
Erosion: NA

Profile Morphology:
Horizon Depth (m)

Described by: Reng
Description

Depth (m)	Description	Field pH Depth (m)	pH
0–0.20	Silty Clay (CL–CH) (2.5YR3/4) weak s/a blocky to prismatic mod subplastic (2–5,1–2 cm) rough ped faces hard dry consistency	0	6.0
		0.2	7.0
0.2–0.45	Med.–Heavy Clay (CH) (2.5YR4/6) weak to mod. s/a blocky (2–5,1–2 cm) some fine gravel (<5%), smooth ped faces	0.4	8.0
		0.6	8.5
0.45–0.80	Med.–heavy Clay (CH) (2.5YR4/6) weak angular prismatic structure, v. hard dry consistence, just moist shiny peds	0.8	8.0
		1.0	8.0
0.8–1.5(+)	Med.–heavy Clay (CH) with soft carbonate segregations; mod. s/a blocky to prismatic structure, (5–10 breaking to <1–5 strong developed) up to 10% fine Fe. gravel		

Comments: Photo 2/10 – Survey peg TK826 – Bore R224

YONGALA – SITE DESCRIPTIONS

Site No: 31
AMG Ref: E 23°22'.560
S 148°30'.766
Soil Type: 5.1
Great Soil Group: Red brown and brown clays
Principal Profile Form: Uf6.31
Substrate Material: NR
Geological Ref: Cz
Drainage Status: Runon Runoff Profile
F/prone Mod. S
Vegetation: Brigalow – some Moreton Bayash

Survey: Yongala
Landform Unit: Qa2/5.1

Landform Element: Plain
Slope (%): 1
Microrelief: NA
Surface Coarse Fragments: NR
Surface Condition: Hard set
Erosion: Severe gullying

Date: 13/6/92

Profile Morphology:
Horizon Depth (m)

Described by: Reng
Description

Field pH
Depth : pH
(m)

A1	0–0.2	Silty Clay (CL) reddish brown, becoming medium clay at 0.2 m
	0.2–0.4	Medium Clay (CH) (5YR4/6) weak to mod. developed s/a blocky structure (2–5,1–2 cm)
	0.4–0.6	As above but appears somewhat less well–structured
	0.6–1.3(+)	Medium Clay with up to 30% of fine (<0.5 cm) calcareous/ ferruginous gravel

Comments: Similar profile to site 27

Site No: 32
AMG Ref: E 23°22'.738
S 148°31'.957
Soil Type: 4.2
Great Soil Group: Brown Podzolic
Principal Profile Form: Db1.12
Substrate Material: Weathered rock
Geological Ref: Ta
Drainage Status: Runon Runoff Profile
Mod. Rapid ID
Vegetation: Broadleaf ironbark some brigalow

Survey: Yongala
Landform Unit: Ta5/4.2

Landform Element: Interfluve
Slope (%): 1–2
Microrelief: NA
Surface Coarse Fragments: NA
Surface Condition: –
Erosion: NA

Date: 13/6/92

Profile Morphology:
Horizon Depth (m)

Described by: Reng
Description

			Field pH Depth : (m)	pH
A11	0–0.05	Fine sandy silt loam (SC)– dark brown	0	6.5
A12	0.05–0.35	Fine sandy clay loam (SC–CL) – dark brown grading to fine sandy light clay 3.5	0.2	6.5
			0.4	7.0
B	0.35–0.60	Med. Clay (CH) (10YR5/6) s/a blocky to prismatic, 2–5 cm rough ped faces	0.6	7.5
			0.8	7.5
	0.60–1.2	Med. clay (CH) <10% s/a Fe. gravel, weak – mod. angular blocky structure (2–5,1–2 cm)	1.0	7.5
C	1.2–1.3	Coarse chert cobbles in clayey matrix, not able to dig with backhoe – up to 30 cm diam.		

Comments: TK816 – survey work – Diversion Channel alignment
Adjacent to rocky outcrop area with dense bushy acacia cover

YONGALA - SITE DESCRIPTIONS

Site No: 33
AMG Ref: E 23°22'.738
S 148°30'.657
Soil Type: 2.1
Great Soil Group: Alluvial Soil
Principal Profile Form: Uc1.43
Substrate Material: Alluvium
Geological Ref: Qa
Drainage Status: Runon Runoff Profile
F/prone Mod. WD

Survey: Yongala
Landform Unit: Qa1/2.1

Landform Element: Levee
Slope (%): 1
Microrelief: NA
Surface Coarse Fragments: NA
Surface Condition: Not hard set
Erosion: Bank scouring

Date: 13/6/92

Vegetation: Moreton Bayash, Poplar box mod. poor native grass groundcover

Profile Morphology:
Horizon Depth (m)

Described by: Reng
Description

Horizon	Depth (m)	Description	Field pH Depth (m)	pH
A1	0–0.1	Fine grained sand (SP) brown loose, apedal	0	6.0
	0.1–0.95	As above but med. dense, mod. strong dry consistence (5YR4/4)	0.2	6.0
	0.95–1.20	Clayey sand (SM–SC) in Fe. gravel, weakly cemented, reddish brown & grey diffusely mottled	0.4	7.0
			0.6	7.0
			0.8	6.0
			1.0	6.0

Comments: Adjacent to Boggy Creek – floodplain, sandy materials extend back 20 m from Creek then rise to adjacent Box country with duplex soils.
Photos 2/15–16 of Boggy Creek

Site No: 34
AMG Ref: S 23°22'.860
E 148°30'.490
Soil Type: 5.1
Great Soil Group: Red-Brown Clay
Principal Profile Form: Uf5.31
Substrate Material: Tertiary sediments
Geological Ref: Ta
Drainage Status: Runon Runoff Profile
Mod. Mod. Slow

Survey: Yongala
Landform Unit: Cz2/5.1

Landform Element: Mound
Slope (%): Overall 1–2 cm, local 10–20%
Microrelief: Gilgai 10 m x 0.5 m
Surface Coarse Fragments: Some sparse Fe. gravel and stone
Surface Condition: N/Hard set
Erosion: NA

Date: 13/6/92

Vegetation: Brigalow woodland

Profile Morphology: Not Described
Horizon Depth (m)

Described by: Reng
Description

Depth (m)	pH

Not described in detail.
Uniform fine-textured reddish brown (5YR4/6) clay possibly with a very thin surface veneer of somewhat subplastic light clay (granular – slightly pulverulent)

Comments: Photo 2/17
Survey peg – 304

YONGALA - SITE DESCRIPTIONS

Site No: 35
AMG Ref: NR

Survey: Yongala
Landform Unit: Qa2/4.3

Date: 13/6/92

Soil Type: 4.3
Great Soil Group: Solodic
Principal Profile Form: Dr2.23
Substrate Material: NR
Geological Ref: Ta
Drainage Status: Runon Runoff Profile
F/prone Slow ID
Vegetation: Juvenile *E. tessilaris*/Poplar Box

Landform Element: V. gently inclined plain
Slope (%): 1
Microrelief: NA
Surface Coarse Fragments: NA
Surface Condition: Hard set
Erosion: NA

Profile Morphology:
Horizon Depth (m)

Described by: Reng
Description

Field pH
Depth (m) : pH

A1	0–0.15	Silty Clay Loam (CL–ML), dark brown, subplastic	0	6.0
A2	0.15–0.3	Silty Clay Loam (CL–ML)	0.2	6.5
B	0.3–0.85	Heavy Clay (CH), (5YR4/6) weakly developed, med. s/a blocky structure 2–5 cm	0.4 0.6	6.5 8.0

Comments: Area of young *E. tessilaris* adjacent Pop. box area

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Site No: 36
AMG Ref: NR

Survey: Yongala
Landform Unit: Cz2/5.1

Date: 13/6/92

Soil Type: 5.1
Great Soil Group: Red-Brown Clay
Principal Profile Form: Uf6.31
Substrate Material: Alluvium
Geological Ref: Ta
Drainage Status: Runon Runoff Profile
Mod. Mod. Slow
Vegetation:

Landform Element: Gently inclined plain
Slope (%): 2
Microrelief: NA
Surface Coarse Fragments: NA
Surface Condition: Not hard set
Erosion: NA

Profile Morphology:
Horizon Depth (m)

Described by: Reng
Description

Field pH
Depth (m) : pH

A	0.022	Silty clay (CL–CH) – mod. well structured
B1	0.2–0.5	Gravelly clay (GC–CH), (5YR4/6), fine Fe. gravel mostly <1 cm, (<20%) increasing with depth to <50%
B2	0.5–1.0	Gravelly clay – clayey gravel (GC–CH); ironstone gravel 2–5 cm, in med. clay matrix
BC	1.0(+)	Med. heavy clay, (CH), some calcareous soft segregations – dark reddish brown and pale reddish brown diffusely mottled some (<10%) Fe. gravel on ped faces.

Comments: Strip to 40 cm

YONGALA – SITE DESCRIPTIONS

Site No: 37
AMG Ref: NR

Survey: Yongala
Landform Unit: Cz2/4.3

Date: 13/6/92

Soil Type: 4.3
Great Soil Group: Solodized Solonetz
Principal Profile Form: Dr2.43
Substrate Material: NR
Geological Ref: Cz
Drainage Status: Runon Mod. Runoff Mod. Profile ID
Vegetation:

Landform Element: Lower slope
Slope (%): 1–2
Microrelief: NA
Surface Coarse Fragments: NA
Surface Condition: Hard set
Erosion: Minor scalding

Profile Morphology:
Horizon Depth (m)

Described by: Reng
Description

Field pH

Horizon	Depth (m)	Description	Depth (m)	pH
A1	0–0.25	Silt loam, brown (CL–ML)	0.1	6.4
A2	0.25–0.45	As above gravelly and bleached (SM–ML)	0.45	7.1
B1	0.45–0.7	Med.–heavy clay CH, weak blocky, strong, columnar (5YR4/8),	0.9	9.2
B2	0.7–1.2(+)	Med.–heavy clay (CH) massive		

Comments:

Site No: 38
AMG Ref: NR

Survey: Yongala
Landform Unit: Ta5/4.2

Date: 13/6/92

Soil Type: 4.2
Great Soil Group: Red Podzolic
Principal Profile Form: Dr2.11
Substrate Material: Weathered sandstone
Geological Ref: Ta/Pb
Drainage Status: Runon Mod. Runoff Rapid Profile ID
Vegetation: Eucalypt woodland, mainly ironbark

Landform Element: Gently inclined plain
Slope (%): 1–2
Microrelief: NA
Surface Coarse Fragments: NA
Surface Condition: Hard set
Erosion: Surface sheet/scalding

Profile Morphology:
Horizon Depth (m)

Described by: Reng
Description

Field pH

Horizon	Depth (m)	Description	Depth (m)	pH
A1	0–0.1	Silty Clay Loam, dark red brown massive	0.2	6.2
B1	0.1–0.9	Silty Medium Clay (CL–CH) (10YR4/8) friable brittle breaking to fine nutty structure	0.35	6.6
B2	0.9–1.2	Ferruginous Gravelly Clay (GC)	0.85	5.5
C	1.2–1.4	Sandy Clay (CL): yellowish brown with small cobbles of chert – backhoe not able to penetrate		

Comments: Diversion channel – mod. steeply dipping; Permian rock exposed in nearby creek.

YONGALA – SITE DESCRIPTIONS

Site No: 39
AMG Ref: NR

Survey: Yongala
Landform Unit:

Date: 13/6/92

Soil Type: 4.3
Great Soil Group: Solod
Principal Profile Form: Db2.42
Substrate Material: Mottled zone
Geological Ref: Ta
Drainage Status: Runon F/prone Runoff Mod. Profile ID

Landform Element: Drainage flat; Ta2/4.3
Slope (%): 1–2
Microrelief: NA
Surface Coarse Fragments: Sparse stone
Surface Condition: Hard set
Erosion: Severe gullying

Vegetation: Eucalypt woodland predominantly narrow-leaf ironbark

Profile Morphology:
Described by: Reng

Horizon	Depth (m)	Description	Field pH Depth (m)	pH
A1	0–0.2	Sandy Loam (SC–CL) dark brown massive	0.1	6.0
A2	0.2–0.35	Silty fine sand loam (CL–ML) bleached horizon	0.3	6.3
B1	0.35–0.65	Light–medium Clay (CL) (10YR4/4) – brown, weakly structured to massive	0.55	7.6
B2	0.65–1.2	Medium–heavy Clay (CH), (5YR4/8) reddish brown–brown diffusely mottled	0.95	6.8
B–C	1.20–1.70(+)	Gravelly Clay (GC) mottled grey and dull brown, underlain by Ferruginised claystone – mottled zone		

Comments:

ANNEXURE B

SOIL CHEMICAL/NUTRIENT ANALYSIS TEST METHODS

ANNEXURE B

SOIL CHEMICAL/NUTRIENT ANALYSIS TEST METHODS (SGS AUSTRALIA PTY LTD)

Analysis			Units	Test Method
pH	=	pH	ppm	1:5 0.01M, $CaCl_2$
Al	=	Aluminium	ppm	1:5 0.01M, $CaCl_2$
N	=	Nitrate Nitrogen	ppm	Aqueous Buffer
P2	=	Phosphorus	ppm	Bicarbonate 16 Hr
K	=	Potassium	ppm	Ammonium Acetate
S	=	Sulphate Sulphur	ppm	Calcium Phosphate
Ca	=	Calcium	ppm	Ammonium Acetate
Mg	=	Magnesium	ppm	Ammonium Acetate
Cu	=	Copper	ppm	EDTA
Zn	=	Zinc	ppm	EDTA
Mn	=	Manganese	ppm	EDTA
Fe	=	Iron	ppm	EDTA
B	=	Boron	ppm	Hot water/$MgCl_2$
Om	=	Organic Matter	%	Walkley–Black
EC	=	Electrical Conductivity	dS/m	1:5 soil/water
TSS	=	Total Soluble Salts (Est)	ppm	1:5 soil/water
Na	=	Sodium	ppm	Ammonium Acetate
Cl	=	Chloride	ppm	1:5 soil/water
CEC	=	Cation Exchange Capacity	mEquiv $100g^{-1}$	Calculation
ESP	=	Exchangeable Sodium Percentage	%	Calculation
EPP	=	Exchangeable Potassium Percentage	%	Calculation
ECP	=	Exchangeable Calcium Percentage	%	Calculation
EMP	=	Exchangeable Magnesium Percentage	%	Calculation
CaMg	=	Calcium:Magnesium Ratio	%	Calculation
EAP	=	Exchangeable Aluminium Percentage	%	Calculation

ANNEXURE C

C1 Land Resource Attributes – Explanation of Terms

C2 Land Suitability for Cattle Grazing/Improved Pasture, Mine Lease Area Analysis

C3 Land Suitability for Cattle Grazing/Improved Pasture, Analysis of Area to be Disturbed

ANNEXURE C1

The following land resource attributes have been considered in deriving the land suitability classification for beef cattle grazing and improved pastures.

The impact of each attribute (limitation) assessed has been allocated into one of five levels of severity of constraint with respect to the land use enterprise being considered. The assessments are largely qualitative and based on soil/site observations, the results of soil physical and chemical testing undertaken and previous experience with similar soil landscape environments within the general vicinity. The levels of limitations assessed are:

Rating 1	Nil or negligible limitation
Rating 2	Minor limitation
Rating 3	Moderate limitation
Rating 4	Severe limitation
Rating 5	Extreme limitation

The land is considered less suitable as the severity of the limitations increases. The combined effects of the limitations assessed permits the appropriate land suitability class rating to be determined.

The following resource attributes have been considered in deriving the land suitability classification for beef cattle grazing and improved pastures.

Water Availability (m). This refers the limitation to pasture growth due to availability of soil water supply – plant available water capacity (PAWC).

Uniform clay soils at least 0.5 m deep were rated 1; clay soils <0.5 m deep were assessed as having a minor limitation (rating 2) as were the gradational loamy red and lateritic red earths, and those duplex soils with loamy surficial soil horizons.

Duplex soils with sandy surface soils, and the coarse to medium textured alluvial soils were considered to provide a moderate limitation (rating 3). The sandy lateritic yellow earths and shallow rocky soils were considered (overall) to have low PAWC and have been rated as level 4.

Nutrient Deficiency (n). The main limiting factors to beef production from pastures is governed by the availability of nitrogen, phosphorus and to a lesser extent potassium and calcium. Soil nutrient levels for the Yongala soils have been rated as follows:

- The units with clay soils supporting brigalow scrub, the shallow cracking clays and the medium to coarse-textured alluvial soils (due to periodic flooding) are considered to have adequate levels of nutrients in the surface soils and have been rated 1.
- Minor limitations were assessed for the thin loamy surface duplex soils, with moderate to severe limitations being allocated to the strongly leached gradational red earths and lateritic red earths and the deeper sandy surface duplex soils.

Soil Physical Factors (p). This attribute refers the limitations to pasture establishment due to soil physical factors such as hard setting surface conditions, surface crusting, poor soil structure, stoniness etc. A moderate to severe limitation has been assigned to the majority of the duplex soil types due to varying degrees of hard setting surface conditions evident, and to the very gravelly and shallow rocky soil units. The brigalow and alluvial soil landscapes, and the loamy surface red earths and lateritic red earths were considered to provide either nil or very low levels of physical limitations.

Salinity (sa). This limitation refers to the potential for reduced productivity due to the presence of excess soluble salts in the soil. A minor salinity limitation was assigned to the deep duplex soils and clay soils associated with the poplar box and brigalow vegetation associations. Those soils tend to have increasing levels of salinity below a depth of about 0.4 – 0.5 m. Salinity limitations were not considered to be significant elsewhere.

Rockiness (r). This refers to rock outcrop and coarse fragments in the surficial soil layer which may impede seed germination and/or cultivation. Those soils on the steeper and dissected slopes and scarps were assigned a severe to extreme rating due to rockiness. Elsewhere, only the lateritic gravelly red and yellow earth soils were considered to present a minor limitation with respect to rockiness.

Microrelief (g). This refers to the presence of gilgai microrelief (local mounds and depressions) which may impede surface trafficability of machinery for cultivation. Surface water ponding in depressions can also present limitations due to these features. Only the clay soils associated with brigalow scrub and cracking clay soil areas were considered to present a minor limitation in this regard.

Wetness (w). This limitation relates to the adverse effects of excess water on pasture productivity and to the general trafficability of the surface following prolonged heavy rain. Only the cracking clay soil areas and brigalow soil landscapes have been given a minor wetness limitation.

Water erosion (e). The criteria used to assess the water erosion limitation under beef cattle grazing are primarily surface slope and associated soil types, and soil dispersion characteristics. Accordingly, all land units with duplex soil types associated, and/or with surface slopes greater than 3% have been considered to present either a moderate or severe water erosion limitation depending on local conditions. Those units which have slopes <3% and have deep soils with high infiltration rates, such as the sandy alluvial soils and the red earth and lateritic red/yellow earths, are considered to be more resistant to erosion and present a lesser limitation. The brigalow soil landscapes were also considered to present only a minor erosion limitation.

Flooding (f). Land periodically inundated by overflow flooding has a flooding limitation which depends upon frequency, duration, depth and velocity of flood waters. The stream flats adjacent to Boggy Creek have been assigned a moderate to minor flooding limitation.

Topography (t). Topography affects the use of machinery for cultivation and harvesting operations. For example, land with frequent or deep, steep-sided gullies and/or uneven rocky slopes will impede the efficient use of machinery. Accordingly land units with steep rocky uneven slopes have been given a moderate to extreme topographic limitation rating, as have those land units which exhibit intensive and/or deep gully erosion.

Vegetation (v). This limitation relates to clearing of timber which is essential to establish sown pastures. The long term benefits of clearing for pasture improvement can be reduced by regrowth and invasion of woody weeds. The vegetation limitation refers to the long term reduction in pasture productivity due to these effects.

ANNEXURE C2

Land Suitability for Cattle Grazing/Improved Pasture
Mine Lease Area Analysis

Land Unit No.	Grazing/Sown Pasture Class	Area (ha)	% of Lease Area
Cz2/5.1	2	71	
Cz3/4.3–5.1	2	50	
Pb3/6.1	2	19	
Qa2/5.1	2	43	
	Total	(183)	11
Cz2/4.3	3	99	
Qa1/2.1	3	94	
Ta3/4.2	3	134	
Ta5/4.2	3	355	
	Total	(682)	41
Cz5/4.3	4	16	
Qa2/4.3	4	27	
Ta2/4.3	4	52	
Ta3/3.1	4	52	
Ta3/3.2	4	241	
Ta3/3.3	4	100	
Ta4/1–3.1	4	110	
Ta5/4.1	4	26	
	Total	(621)	37.5
Ta6/1–4.2	5	152	
Ta8/1.1	5	24	
	Total	(176)	10.5
Mine Lease Area (Total 1664 ha)			

ANNEXURE C3

Land Suitability for Cattle Grazing/Improved Pasture
Analysis of Area to be Disturbed (Pits YS, YC and YN)

Land Unit No.	Grazing/Sown Pasture Class	Area (ha)	% of Lease Area
Cz2/5.1	2	25	
Cz3/4.3–5.1	2	27	
Qa2/5.1	2	40	
	Total	(92)	21
Cz2/4.3	3	64	
Qa1/2.1	3	67	
Ta3/4.2	3	33	
Ta5/4.2	3	67	
	Total	(231)	53
Cz5/4.3	4	3	
Qa2/4.3	4	20	
Ta2/4.3	4	35	
Ta3/3.1	4	12	
Ta3/3.2	4	39	
	Total	(109)	25
Ta6/1–4.2	5	3	
	Total	(3)	1
Disturbed Area (Total 435 ha)			

APPENDIX 4

YONGALA MINE
BIOLOGICAL SURVEY

TABLE OF CONTENTS

BIOLOGICAL SURVEY

1.0 VEGETATION

1.1 Existing Vegetation

The majority of the Yongala study area retains its original vegetation, although a varying degree of disturbance, as a result of grazing activities, is evident. The vegetation associations found within the project area correspond fairly closely with specific soil types and depth of the solum, as well as topographic position within the landscape. In general, the soils range from moderately shallow (<0.5 m – with low nutrient levels) on the lateritic gravelly ridges and undulating to low hilly areas through moderately deep (0.5–1.0 m) on the gently inclined dissection slope interfluves to deep (>1.0 m) on the outwash slopes and plains and alluvial flats and terraces where nutrient levels are highly due to periodic flooding.

A narrow riverine vegetation is associated with Boggy Creek, a small ephemeral stream running through the middle of the site. This creek is poorly developed as evidenced by the steeply incised banks and medium grained, mobile sandy stream bed deposits. No permanent pools were evident and runoff from the hard surfaces of the surrounding soils would be rapid and short–lived. Some permanent water is present in dams constructed for stock watering, however both the availability of water and the habitat types are limiting factors for wildlife in this area.

Mapping of the vegetation was carried out initially by reference to aerial photography, and verified by subsequent ground truthing. Overlap between dominant tree species as well as shrub and/or ground cover was common across the site. Community boundaries are thus often not distinctive, and the mapped boundaries represent the middle of the ecotone in such cases.

The vegetation communities identified have been mapped on Figure 25 and are described below.

Narrow–Leaved Ironbark Bloodwood Woodland

This community is found on mid and upper hillslopes, hillcrests and plateau or plateau surfaces developed on red and yellow earths or shallow rocky soils. The dominant trees include narrow–leaved ironbarks *(Eucalyptus crebra* and *E. drepanophylla)* and bloodwoods – red bloodwood *(E. dichromophloia)* and large fruited bloodwood *(E. polycarpa).* The ghost gum *(E. papuana)* is occasionally present.

Moreton Bay ash *(E. tessellaris)* and iron wood *(Acacia excelsa)* were present on the plateaus. Lancewood *(Acacia shirleyi)* occasionally occurred on some hillslopes and crests as did Mountain Yapunyah *(Eucalpytus thozetiena).*

Small trees and shrubs commonly include red ash *(Alphitonia excelsa),* quinine bush *(Alstonia constricta)*, black thorn *(Bursaria incana)*, Leichhardt bean *(Cassia brewsteri), Erythroxylum australe, Grewia retusifolia,* and quinine berry *(Petalostigma pubescens).*

There is a sparse to moderate ground cover of grasses including three awned spear grass *(Aristida benthamii),* dark wire grass *(A. calycina),* purple wire grass *(A. ramosa),* pitted blue grass *(Bothrochloa decipiens),* desert blue grass *(B. ewartiana),* barbed wire grass *(Cymbopogon refractus),* leafy nine-awn *(Enneapogon spp., E. lindleyanus, E. polyphyllus),* love grass *(Eragrostis sororia),* mountain wanderrie *(Eriachne mucronata),* black spear grass *(Heteropogon contortus)* and kangaroo grass *(Themeda triandra).*

Lancewood – Mountain Yapunyah Open Forest

This community is found on scarps and hillslopes on shallow rocky soils and shallow red and yellow earths. Pure stands of dense lancewood *(Acacia shirleyi)* are locally abundant particularly on steep scarps and slopes. Mountain yapunyah *(Eucalyptus thozetiana)* occurs in association with lancewood on middle and lower hill slopes and here a shrub layer of *Erythroxylum australe,* wilga *(Geijera parviflora)* and currant bush *(Carissa ovata)* is usually found. Other small trees/shrubs present include quinine bush, red ash and *Canthium* spp.

There is a sparse to dense ground cover of grasses including hooky grass *(Ancistrachne uncinulata),* wire grass *(Aristida caput-medusae), Calyptochloa gracillima,* love grass *(Eragrostis spp.)* and *Paspalidium distans.* Forbes such as Sida spp. and sage *(Plectranthus parviflorus)* may be present.

Brigalow – Mountain Yapunyah Open Forest

This community is found on lower hill slopes and foot slopes on texture contrast soils and clay soils.

Both of these species are present in the mid to upper slopes, above which brigalow, and then lancewood become the dominant species. There is a shrub layer of emu apple (*Ominia acidula)*, currant bush, red ash, boonaree (*Heterodendron diversifolium)*, and Leichhardt bean. Yellow-wood is sometimes present.

There is a dense but well grazed ground cover of spear grass (*Aristida* spp.), curly windmill grass (*Enteropogon acicularis),* brigalow grass (*Paspalidium caespitosum)* and *Sporobolus* spp., ray grass (*S. antinoctadus)* and fairy grass *(S. caroli).*

Poplar Box Open Woodland

This community is found on the lower hill slopes and foothills on texture contrast soils mainly with thin sandy or loamy surface horizons. Silver-leaved ironbark can be found on the lower slopes, with some narrow-leaved ironbark, and brigalow.

Shrubs include willow wattle *(Acacia salicina)*, black teatree (*Melaleuca bracteata),* yellow wood (*Terminalia oblongata),* currant bush, red ash, and emu apple.

On one small stony outcrop, yellow–wood was found as a stand to 6 metres tall, with black teatree.

Grasses are common and include forest blue grass, Queensland blue grass, kangaroo grass, black spear grass, barbed wire grass, feather top wire grass, and nine–awn.

Ironbark – Poplar Box Open Woodland

This is similar to the previous community but with a distinctive presence of narrow–leaved ironbark. It is found on the upper slopes and represents a wide ecotone between the poplar box and ironbark–bloodwood communities. Understorey species are usually more dominant with a corresponding decrease in the grass coverage.

Riverine

Because of the small size and ephemeral nature of Boggy Creek, the riverine community is not well developed, nor well defined. However, a variety of species distinctive to this habitat are present.

These include blue gum (*Eucalyptus tereticornis)*, river red gum (*Eucalyptus camalduensis)*, ghost gum (*Eucalyptus papuana),* and black teatree. The channel benches and terraces include Moreton Bay ash (*Eucalyptus tesselaris)*, silver leaved ironbark, poplar gum, yellow wood, brigalow, willow–wattle, Leichhardt bean, and red Bauhinia as mixed stands.

Unlike areas further downstream which have grasses adapted to wetter areas, the species in this area are dryland species found throughout the area.

Selectively Cleared / Highly Disturbed

These areas include those previously cleared for grazing purposes as well as the larger scalds most of which have little, if any, ground cover.

Regrowth areas have not been identified, however, they are a problem across the study area. Thick stands of *Acacia* spp. are evident in many places as well as brigalow and thorny species such as currant bush and *Caparsio* spp.

1.2 Significance of Vegetation Types

The flatter sections of the study area include grassy eucalypt woodlands, brigalow scrub and mixed shrub woodland. The steeper rocky terrain communities of ironbark – bloodwood woodland, lancewood – mountain yapunyah open forests.

No rare or endangered plant species were found, and from the literature available there was no indication of any rare species occurring in the area.

The conservation status of brigalow communities and associated softwood scrubs in Queensland has been reviewed by Sattler and Webster (1984) and is regarded as inadequate. It is recognised that any remaining occurrences of poorly conserved communities, especially softwood and brigalow softwood, should be preserved if large enough to buffer the external influences of a man modified surrounding landscape. Larger areas of brigalow–mountain

yapunyah and brigalow–yellowwood mixed woodland occur elsewhere in the region, and are likely to be of higher quality than those in the study area. Whilst brigalow is present in the study area, no softwood communities occur in this area.

1.3 Impact on Vegetation

The area to be affected by mining (YC Pit) is an area approximately 900 metres wide and 3,000 m long (approximately 250 ha). The Boggy Creek watercourse is located in the eastern portion of this area (see Figure 12). The vegetation communities to be affected by this project include:

- Poplar box open woodland.
- Brigalow – poplar box mixed woodland
- Brigalow – mountain yapunyah open woodland
- Riverine open woodland

The total area of each community and the percentage to be affected within the study area is given in Table A4.1.

Table A4.1

Vegetation Communities – Area of Disturbance

Vegetation Community	Area (ha)	% of YC Pit
Poplar box open woodland	70.8	13
Brigalow–poplar box mixed low woodland	82.4	26
Brigalow – mountain yapunyah open forest		
Riverine	28.8	29

With regard to the impact on the riverine vegetation in particular, these results may be a little misleading. As described earlier this community is neither well defined nor well developed and the mapping boundaries include all of the species from this community even though some may be at their distribution limits. The status of this community is thus considered to be quite low especially compared with similar areas further downstream and elsewhere in the region. The impact of over–grazing throughout the study area is quite considerable with poor ground cover, especially around watering points and stockyards. Woody weeds are prevalent in the area which in turn, because of their growth form, reduce grass cover. Soil compaction, and erosion are secondary impacts observed in the study area.

The loss of brigalow mixed woodland and poplar box woodland, in either a local nor regional context, is not considered significant.

2.0 FAUNA

2.1 Existing Fauna

Terrestrial

A fauna survey of the study area was undertaken in conjunction with the vegetation survey. The area contained the following broad habitat types for terrestrial wildlife.

- **Wooded Areas**
  - Woodland
  - Forest
- **Farm Dams.**

Compared with other areas both locally and regionally, the habitat type and associated fauna are considered to be quite depauperate. The only marsupials observed were the grey kangaroo, and a dead dingo, possibly the victim of a baiting programme. No scratch marks on trees nor scats were observed in the area.

Domestic cattle were common as a result of the primary activity being grazing. This has had an adverse impact on native herbivores, (mainly macropods) and granivores (mainly various species of birds).

Aquatic

Because of the ephemeral nature of Boggy Creek, few opportunities exist in the study area for aquatic fauna, apart from those with short life histories. Similarly, no permanent or semi-permanent waterholes were observed in the area.

2.2 Significance of Fauna

Gordon (1984) indicates that as a result of the clearing of native vegetation and settlement within the brigalow belt, several native mammals have declined in numbers and distribution and may even be extinct. Two endangered species listed include the Queensland Hairy Nosed Wombat *(Lasiorhinus barnardi)* and the Bridled Nailtail Wallaby *(Onychogalea fraenata)*. However it is unlikely that these two species would occur in the mining area due to the lack of preferred habitat.

No bird species are known to be restricted to the habitats found in this area (Schodole, and Tidemann, eds, 1990)

2.3 Effects on Fauna

Terrestrial

It can be expected that species whose home ranges are within the area to be cleared (eg. small marsupials and rodents, reptiles, sedentary birds) may not survive destruction of their habitats. Larger, more mobile mammal species eg. grey kangaroo, wallabies, dingo, and most bird species will be able to migrate to other suitable areas. Progressive clearing of vegetation will facilitate the migration of wildlife.

Aquatic

The effects of mining on the aquatic ecosystems of Boggy Creek and the Nogoa River should be minimal. All inpit groundwater and rainfall runoff will be pumped into the pit water dam for reuse for haul road dust suppression. It is possible that discharge to Boggy Creek may occur following an extended period of intense rainfall, however such water is unlikely to contain any pollutants in quantities detrimental to aquatic ecosystems and the dilution afforded by the natural catchment system during these events should be such that deleterious effects will not occur.

for **HOLLINGSWORTH DAMES & MOORE**

BILL GARDYNE
Senior Biologist

REFERENCES

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APPENDIX 5

YONGALA MINE
WATER QUALITY DATA

Table 5.1

Boggy Creek – Rising Stage Water Quality Data

Date	05–Mar–86	18–Dec–91	18–Dec–91	20–Jan–92	20–Jan–92	20–Jan–92	20–Jan–92
Bottle No.[1]	1	1	2	1	2	3	4
pH	7.25						
Alkalinity	24						
Turbidity	805						
TSS	15800	7350	2520	4600	8090	7110	7910
TDS	55						
EC	87						
Ca	3.13						
Mg	2.99						
Na	14.5						
K	3.98						
Cl	16						
SO4	4.34						
HCO3	24						
N	0.18						
NO3	0.02						
NO2	0.02						
NH3	0.06						
P	1						
Fe	12.8						
Mn	0.02						
Phenols	0.1						
As	0.001						
Cu	0.01						
Hg	0.001						
Zn	0.08						
Cr	0.03						
CO3	1						
SAR	1.408						

Note: All units in mg/L except Turbidity (NTU) and EC (µs/cm).
1. Bottle No. 1 at bottom, 5 at top.

APPENDIX 6

YONGALA MINE
STUDY TEAM

YONGALA MINE

STUDY TEAM

Project details were provided by Ensham Resources Pty Limited.

The following Hollingsworth Dames & Moore personnel were involved in the project.

Study Management	– Chris Pigott, BE, MUS Stuart Ritchie, BE(Agr)
Land Resources	– Gavan Renfrey, A.Ma.Sc Robert Crossley, B.Ag.Sc, M.Ag.Sc
Water Resources	– Yin Foong, Bsc, M.App.Sc Stuart Ritchie, BE(Agr) Bron Smolski, BSc, MSc
Conservation Values	– Bill Gardyne, BSc
Social Issues	– Stuart Ritchie, BE(Agr)

ANNEXURE "A"

MINING LEASE NUMBER 70049

SPECIAL CONDITIONS

1. The holder shall submit a Plan of Operations in accordance with Section 7.48 of the Mineral Resources Act.

2. The holder shall conduct mining activities authorised by the lease in compliance with the approved EMOS and the current Plan of Operations.

3. The holder shall submit for approval a notice of variation of an approved EMOS to the Minister not less than two months (or such shorter period as the Minister in a particular case approves) before commencing any operations which would require amendment of the EMOS.

4. The holder shall with each Plan of Operations submit an Environmental Audit Report as described in the policy document "Environmental Management for Mining in Queensland" dated 5 November 1991 (hereinafter called "the Policy").

5. The holder shall, with each Plan of Operations prepare a Schedule of Rehabilitation Costs as described in the Policy, and shall have this amount confirmed by Audit, and shall submit this amount as security with the Plan of Operations in a form acceptable to the Minister.

6. The holder shall ensure that amounts of contaminated water, waste, noise, dust. gases, ground vibration or other nuisance factors generated on the lease and affecting areas outside the boundaries of the lease are as prescribed by any licence or otherwise at levels acceptable to the Minister.

7. The holder shall submit with any notice of surrender of the lease an audited Rehabilitation Report which certifies that the holder has complied with the approved EMOS and the current Plan of Operations.

END OF SEVEN SPECIAL CONDITIONS

DRAFT 21.12.92