



HOLLINGSWORTH DAMES & MOORE

**ENSHAM COAL PROJECT
IMPACT ASSESSMENT STUDY**

ENSHAM RESOURCES PTY LTD

**ENSHAM COAL PROJECT
IMPACT ASSESSMENT STUDY**

MAY 1990
HOB0449



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GLOSSARY

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Abbreviations

AEP	-	annual exceedence probability
AHD	-	Australian Height Datum
ANFO	-	ammonium nitrate fuel oil
ATP	-	authority to prospect
B	-	boron
C	-	Celcius
Ca	-	calcium
CEC	-	cation exchange capacity
Cl	-	chlorine
CO	-	carbon monoxide
Cu	-	Copper
dB	-	decibel
dB(A)	-	A weighted decibel
DWT	-	dead weight tonne
EC	-	electrical conductivity
EP	-	equivalent person
ESP	-	exchangeable sodium percentage
Fe	-	iron
FSS	-	falling stage flood sampler
g	-	gram
g/s	-	gram per second
ha	-	hectare

HC	-	hydrocarbon
HCO ₃	-	bicarbonate
K	-	potassium
kL	-	kilolitre
km	-	kilometre
km/h	-	kilometre per hour
kV	-	kilovolt
L	-	litre
L ₁₀	-	level of noise exceeded 10% of the time
L ₉₀	-	level of noise exceeded 90% of the time
L _{eq}	-	equivalent noise level
m	-	metre
m ²	-	square metre
m ³	-	cubic metre
Mbm ³	-	Million bank cubic metres
m-equiv	-	milli equivalent per 100 grams
Mg	-	magnesium
mg	-	milligram
mg/L	-	milligram per litre
mg/m ² /day	-	milligram per square metre per day
ML	-	megalitre
ml	-	millilitre
mm	-	millimetre
Mn	-	manganese
Mo	-	molybdenum
m/s	-	metre per second

m ³ /s	-	cubic metre per second
mS/cm	-	milli Siemen per centimetre
Mt	-	million tonnes
Mtpa	-	million tonnes per annum
MV	-	megavolt
MW	-	megawatt
N	-	nitrogen
Na	-	Sodium
NO _x	-	oxides of nitrogen
P	-	phosphorous
PABX	-	private automatic branch exchange
pH	-	see Technical Terms
PMF	-	probable maximum flood
PPF	-	principal profile form
QEC	-	Queensland Electricity Commission
QWRC	-	Queensland Water Resources Commission
RL	-	reduced level
ROM	-	run of mine
RSS	-	rising stage flood sampler
s	-	second
S	-	sulphur
SO ₂	-	sulphur dioxide
t	-	tonne
tpa	-	tonne per annum
tph	-	tonne per hour
TSP	-	total suspended particulate

USC	-	unified soil classification
USEPA	-	United States Environmental Protection Agency
VHF	-	very high frequency
Zn	-	zinc
μg	-	microgram = $1 \times 10^{-6}\text{g}$
$\mu\text{g}/\text{m}^3$	-	microgram per cubic metre
μm	-	micrometre

Technical Terms

Aeration Pond	-	A shallow dam in which the liquor is neutralized by the action of oxidization.
Ash	-	Incombustable residue remaining after coal has been burnt.
Beneficiation	-	The process of reducing or concentrating ores.
Borrow	-	All materials used in making embankments which do not necessarily come from excavation.
Box-Cut	-	Initial open pit excavation.
Coal measures	-	Strata containing coal beds.
Coal types	-	Those differences due to variation in the kind of plant material of which the coal is composed or the process of coalification.
Construction phase	-	The period of time during which the mine is prepared and associated infrastructure is completed prior to the mining operation commencing.
Construction workforce	-	The workforce associated with the construction phase of the mining operation.
Emerson Crumb Test	-	A procedure for determining the soil aggregate stability when immersed in water.
Hardgrove Index	-	A measure of coal grindability. Ascending index values denote increasing ease of grinding.
Haul road	-	The road which permits the transportation of coal and waste material around the mine.
Input-output analysis	-	An analysis of the sectors of the economy and an identification of the economic effects of interactions between sectors.
Interburden	-	A layer of sub-surface waste material separating coal seams of economic value
Jig (washbox)	-	A machine in which feed coal is stratified by specific gravity in water by air pulsation.
Multiplier effects	-	The measure of indirect population growth as a result of a direct change in population in some sector.

Operation phase	-	The period of time following the construction phase when the mine is operational.
Operational workforce	-	The workforce associated with the operation of the proposed mine.
Overburden	-	Surface waste overlying an economic coal seam
pH	-	A measure of acidity denoted by the common logarithm of the reciprocal of the hydrogen ion concentration. Values vary from 1, indicating ultra acidity through 7, indicating neutral conditions to a maximum of 14 indicating ultra alkalinity.
Preparation Plant	-	The plant for the cleaning and sizing of raw coal prior to beneficiation.
Raw Coal	-	Coal which has received no preparation other than crushing or screening.
Run of Mine (ROM)	-	Coal as delivered from the mine and prior to treatment
Sedimentation ponds	-	A dam which allows the settling of solid particles of soil and mineral from a liquid.
Spiral Separators	-	A static machine used for the gravity separation of fine coal by centrifugal action.
Spoil	-	Waste material from removed overburden or interburden.
Tailings	-	The reject from the preparation plant.

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1.0 SUMMARY

1.0 SUMMARY

1.1 The Proposal

The proposed Ensham coal mine will be located in the Bowen Basin in Queensland, Australia. It will be situated approximately 45 kilometres east of Emerald and approximately 16 kilometres north-west of the town on Comet. Both Emerald and Comet are located on the Capricorn Highway which links Emerald to Rockhampton.

The initial mine plan is based on 15 years of operations at a maximum production rate of 3.6 million tonnes of thermal coal per year. Coal will be mined by open cut methods, washed at the mine site and railed to the port of Clinton, Gladstone for export. An application for a Mining Lease has been made.

1.2 The Project

1.2.1 Mine Site

The coal reserves at Ensham occur within the Late Permian Rangel Coal Measures; a major coal-bearing sequence recognised throughout most of the Bowen Basin. Drilling has identified up to 6 coal seams with the open cut area being located in the shallow coal region where a number of seams coalesce to form a single seam of 4 metres to 6 metres in thickness. Strata dips are gentle ($<5^\circ$) and major structural impediments to mining are not anticipated. The coal is primarily a low to moderate ash, high energy, medium volatile, low sulphur coal suitable for power generation. Open cut Measured Reserves of 76 million tonnes have been delineated for seams greater than 1.5 metres thick to an overburden depth of 60 metres in the initial mining area.

In line with normal practice in the region, a standard dragline sidecast with extended bench stripping method will be used for overburden removal. Once exposed, the coal will be removed by a shovel and truck operation and hauled to the preparation plant.

When crushed and washed, the dewatered coal product will be conveyed to the product stockpiles before being loaded onto unit trains.

A short branch rail spur and balloon loop will be constructed from the mine to the existing Gregory Mine Railway. This will allow the coal to be shipped via the Central Rail Line to the Clinton Coal Terminal at Gladstone. Some modifications and expansion to this terminal will be required to allow for the storage and handling of Ensham coal.

Mine infrastructure will include the normal maintenance buildings and equipment, administration and ancillary buildings and structures and will be accessed via a bitumen sealed road from the Capricorn Highway.

Water for coal washing, road watering and general industrial use will be obtained by collecting run off, pumping from the mine and re-circulating of wash water. When these sources are insufficient, make up water will be obtained from the Nogoa River.

An onsite water treatment plant will produce potable water, using feed water drawn from the Nogoa River.

Electrical power for the mine will be supplied from the Queensland Electrical Commission substation at Lilydale by way of a proposed 66 kilovolt transmission line.

1.2.2 Emerald

It is proposed to accommodate the mine workforce in Emerald. Current planning is to construct a number of subdivisions dispersed throughout the town. This may include the development of some land on the eastern side of the Nogoa River. The subdivisions will be comprehensive developments designed and constructed to the standards of the Emerald Shire Council.

The existing water supply system will be augmented by way of additional water mains and service reservoir storage as necessary.

The present sewerage treatment plant in Emerald is currently being enlarged and additional works (including a rising main and pumping station) will be provided to service the Ensham workforce.

1.3 Environmental Impacts and Control Measures

The development of the mine will have significant and favourable impacts at the regional, state and national levels particularly for income and for employment. Also the development will cause a number of changes to the local environment; these have been identified and proposals formulated to mitigate against adverse impacts.

1.3.1 Natural Environment

The mining of coal will result in disturbing an area averaging 220 hectares per year over the 15 year mine plan. The disturbance will consist of progressive clearing, overburden dumping and mining. Currently an area of 3500 hectares, of the properties affected by the mine lease, is ploughed or under cultivation. Overburden spoil piles will be re-contoured progressively and suitable vegetation cover established.

Ninety percent of the Ensham study area has been cleared already, for either cropping or grazing activities and none of the vegetation communities to be removed by the mining operation are rare or otherwise especially worthy of preservation. Because of the vegetation disturbance, fauna of the area is species poor, although some species have benefited from the increase in grassland habitat. The extensive areas of ploughed land, currently being cultivated, will be significantly reduced once development commences.

The current 15 year mine plan does not include mining in the floodplain of the river except in two relatively small areas. Nevertheless this report has considered that floodplain mining may occur at some time in the future and an assessment of one method by which such mining could take place is given in Section 4.9.

Boggy Creek will require diversion in Year 5 and this will be in accordance with Water Resources Commission requirements. The design parameters of the diversion channel have been selected to ensure minimal erosion and to maintain bed stability.

There will be a number of changes to surface water runoff quality and quantity. The reduction in ploughed areas should produce an increase in runoff and a reduction in silt load. The construction of roads will produce a temporary increase in silt load until the drains have been re-grassed. In the mine area, all runoff flowing towards the haul roads and from spoil piles and cleared areas, will be intercepted in sedimentation ponds to allow the settlement of suspended sediment prior to discharge. All mine pit water will be discharged to evaporation ponds and used for road watering or in the coal washery or evaporated.

All runoff from coal stockpiles and industrial areas will be directed to either an evaporation pond or the raw water dam and finally either evaporated or used in the coal washery or for road watering. Grease and oil separators will be provided for runoff from the maintenance areas where greases and oils are used.

The mining operation will create dust levels within 1 to 2 kilometres of the mine from overburden removal, blasting and coal handling but will eliminate dust levels now caused from cultivation in the same area. Centres of population will not be affected although the two nearest residences (greater than 3 kilometres distance) which will be occupied during the mining may occasionally experience elevated dust levels under rare occasions of extreme weather conditions. Dust suppression techniques will be applied where possible, e.g. conveyor transfer points, coal stockpiles, etc. but some dust creation is unavoidable (e.g., from blasting, overburden dumping), during periods of high winds.

Noise is not expected to be a problem because of the distance to centres of population and rural residences. The most audible noise will be blasting, however it occurs only infrequently. Adequate warning will be given to all those likely to be affected by the blasting noise.

During the life of the mine, land use within the mine area will be altered from grazing and cropping to mining. Progressive rehabilitation of the overburden spoil piles will enable the return of this land to grazing and agricultural activity when mining has terminated.

1.3.2 Man—Made Environment

The project will effect a number of changes on the existing man—made environment.

The mine workforce will be accommodated in Emerald. The current estimated population of the town is approximately 6,200 and this is expected to increase by approximately 1,085 due to the Ensham Project. The town has already experienced rapid population growth from a similar source, as the Gregory Mine (which opened in 1979) already accommodates the majority of its workforce in Emerald.

The direct and service workforces generated by the mine development will enhance employment opportunities both locally and on a wider scale, while at the same time strengthening the town's industry structure. To ensure that a suitable workforce is available to operate the mine, the Company will implement a number of on—site training and apprenticeship programmes.

During the construction phase of the mine, those workers associated with constructing mine facilities will be accommodated at a mine camp while those workers involved in providing town infrastructure facilities will be housed in Emerald. A number of subdivisions will be developed in the town to provide suitable accommodation for all operational workers. Adequate housing will be provided to ensure that the project's workforce will not have an adverse effect on existing accommodation facilities in Emerald.

The increased population generated by the mine development will be accompanied by a significant increase in demand for a wide range of commercial and industrial services. Initially, this will provide a stronger customer base for existing services in the town, and in the longer term, will provide the basis for the establishment of new facilities and services which will benefit the whole community. Community facilities and services like health, education, welfare and recreation will also be in strong demand and where necessary, these will be expanded to ensure that both the incoming and existing populations are adequately catered for.

During the peak year of the construction phase (Year -1/+1), the project will generate both directly and indirectly over 880 new jobs in Australia, over 620 of which will be in Queensland. This will result in an additional \$30.0 million income nationally and \$25.6 million in the state. In a typical year of the operational phase (Year 10), the employment Australia wide will be about 1100 with over 870 of that being in Queensland. The income generated nationally will be \$122.5 million and in Queensland it will be \$98.8 million. The sale of the coal will generate an export income of \$194 million (in 1990 terms).

An archaeological survey of the mine area raised no objection to the mine being developed. It did note a significant site adjacent to Duckponds Lagoon, however this area is not currently proposed for open cut mining. Should this situation change in the future, further investigations of the site will be undertaken before the area is disturbed.

1.3.3 Environmental Safeguards

When the project proceeds, the environmental safeguards proposed in this study will be implemented. Environmental aspects will be closely monitored and liaison will be maintained with relevant government departments and statutory authorities.

2.0 INTRODUCTION

2.0 INTRODUCTION

2.1 Background

Initial exploration for coal in the Emerald area was commenced in the mid 1960's. Exploration drilling by the Geological Survey of Queensland commenced in 1971 and continued in stages until 1983. In early 1984, Authority to Prospect (ATP) 426C was granted to a consortium of companies for detailed evaluation of mining potential and eventual development. The Authority to Prospect lapsed in February, 1990 and a new Exploration Permit No. 505 was issued October, 1990 to the following consortium. The consortium of companies is summarised at Table 2.1.

Table 2.1
Consortium of Companies

Company	Ownership (%)
Bligh Coal Limited	47.5
Idemitsu Queensland Pty Limited	47.5
Lucky-Goldstar International (Australia) Pty Ltd	5.0
Total	100.0

Exploration by AQC-Pacific commenced in March 1984. Since that time exploration has continued and AQC-Pacific has prepared a feasibility study for the Ensham open cut area for an initial 15 year period. The scope of this study and the various consultants responsible are as follows:

- Geology, mining engineering infrastructure and coal processing (AQC-Pacific)
- Geology, mining engineering, infrastructure and coal processing (Davy McKee Pacific Pty Ltd)
- Infrastructure studies (Cameron McNamara)
- Electrical requirements (Mertz McLellan and Partners)
- Geotechnical investigations (Golder Associates)
- Coal utilisation (ERM Consultants Pty Ltd)
- Bucket wheel excavator applications (Rheinbraun Consulting Aust. Pty Ltd)
- Hydrological studies (Blain Johnson)
- Town infrastructure (Blain Johnson)
- Impact assessment studies (Hollingsworth Dames & Moore).

2.2 Project Scope

The Ensham Coal Project involves the construction and operation of an open cut coal mine on the Ensham coal deposit in the Bowen Basin in central Queensland. The deposit is located approximately 45km east of Emerald.

The feasibility study has recommended mining at a rate of 3.6Mtpa of steaming coal. The product coal will be railed to Clinton Coal Terminal at Gladstone for export. The study considered an initial 15 year mine plan only. Subsequent to this phase, further coal would be won by open cut mining and by underground mining.

Within the 15 year mine plan, the operational workforce would peak at 407. This workforce will be accommodated in Emerald.

The regional locality and site location of the project are shown on Drawings 2.1 and 2.2 respectively.

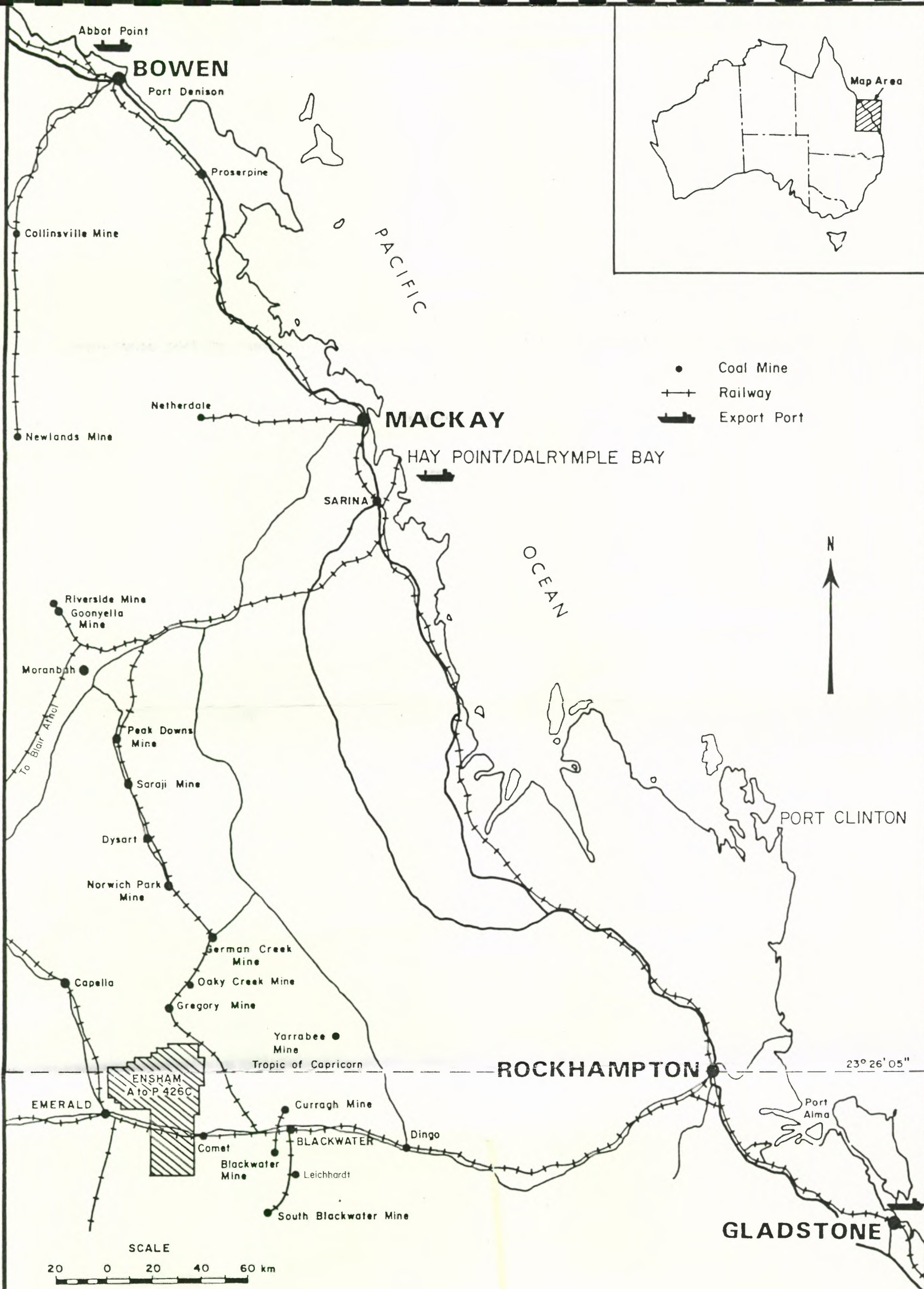
2.3 Study Objective

The principal objective of this study is to identify all likely interactions and to assess the consequential environmental impacts that would result from the implementation of the development proposals as currently envisaged. These proposals are discussed in Section 3.0. The environmental effects have been considered for both the natural (physical and biological) and man-made (community and social) environments. Where relevant, this report has also proposed environmental controls and safeguards to minimise any likely detrimental effects.

2.4 Study Guidelines

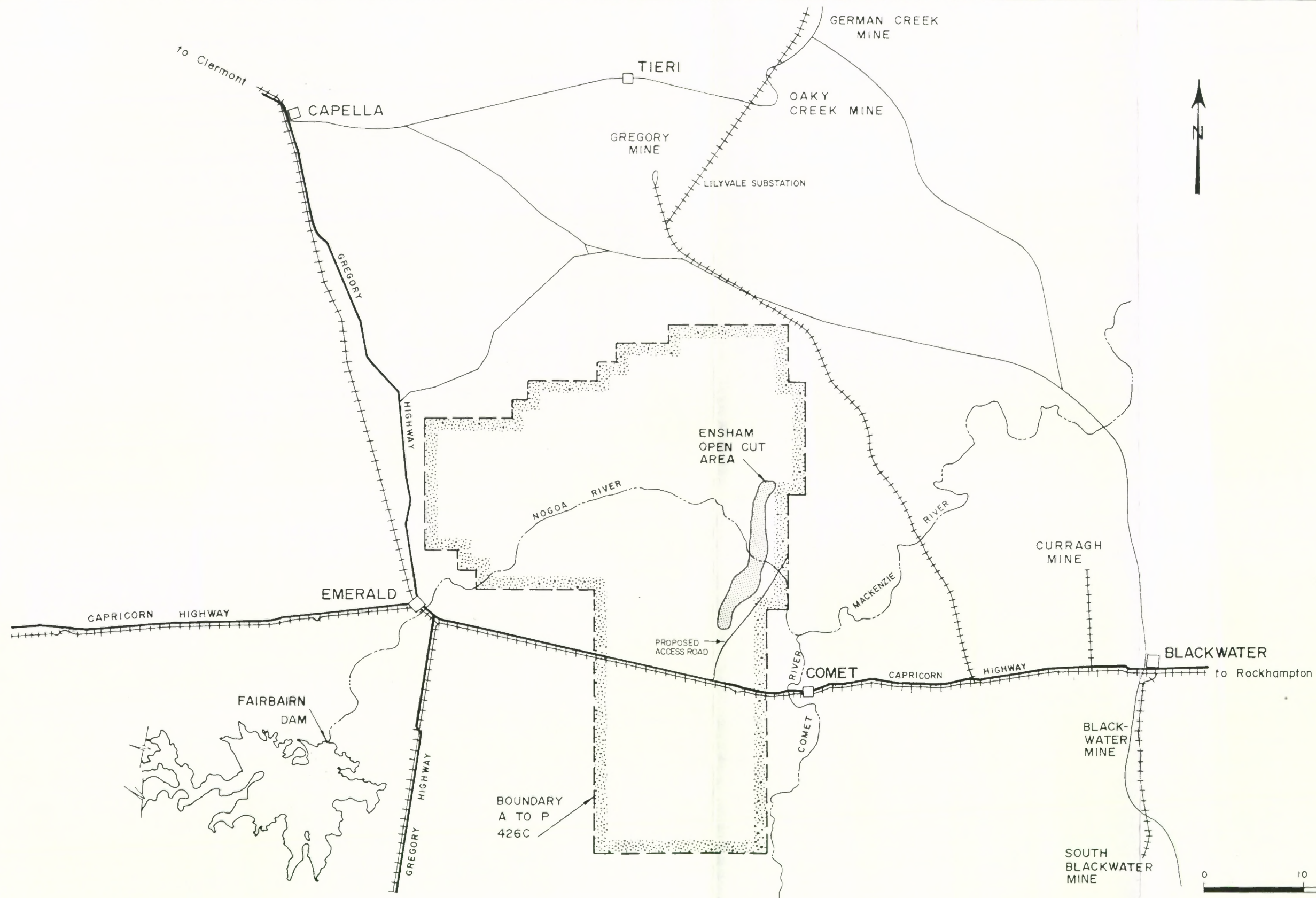
The study was undertaken in accordance with the requirements of the publication of the Premier's Department entitled "Impact Assessment of Development Projects in Queensland", March, 1980. In accordance with the procedures outlined in this publication, the Premier's Department sought the requirements of all relevant government departments and authorities. These requirements were collated into a set of guidelines for the Impact Assessment Study. A copy of these guidelines is presented in Appendix 10.

The then Commonwealth Department of Arts, Heritage and Environment has reviewed the above guidelines and has noted some additional requirements. A copy of these additional requirements is also included in Appendix 10.



ENSHAM COAL PROJECT

 HOLLINGSWORTH DAMES & MOORE			
TITLE REGIONAL LOCATION			
DATE	AUGUST 1988	DRG. APPR'D	<i>Cup</i>
DRG. NO.	2	1	



SCALE 1:400 000

ENSHAM COAL PROJECT

	HOLLINGSWORTH DAMES & MOORE
TITLE	LOCALITY PLAN
DATE JANUARY 1987	DRG APPR'D. <i>cap</i> DRG. NO. 2.2

3.0 THE PROPOSED PROJECT

3.0 THE PROPOSED PROJECT

3.1 General

Authority to Prospect 426C was granted to the Ensham Joint Venture in early 1984. Exploration and evaluation of the Ensham coal deposit by AQC-Pacific were undertaken during 1984 and 1985.

Davy McKee Pacific Pty Ltd was commissioned to carry out the Ensham Coal Project - Mine Area Study. This section of the report is largely based on their Project Report which developed a mine plan for the initial 15 year period at a production rate of 3.6Mtpa of steaming coal.

3.2 Coal Reserves

The coal reserves at Ensham occur within the Late Permian Rangal Coal Measures, the uppermost formation of the Blackwater Group.

The seams considered to be of economic significance are the Aries Castor (A2C, A22C) seams in the central portion of the open cut area and their component seams, the A2, C and C22 seams towards the northern and southern extremities. The overlying Aries 1 seam, although only around 1m thick, may also be recovered, particularly in the north of the open cut area where it is close (+/- 10m), to the underlying A2C seam.

The vast majority of the total in situ open cut reserve (around 82%) is contained within the A2C and A22C seams. These seams are generally 4-6m thick and have been delineated over a strike length of some 10km. Where the seams split into their component seams, the A2 seam, with an average thickness of 2.4m, and the C seam, with an average thickness of 2.5m, are of primary interest and have been included in the open cut mineable resource calculation. The C22 split, which splits from the base of the A2C seam, is important because it is likely to be recovered in the mining of the A2C seam.

All reserves within the Ensham open cut area conform with the measured reserves category as defined in the Australia Code, 1986. These are summarised at Table 3.1. Mineable in situ reserves of 79.28Mt have been calculated based on five open cut pits designed by Davy McKee Pacific. The areas immediately surrounding the Nogoa River and within structural domain D (the highly faulted zone in the southern part of the central area), have been excluded from the mine plan and the mineable reserves calculation.

Table 3.1
Reserve Summary

Mineable In Situ	Recoverable	ROM
79.28	54.52	54.96

3.3 Coal Quality

The Ensham coals are generally classified as medium volatile bituminous. Detailed evaluation has identified a number of possible product options including:

- a raw coal thermal coal (whole seam basis)
- a beneficiated thermal coal (whole seam or top ply A2C/A22C)
- a beneficiated coking coal (bottom ply A2C/A22C)

Beneficiation of the coal on a whole seam basis would produce a high energy, medium to high volatile, moderate ash, low sulphur thermal coal with typical specifications as presented in Table 3.2.

Table 3.2
Typical Thermal Coal Product Specifications

Property	Quantity
Total Moisture	10.0%
Air dried basis	
Moisture	3.3%
Ash	10.0%
Volatile Matter	27.2%
Specific Energy	29.3 MJ/kg
	7000 kcal/kg
Total Sulphur	0.4%
Nitrogen	1.7%
Phosphorous (as P)	0.06%

3.4 Clearing

The surface of the mining area will be cleared of trees or undergrowth prior to mining activities. This will not be a major task since most of the area has already been cleared for grazing and crops.

However, where at all possible, the vegetation will be cleared progressively in advance of the expanding cut to allow for migration of wildlife. The vegetation will be removed and disposed of by controlled burning. The total area to be eventually cleared for the open cut mine, plant areas and access is approximately 3,250ha.

Topsoil removal will be carried out approximately two strips in advance of mining operations. A 35m³ cubic metre open bowl scraper will be used to load, haul and dump the topsoil. Initially, topsoil will be placed in temporary stockpiles until spoilpile reclamation work commences in year 3. At that time, the topsoil will be directly dumped to reclamation areas and the temporary dumps will be removed.

The annual mining schedule and stripping programme is shown on Drawing 3.2 for the initial 15 year mine period.

3.5 Overburden Removal

The overburden consists of alluvium, weathered sediments, Tertiary sediments and Triassic/Permian sediments.

The alluvium is weak material and overlies the stronger Triassic/Permian sediments which will require drilling and blasting. South of the Nogoia River recent alluvium has an average thickness of 16m and a maximum recorded thickness of 25m. The older alluvium at the base is about 10m thick. The alluvium consists of significant vertical sections of loose sand and would be unsuitable to drill through. Hence in this area it is proposed to develop an advanced bench excavation to remove alluvium from the top of the Triassic/Permian strata prior to drilling. North of the Nogoia River the alluvium is less than 5m thick and is considered suitable for direct drilling from the surface to the Triassic/Permian strata.

Depth of weathering of sedimentary material is fairly consistent at about 20m below the surface. Fresh rock therefore occurs a small distance below the base of the alluvium.

The Tertiary sediments form a minor proportion of overburden in the mining area north of the Nogoia River. This material is suitable for stable excavation and drilling once the first few metres are penetrated.

The Triassic/Permian strata consists of interbedded sandstone, siltstone and mudstone, similar to that experienced in other strip mining operations in the Blackwater area. The rock strength is moderately high to high and will require drilling and blasting.

North of the Nogoia River where the alluvium is thin a standard extended bench dragline operation method will be used. South of the Nogoia River an extended bench dragline system will also be used except that a nominal 65m advanced bench will be bulldozed or chop cut onto the previous blasted bench to form the platform for the advancing dragline. This process allows the exposure of the Triassic/Permian strata for drilling and blasting one strip in advance of normal extended bench dragline operations.

Dragline operations will proceed to a digging depth of 55m (including 10m of chop cut) prior to the introduction of prestripping to remove excessive overburden. Dragline operations will be carried out 3 shifts per day, 7 days per week, 363 days per year using a four crew roster system.

Prestripping operations will be introduced to remove overburden in excess of 55m thickness. The main prestripping activities will commence in Year 7 and a 42m³ dipper capacity rope shovel together with four 218 tonne capacity rear dump trucks will be commissioned to assist in this task. Such a fleet will be capable of removing a nominal 5.5Mbm³ of prestrip overburden per year.

Drilling and blasting of most of the prestrip will be required, particularly north of the Nogoia River. In areas of deep alluvium, such as is present on the south side of the Nogoia River, it will be necessary to prestrip in 2 benches, with the upper bench dug unshot to avoid blast hole instability.

3.6 Coal Extraction

Following stripping of the overburden, coal will be excavated using hydraulic face shovels. This method will minimise the generation of coal fines and will enable easy identification of the interface between the upper and lower plies. About 14% of total coal mined will be blasted. This will occur in the southern section where the upper ply is in excess of 2.0m thick. Two coal mining faces will generally operate at any time. The annual throughput of coal will be 1.915Mtpa of new coal for Years 1 to 3, rising from 4.176 to 4.250Mtpa for Years 4 to 15.

3.7 Mobile Equipment

The major items of mobile mining equipment to be used for overburden removal, coal extraction and road construction are given in Table 3.3.

Table 3.3
Major Mining Equipment

Item	Quantity	Typical Description	Size
Draglines			
Dragline	3	B.E. 1570/ Marion 8200	57m ³
Shovels			
Prestripping Shovel	1	Marion 301M	42m ³
Hydraulic Excavator-Coal	2	Hitachi Ex 1800	14m ³

Table 3.3 cont'd
Major Mining Equipment

Item	Quantity	Typical Description	Size
Bulldozers & Scrapers			
Tracked Bulldozer	8	Cat D10N	415kW
Tracked Bulldozer	2	Cat D11N	609kW
Wheeled Bulldozer	2	Cat 988B	280kW
Open Bowl Srafer	3	Cat 657E	35m ³
Trucks			
Rear Dump	4	Dresser 830E	686kW
Bottom Dump	4	Cat 776	649kW
Bottom Dump	4	Cat 784	649kW
Explosives	1	International 1950D	12t
Tip	1	International 1950D	12t
Pump Crew Truck	1	International 1950D	12t
Water Truck 80kl	2	Cat 777B/Hockney	686kW
Water Truck 20kl	2	Mercedes 3233/ Hockney	243kW
Drills			
Overburden Drill	3	Marion M4	311mm
Truck Mounted Drill	1	Gardner Denver Mayhew 1000	5.25inch
Blasthole Dewatering Pump	1	Legra 200	
Blasthole Stemmer & Trailor	1	Mustang	
Loaders & Graders			
Wheeled Loader	1	Dresser 580	15.3m ³
Wheeled Loader	2	Dresser 580	10.5m ³
Cable Carrier	1	Cat 988EB	280kW
Fel/Backhoe	1	JCB 3CX	0.5m ³
Grader	2	Cat 169	205kW
Support Equipment			
Transfer Pump	3	Hanson Sykes HSU4	25 L/sec
Pit Pump	4	Hanson Sykes UVO6HH MV 290S	69 L/sec
Mobile Lighting Plant	11	J & P Richardson	20kW
Fresh Water Trailor	1	Hockney	-

3.8 Rehabilitation

The total area of the mining site and plant site is approximately 3,250ha. Progressive mining down dip will result in extensive disruption of the natural land surface. Overburden removal using draglines will leave a series of peaked ridges aligned along the strike of mining. The surface will then be recontoured similar to the surrounding topography before revegetation can take place. This will be achieved by a combination of regrading by a tracked bulldozer and finished by grader. Topsoil from ongoing highwall operations will be dumped and spread on the regraded surface. Finally seeding and fertilising will be carried out to establish suitable stabilising vegetation. Details of the proposed rehabilitation programme are given in Section 4.8.

3.9 Drainage Control

In order to control in pit groundwater inflow and rainfall, mobile pumping equipment will be employed. However, since the pit water will have a high salinity it will not be discharged to natural water courses. It will be pumped into evaporation ponds located west of the haulroad.

The site proposed for the industrial facilities and the associated coal stockpile and loadout area drains westward to Boggy Creek. The existing drainage paths will be modified by the earthworks proposed and all stormwater runoff will be diverted to either an evaporation pond or the raw water storage dam as shown on Drawing 4.6. The raw water storage will be the main source of process water used in the coal washery as well as supplying water for road watering.

The operation of the mine will necessitate the diversion of Boggy Creek in order to allow mining in the far north of the mine area. The design of the diversion channel will ensure that downstream sediment deposition will not increase and that flood levels will not be affected. Appropriate approvals will be sought from the Queensland Water Resources Commission prior to any creek diversion.

3.10 Raw Coal Handling

A plan of the mine area showing the location of the mine pits, the industrial area and the haul roads is given in Drawing 3.3.

Raw coal from the mining operations will be loaded into bottom dump trucks and hauled to the ROM bins or ROM stockpile located in the industrial area to the east of Boggy Creek. Here the coal will be dumped either directly into the steaming coal feed hopper or onto ROM stockpiles. The dump hopper will have a capacity of 350t.

The raw coal stockpile will be maintained at a nominal capacity of 13,300t. The stockpile has a live capacity of 1,600t live capacity with one stockpile activator and feeder installed. This allows the stockpile to provide about 4 hours of feed to the plant without the assistance of bulldozers. Additional back-up storage capacity is provided by a ROM stockpile of 10,000t.

3.11 Preparation Plant

Details of the flowsheet for coal handling are shown on Drawing 3.4.

The coal preparation plant will be located to the east of the ROM area. Raw coal is extracted from the 50t capacity jig feed surge bin at 340tph by 2 electromagnetic feeders, installed at the upper level of the coal preparation plant. Raw coal discharges from the surge bin feeders into the jig feed chute where it is wetted and slurried with water. The jig is a baum type jig, which is able to separate the high ash reject material. The rejects are transported from the plant to a 300t capacity reject bin by conveyor.

Sieves and screens will be used to dewater and grade the coal into the required size fractions. The largest size fraction (100mm x 40mm) is crushed and transported from the preparation plant. The product from the bottom deck of the classifying screen (40mm x .5mm) is dewatered prior to transportation from the preparation plant. The minus .5mm fraction from the classifying screen underflow is pumped to the classifying cyclone clusters for desliming.

Fine coal (.5mm x .075mm) is collected from the jig module classifying cyclones and beneficiated and dewatered by way of 2 spiral banks. The spirals will provide a separation into clean coal, middlings and reject fractions. Middlings from the spiral separation will be recirculated to the fine coal sample to optimize the spiral separator efficiency. Rejects from the spiral separators gravitate to the rejects dewatering screen for dewatering prior to discharging onto the reject conveyor.

The preparation plant includes a closed water circuit utilizing a thickener to allow separation of the tailings prior to pumping to the tailings dam. Decanted water from the thickener returns to the clarified water tank for reticulation through the plant as process water. Water level in the clarified water tank will be maintained by the addition of water from the raw water storage dam. An average water make-up of approximately 130kL/h to the clarified water tank will be required when the mine is operating at the full production level.

The plant building will consist of an open frame steel structure provided with a roof only. Structural steel and platework will be abrasive blasted and primed with an inorganic zinc rich primer before final coating with a high build epoxy for corrosion protection. Only minor painting maintenance will be required during the plant life. The floors are generally open grid mesh type. The ground floor of the plant is to be kerbed concrete with sloping concrete surfaces to the various floor drainage sumps.

3.12 Product Stockpile and Loading

Steaming coal product will be conveyed from the coal preparation plant to the product coal stockpile. The product stockpiles will be provided to the east of the preparation plant and will have a nominal capacity of 35,000t of coal. The implementation of revised working standards allowing production for the full year minimises the need to maintain large product stocks at the mine.

Stockpiled coal is reclaimed by means of 2 stockpile dischargers used in conjunction with 2 vibrating feeders installed in the reclaim tunnel under the stockpile. Steaming coal product is reclaimed at a rate of 4,500tph by conveyor which raises the coal to the

1,000t capacity rail loading bin. This bin provides adequate capacity for surge during loading.

Train loading is under the control of the operator from a control room overlooking the loading chute. An in-motion rail weighbridge will be used to record the loaded weight of each wagon and provide a weight for the total unit train.

3.13 Waste Disposal

Coarse rejects will be generated by the preparation plant at a rate of 490,000tpa. These will be conveyed to a reject bin, with a capacity of 300t, from which they will be transported by 77t capacity rear dump trucks and transported to the tailings dam where they will be used together with other material to raise the height of the dam wall.

The rejects will be dumped in a specially located rejects dump. When dumping is completed in each section, the rejects will be sealed with compacted spoil, topsoiled and vegetated.

The fine rejects or slimes will be pumped a distance of approximately 1,600m from the thickener to the tailings dam to be located on the southern side of the industrial area. The slimes pipeline will be installed above ground.

The earth fill tailings dam, capable of containing the coal preparation plant slimes for at least 15 years, will be constructed. This will be a fully engineered dam structure designed to meet the requirements of the Queensland Water Resources Commission.

Supernatant water will be decanted and from the dam and returned to the raw water pond for re-use in the coal handling and preparation plant.

3.14 Mine Infrastructure

The mine industrial area will be located approximately 16km north of the Capricorn Highway and 1.8km east of the coal subcrop line, on the eastern side of Boggy Creek. The industrial area will service the mine, coal handling and processing operations. The location of the various facilities is shown on Drawing 3.5 with further details provided below.

3.14.1. Mine Buildings

Administration Building

This will be of steel portal frame construction and will accommodate the senior administrative staff, accounts staff, pay office and computer room.

Car Parks

There will be an 18 vehicle staff carpark in front of the administration building and an award employees carpark with space for 180 vehicles immediately to the south.

Workshop/Warehouse Building

This will be a major, composite structure including:

- Mobile equipment repair bay
- Heavy fitting bay
- Warehouse
- Maintenance staff offices
- Electrical workshop
- Electronics/instrument workshop
- Field fitters workshop
- Bucket repair facility.

The building will be of steel portal frame construction with reinforced concrete floor and overhead travelling crane supports in the mobile equipment workshop.

Mobile Equipment Service Building

This will be a simple open sided building which will include the following facilities.

- One haulage vehicle service bay
- One highway truck service bay
- Tyre repair and storage area
- Battery charging station
- One tyre change bay
- Bulk storage tanks for lubricants
- Office, crib room, store and toilets.

Boilermakers and Bucket Repair Facility

The boilermakers workshop will contain a work area of 260m², serviced by a 5t overhead travelling crane. In addition there will be space for stores, crib room, toilets and welders.

On the southern side of the building a 290m² concrete slab will contain an arch pit and a trunion pit to enable one dragline bucket to be repaired at a time.

Mine Office/Change House/First Aid/Security Building

This complex will be an L shaped portal frame building surrounded by verandahs on 3 sides and will include the following facilities:

- Mine office
- Security gate house
- First aid room, waiting room
- Carport accommodation for ambulance, fire tender and rescue vehicle

- Male and female award change house, staff and visitor change house.

The mine office will accommodate mine supervisor, mine, engineering, survey and geology staff.

Ancillary Buildings and Facilities

The administration office will accommodate the managerial and administrative staff in a portal framed building. An 18 vehicle car park is to be located in front of the building.

A fuel store will be built on the south eastern side of the warehouse stores yard. The tank farm will contain space for two 750kL diesel fuel tanks and space for fuel receiving and pump distribution equipment. It will be surrounded by an earth bund and by a chain wire security fence.

The vehicle wash down area will consist of a sloping concrete slab with swivel mounted hose monitors at each corner. In addition there will be hose outlets for washing light vehicles and a mobile high pressure water cleaner. Effluent water will pass through two silt traps with an oil separator installed between the traps. Wash water will be recirculated and no water will be released from the system.

A high explosives magazine will be located about 2km north of the coal preparation plant. This magazine will be of ten tonne capacity. Provision will be made for a detonator magazine box within the compound which will be surrounded by a security fence. The design will be based upon the requirements of the Coal Mining Act, Rules and Regulations.

Mobile crib facilities will be located at the mine sites north and south of the Nogoa River, at the prestripping operation and at the workplace of the field maintenance areas. Each unit will be able to accommodate up to 24 men and will be fitted with a generator, wash and ablution facilities, fresh water tank, refrigerator and other meal preparation facilities.

3.14.2 Roads

Access Road

An 18.75km access road will be constructed from the Capricorn Highway to the parking areas at the mine site. The surface will be bitumen sealed with 2 x 3m traffic lanes and 2 x 1m paved shoulders and will be built to MRD and NAASRA standards for a speed limit of 100km/h. A channelised T intersection will be constructed at its junction with the Capricorn Highway. A multi-span, prestressed concrete bridge will be constructed across the Nogoa River with a causeway across the secondary channel. The bridge surface will be above the two year flood level.

Haul Road

The mine haul roads will be constructed in accordance with the US Bureau of Mines information circular 875B "Design of Surface Mine Haulage Roads".

The haul road widths are constructed to be compatible with the larger trucks (220t bottom dump coal haulers and 218t and rear dump overburden trucks). Pavement design will be initially based on the use of the smaller trucks used in the first 7 or 8 years of operations (136t bottom dump coal haulers and 77t rear dump overburden trucks).

Access for maintenance of heavy vehicles to the industrial area is provided by the construction of 1.25km of one way road and 0.75km of two way road. Additional sections of haul road will be constructed in Years 2, 3, 4 and 5 to provide access to the production ramps.

When the haul roads are located on the floodplains of the Nogoia River or Boggy Creek, characterised by surface layers of expansive clays, roads will be built above the natural surface with minimal cut. In locations at higher levels than the floodplain, cut-to-fill construction will be employed.

Site Roads

All mine and plant site roads will be constructed to all weather gravel road surface. These roads will include the initial northern highwall access road, access roads to the explosives magazine, the sewerage treatment works and the dragline erection area as well as all internal plant roads. Light vehicle roads in the plant area will have a 6m wide running surface, except for the road running alongside the raw coal overland conveyor which has a 4m wide running surface. Heavy vehicle access roads will be constructed to a standard similar to the haul road.

3.14.3 Water Supply

Based on the estimates given in Table 3.4 water consumption including a recirculation volume of 200ML/year) will be 1,075ML/year. Details of the water supply facilities are shown on Drawing 3.6.

Table 3.4
Mine Water Demand (ML/year)

Use	Quantity (ML/year)
Coal Preparation & Handling	1 000
Road Watering	250
Potable & Fire System Water	25
Sub Total	1 275
Less Recirculation	200
Total Make Up Water	1 075

This water will be drawn from bores adjacent to the Nogoia River under a water right from the Water Resources Commission. A significant, but highly variable amount will be obtainable from runoff in the plant area and from water pumped from the mine excavations. In addition water will be recovered from the tailings dam. For this reason, the plant water supply scheme was designed around the concept of obtaining water from all of the above sources with make-up water provided as necessary from the Nogoia River bores.

Water for treatment as potable quality water will be withdrawn from the raw water rising main to the discharge to the raw water dam. This water will decant to a balancing storage. Water will be pumped from this tank to the water treatment plant where it will be filtered and chlorinated. Treated (potable) water will be pumped to a 700kL capacity tank near the industrial area. Of this storage, 250kL will be reserved in "dead" storage for the fire system water supply.

3.14.4 Sewerage System

A package sewage treatment plant sized for construction and operations will be built early in the construction programme. This plant will discharge effluent into an aeration pond created by constructing a small earth dam. This dam will overflow into the tailings dam.

3.14.5 Power Supply

For construction purposes power will be supplied from an existing Capricornia Electricity Board 22kV transmission line located on the southern edge of the

Nogoa River flood plain. A 6km temporary overhead transmission line will be run to the construction camp and substations.

Permanent electrical supply will be drawn from the Queensland Electricity Commission substation at Lilyvale. From here the Ensham Coal Project will construct a 33km, 66kV transmission line along an easement to a switchyard on the western boundary of the mining lease. The exact route of this line will not be determined until a survey is undertaken to identify the preferred alignment with regard to access, existing uses and other constraints. A conceptual alignment is shown on Drawing 3.8. The mine site reticulation will be at both 66kV and 22kV power. The industrial area will be supplied with 11kV power. Total power demand is estimated at 21.5MW at full production.

3.14.6 Communications

During the construction programme, a single channel VHF radio system, and telephone system will be installed.

In the operational phase, those lines will be used for telex, facsimile, and data transmission lines. The residual lines will be accessible through a 60 extension PABX.

3.15 Railway

The rail spur will be constructed from the mine industrial area to the existing Gregory Mine Railway, a distance of 15km. This railway line connects to the coal port of Clinton from where the product coal will be exported. The approximate route of the rail spur is shown on Drawing 3.9.

Unit trains of 100 wagons each with 71t capacity will be used for the transportation of coal. This will provide a total unit train capacity of 5,400t.

The scope of the railway project and the design criteria and construction standards to be adopted will be determined by the Queensland Railways. The required upgrading of the main line is dependent on the rail traffic utilising the system at the time the project proceeds. Such works will be subject to an agreement with the State Government.

3.16 Port Facilities

The Ensham Coal Mine is located about midway between the coal ports of Gladstone and Dalrymple Bay near Mackay. In order to determine which port was to be used a Transportation Option Study was undertaken. This study considered the port and rail capital and operating costs for both alternatives. It concluded that Clinton was the preferred option.

The common user coal export facility at Clinton is capable of loading vessels greater than 220,000DWT at a loading rate of 4,000tph. The terminal was developed initially to serve the Gregory mine and has been progressively expanded to serve the needs of other mines in the central Queensland area. Up to 14.3Mtpa of coal is currently exported through the terminal. Further expansion to reach 30Mtpa has been planned.

The Gladstone Port Authority have recently extended the berthing facility to allow a second ship to be anchored at berth. This has increased the capacity of the port to the degree where sufficient capacity is available for Ensham Coal. The Authority intends to duplicate the rail loading facility during 1990 and this will increase the onshore throughput capacity to enable Ensham Coal to be accommodated. A further stockpile area may be needed, this being dependent upon tonnage throughout when Ensham commits. A further stockpile area can readily be provided within the time frame.

3.17 Construction Workforce

The construction phase has been scheduled over a 48 month period by which time the second dragline will be commissioned. Manning will be variable reaching a peak of about 400 in month 13 of the construction periods.

The construction workforce will be accommodated in a construction camp to accommodate 250 of the workforce and a caravan park for 80. During the peak construction period additional accommodation units will be hired and a further 70 persons will be accommodated in Emerald. Fixed facilities such as service, kitchen/diner etc. are sized to suit the peak camp accommodation requirement of 400. The camp will be located on site (refer Drawing 3.7) and provide the facilities normally required in a camp of this size. These will include:

- Accommodation units
- Kitchen/diner
- Wet/Dry canteen
- Retail Store
- First aid unit and ambulance
- Camp maintenance workshop
- Recreation room.

The camp will be retained until Year 6 to accommodate the construction workforce for the third dragline, building expansions and haul road development. On completion the camp will be disposed of.

3.18 Operational Workforce

3.18.1. Workforce Size

The operational workforce includes all project employees during the pre-production stage together with production employees. The mine workforce will be variable throughout the mine life mainly because of the addition of the third dragline in Year 4. The total workforce schedule is summarised in Table 3.5.

Manning in Year - 1 will consist mainly of senior staff who will be engaged in the project planning and development stages of the project. In Year 1, the manning build up for the main operation will have commenced. The administration and maintenance facilities will have been constructed and erection of the first dragline will have commenced. Year 1 represents the first full year of mining, at which time the administration and coal preparation workforce will have nearly reached their ultimate levels. The mining and maintenance areas will continue to grow as deferred mining equipment is introduced, mainly for increased overburden removal.

Table 3.5
Mine Operations Workforce Schedule

Project Year	-1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Mining	1	44	82	100	144	144	168	212	205	205	201	206	206	206	206	206
Maintenance	1	64	81	95	113	115	117	129	129	129	129	129	129	129	129	129
Preparation Plant	1	26	28	28	35	35	35	35	35	35	35	35	35	35	35	35
Management	6	23	29	29	31	31	31	31	31	31	31	31	31	31	31	31
Total	9	157	220	252	323	325	351	407	400	400	396	401	401	401	401	401

The mine workforce will be accommodated on a number of subdivisions in Emerald, including a larger fully serviced subdivision to be constructed on the eastern side of the Nogoa River as shown on Drawing 3.11. It is proposed to construct 293 houses which will be a combination of high-set and low-set 3 and 4 bedroom houses. Single worker accommodation in the form of 19 duplex units will also be provided. Further details of the accommodation proposals are given in Section 5.4.

3.18.2 Source of Workforce

It is likely that a small number of unskilled and semi-skilled employees will be recruited from the Emerald district. The remainder will be recruited from elsewhere in Queensland. It is unlikely that many skilled workers will be located at Emerald, although some will be recruited from the construction workforce. The remainder will also be recruited from elsewhere in Queensland. For senior mine management and technical expertise it will be necessary to recruit not only in Queensland but also interstate.

In the current industrial climate of high unemployment and the depressed rural industry, there should be no difficulty in recruiting the required numbers of skilled employees.

3.18.3 Training

In order to maintain a skilled workforce, to promote safety and provide promotional opportunities, an extensive programme of on and off the job training is proposed. Details of this programme are given in Section 5.3.2.

3.19 Town Infrastructure

The town of Emerald, being close to the mine operation, was selected as the dormitory base for the housing of the mine workforce. Emerald has an existing population of 6,200 and is located some 45km from the mine industrial area.

3.19.1 Accommodation and Housing

The operations manning requirements and employment program, anticipates a build up of manpower commencing at 9 in Year -1 to 401 in Year 11 (refer Table 3.5).

To accommodate the imported component of this workforce it is proposed to progressively construct 293 houses to suit three levels of mine workforce. These are the Operations Manager, Second Line Managers and Staff and Wages. The majority of the housing will be provided in detached houses suitable for the modern family. Details of the various housing types proposed are given in Section 5.4.2.

Separate accommodation will also be provided for 76 single employees in duplex type self contained housing. Nineteen duplex units will be constructed for this purpose.

3.19.2 Subdivision

As many workers as possible will be accommodated in available suitably serviced allotments throughout the town. The balance will be accommodated in a separate division. This will be achieved by providing a subdivision of 242 lots, the subdivision of further sites within Emerald and the purchasing of a further 15 lots in Emerald to meet housing requirements.

The following services will be provided in the subdivision:

- Kerb to kerb bitumen surfaced road pavements
- Underground stormwater drainage systems
- Reticulated water and sewerage systems
- Telephone services
- Overhead electricity supply.

The design and construction of the subdivision will be to the requirements of the Emerald Shire Council and will be typical of the many subdivisions constructed in other mining towns in the Bowen basin.

3.19.3 External Works

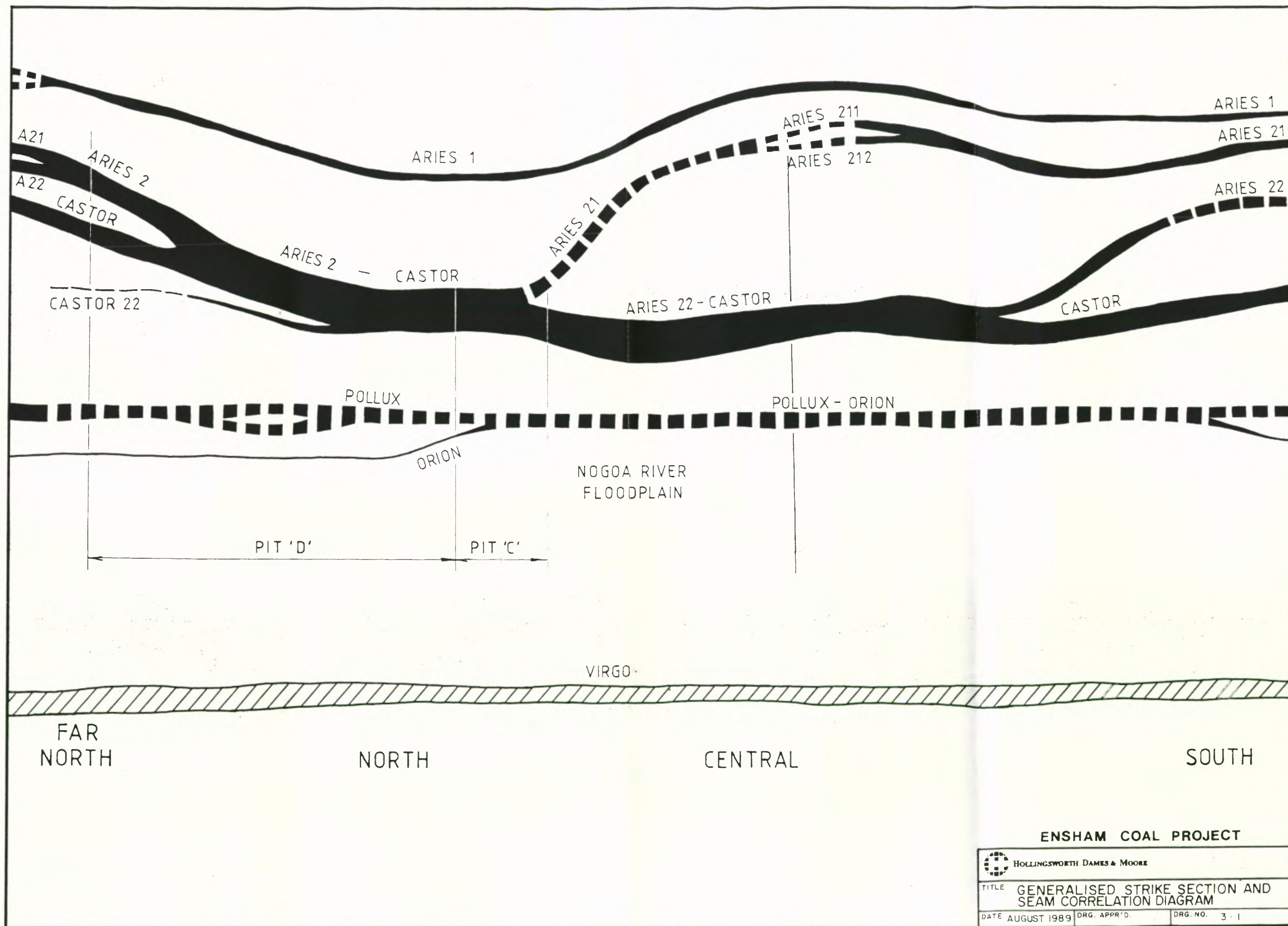
The provision of headworks for the Ensham Coal Project involves the external supply of water and sewerage facilities to the proposed subdivision areas. These works will be constructed in accordance with the requirements of the Emerald Shire Council. Details of the work required are given in Section 5.6.

3.19.4 Domestic Solid Waste Disposal

The town's solid waste disposal area is currently located adjacent the proposed subdivision east of the Nogoa River. Council is planning on relocating this disposal area and will convert the existing dump area into an area for recreational uses.

3.19.5 Community Facilities

Additional recreation and community facilities will be constructed in Emerald to cater for the entry of the Ensham Coal Project population. Details of the town's existing community facilities and the likely effect on them from the Ensham population are given in Section 5.5.



ENSHAM COAL PROJECT



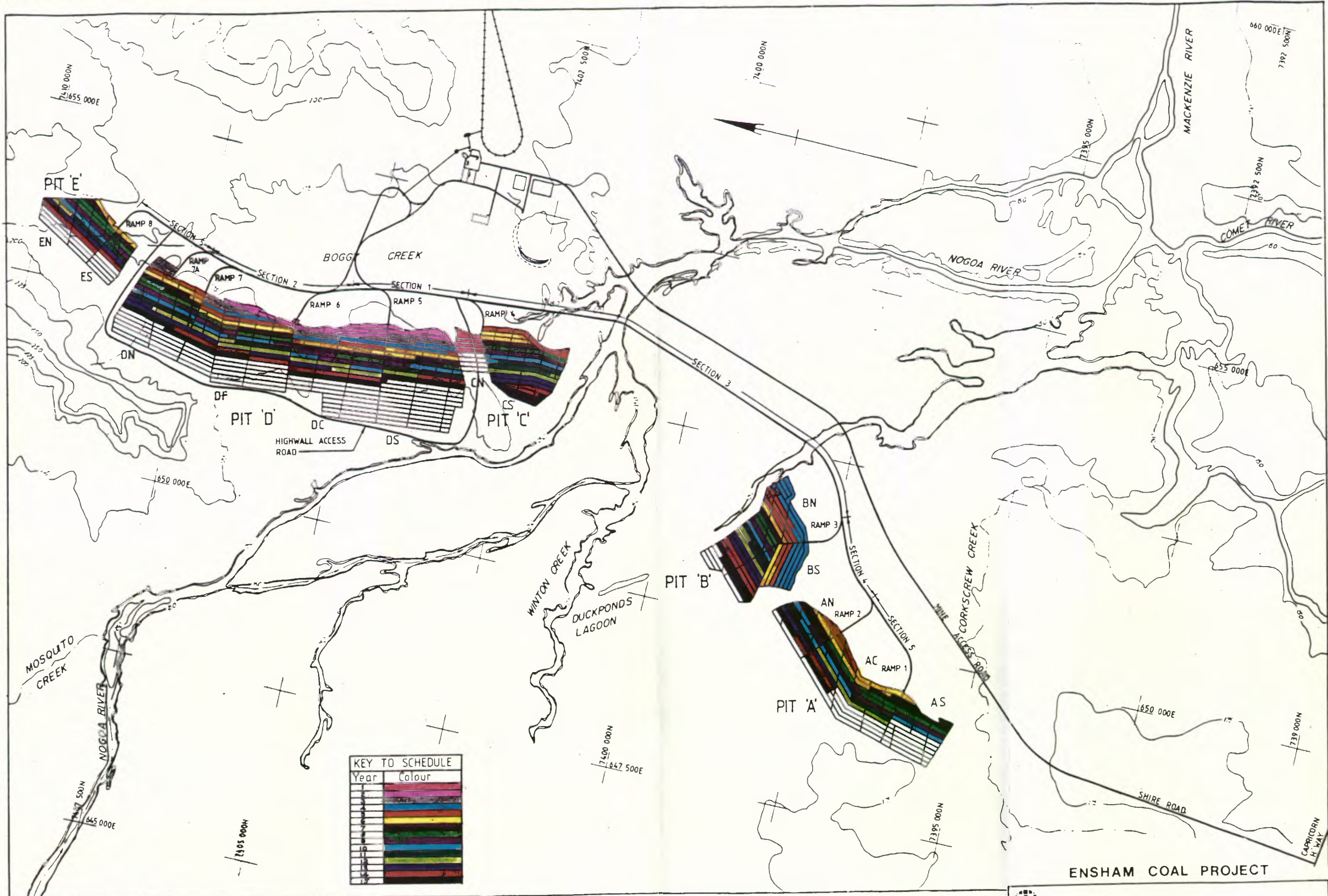
HOLLINGSWORTH DAMES & MOORE

TITLE GENERALISED STRIKE SECTION AND SEAM CORRELATION DIAGRAM

DATE AUGUST 1989

DRG. APPR'D.

DRG. NO. 3.1



ENSHAM COAL PROJECT



HOLLINGSWORTH DAMES & MOORE

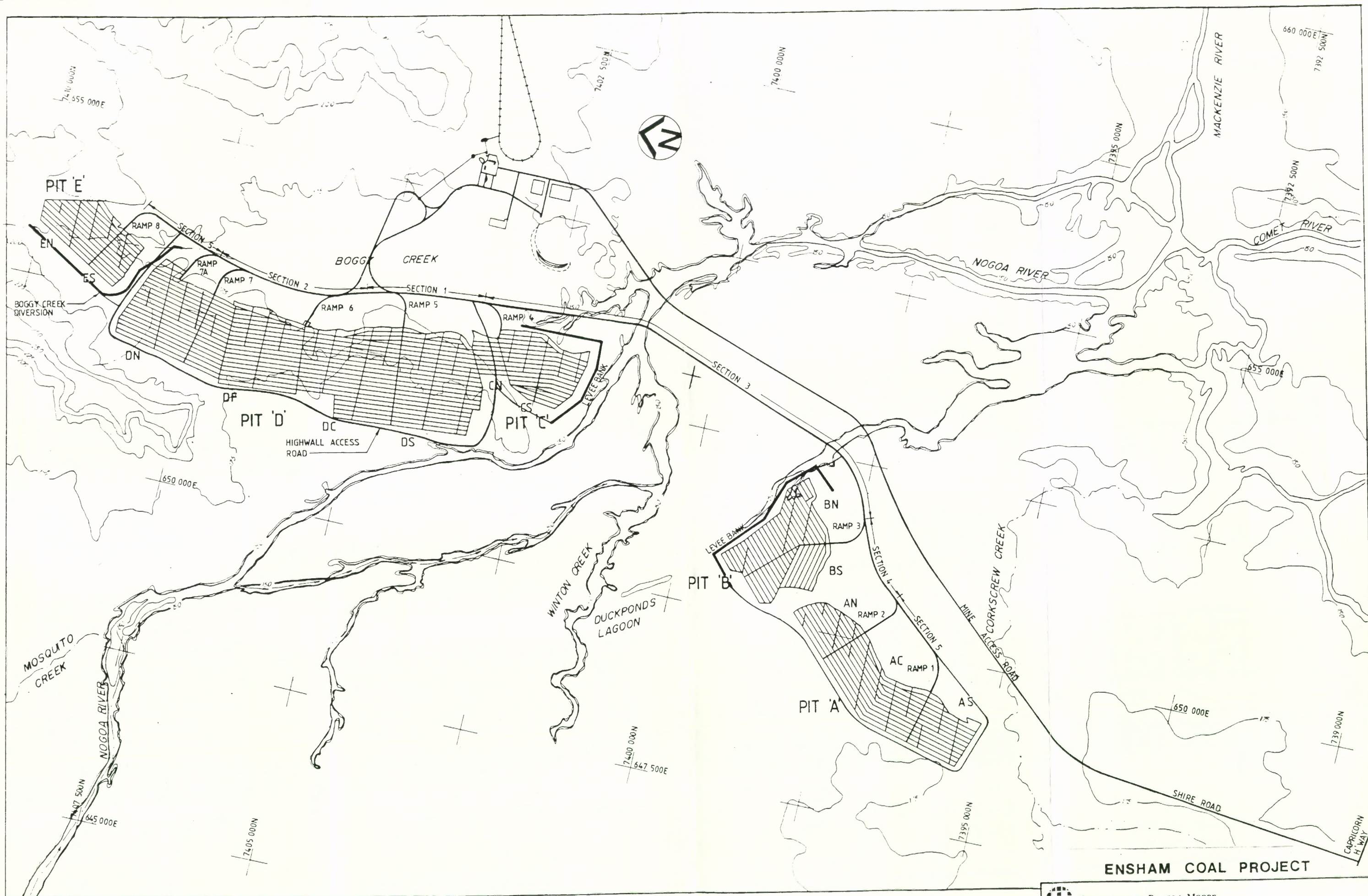
TITLE

ANNUAL STRIPPING SCHEDULE

DATE AUGUST 1989

DRG APPR'D.

DRG. NO. 3.2



SCALE 0 500 1000



HOLLINGSWORTH DAMES & MOORE

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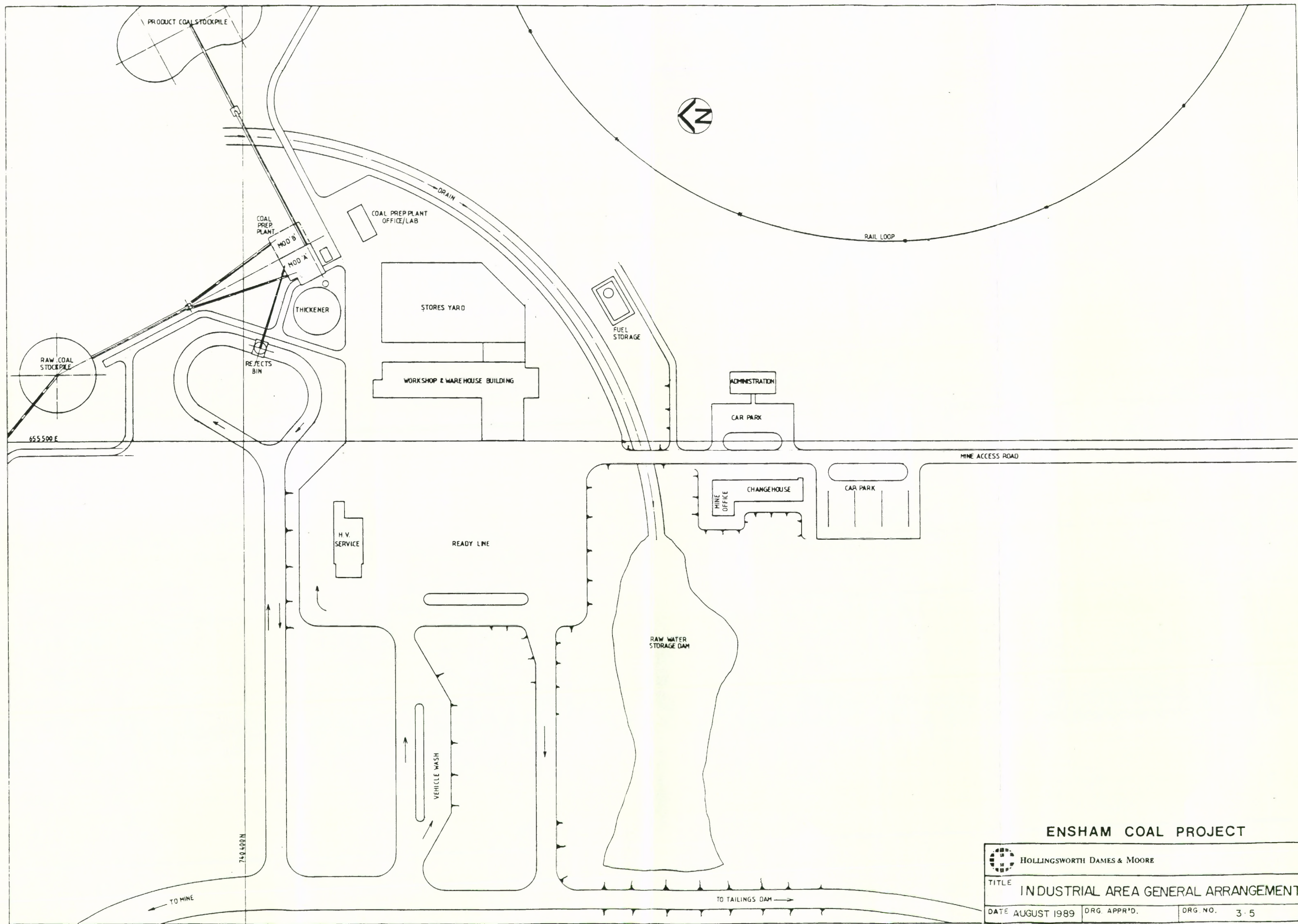
MINE SITE PLAN

DATE AUGUST 1989

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DRG. NO.

3-3



ENSHAM COAL PROJECT



HOLLINGSWORTH DAMES & MOORE

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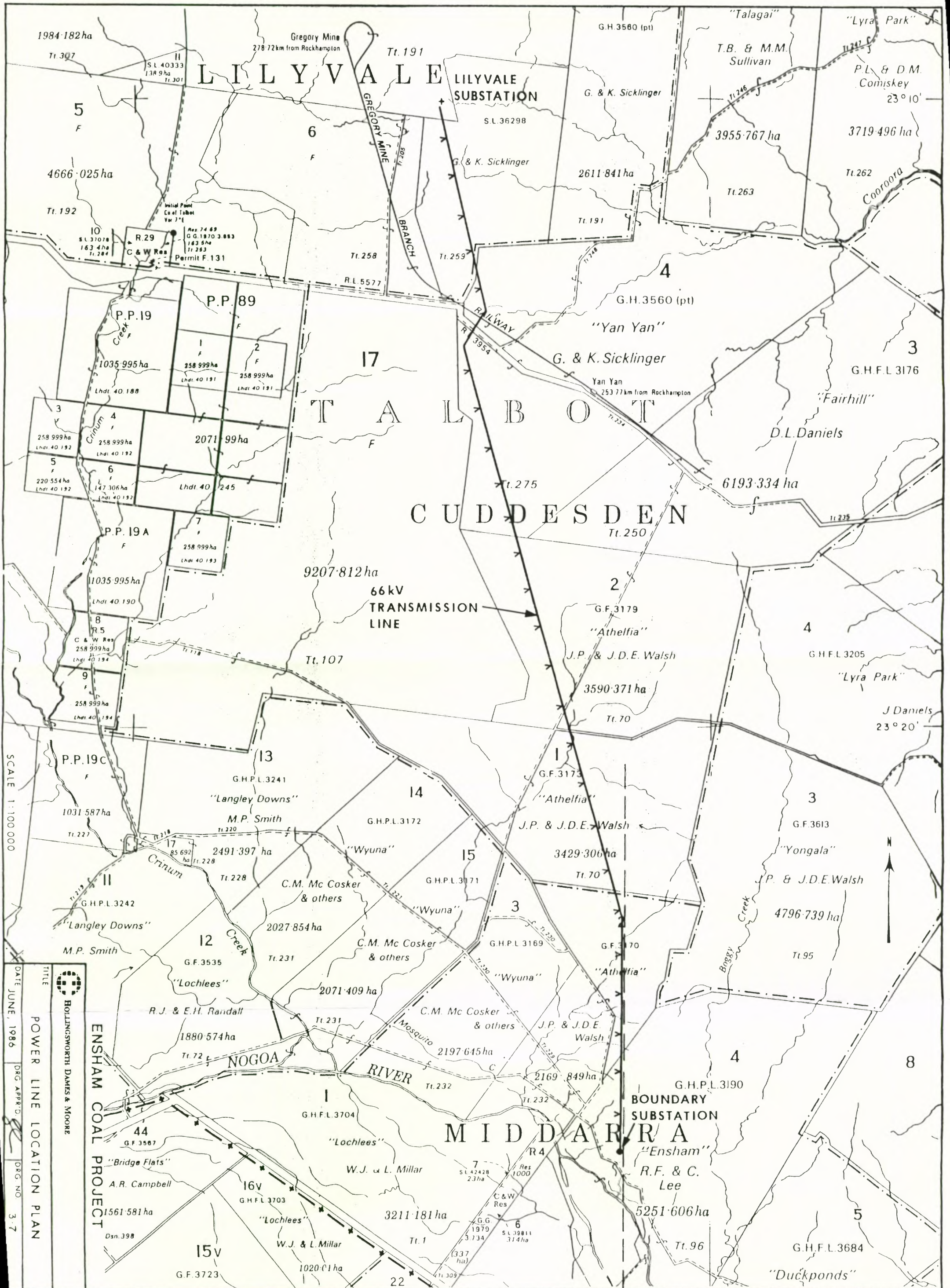
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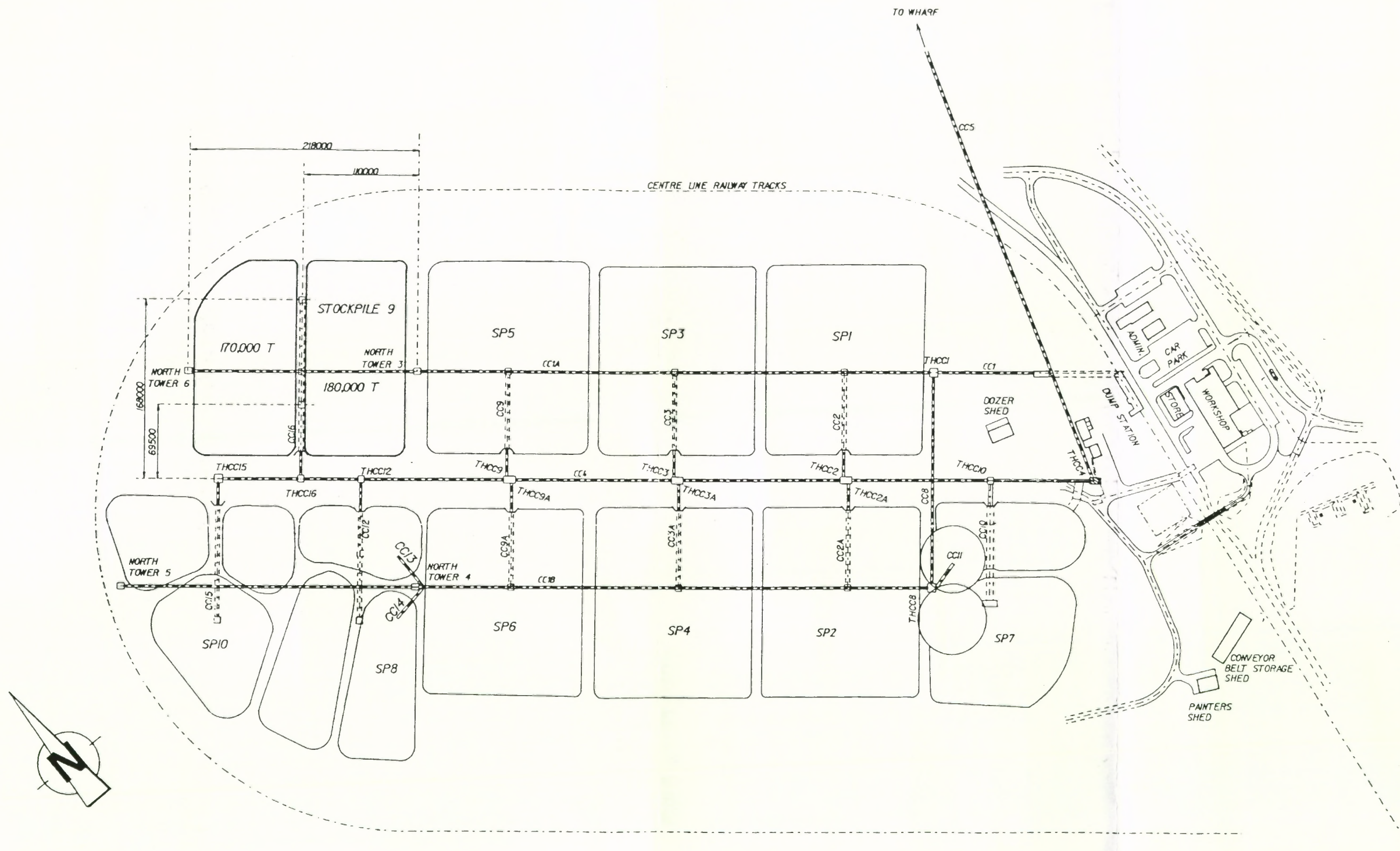
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ENSHAM COAL PROJECT



HOLLINGSWORTH DAMES & MOORE

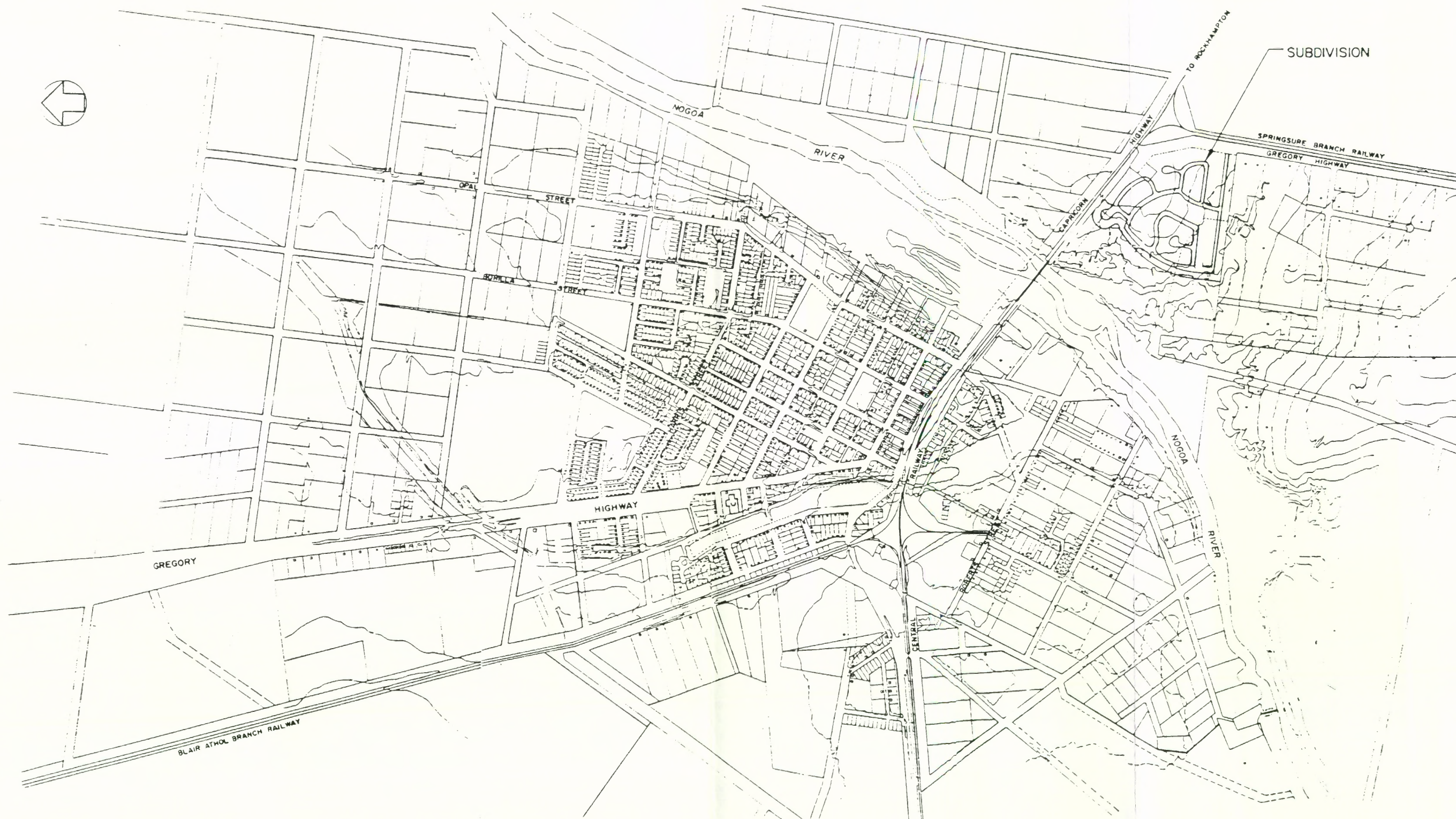
TITLE

CLINTON COAL FACILITY STOCKPILE LAYOUT

DATE AUGUST 1989

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DRG. NO. 3.9



ENSHAM COAL PROJECT



HOLLINGSWORTH DAMES & MOORE

TITLE

EMERALD WORK FORCE ACCOMMODATION PLAN

DATE

JULY 1986

DRG. APPR'D.

DRG. NO.

3-10

4.0 THE NATURAL ENVIRONMENT AND THE EFFECTS OF THE PROJECT

4.0 THE NATURAL ENVIRONMENT AND THE EFFECTS OF THE PROJECT

This section of the report considers the various aspects of the physical environment which are likely to be affected by the project. Such aspects include the natural environmental features such as soil, water and vegetation as well as the atmospheric issues of noise and air quality. Assessment of the soils and vegetation characteristics has been used to form the basis of a rehabilitation strategy for the site. This strategy together with the water quality strategy described in this section have been designed to control the environmental effects of the project to acceptable levels.

4.1 Terrain

4.1.1 Geology

The main geological sequences occurring within the Ensham exploration area include:

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

The coal seams of interest in this study occur in the Rangel Coal Measures; they generally have a low angle dip in a westerly direction and in descending order they comprise the Aries I, Aries II and Castor seams.

The Aries I seams occur as a single seam generally about 0.5m to 1.0m thick throughout the proposed open cut area. The Aries II and Castor seams split and coalesce to a large extent and in the central part of the area they comprise a single seam 4m to 6m thick. It is this seam which is the primary target for open cut mining.

The underlying Pollux and Orion seams in the Rangel Coal Measures and the Virgo seam in the Burngrove Formation are of generally low quality within the area and are not of economic interest at the present time. However the quality of the Pollux seam improves to the north of the proposed mine area.

The stratigraphy can be described as follows:

- Quaternary Alluvium (Qa): comprising the extensive near flat alluvial plains with dark coloured predominantly heavy cracking clay soils.
- Quaternary Colluvial Deposits and Minor Stream Alluvium (Qc): which include out-wash slope/plain deposits and somewhat lighter textured alluvium associated with some of the minor tributary streams.
- Cainozoic Soil Cover (Cz): comprising undulating plains and interfluvies with surficial weathered soils overlying older alluvium, Tertiary sediments or older lithologies.
- Tertiary Sediments (Ta): occurring mainly as dissected plateau remnants comprising lateritised argillaceous quartz sandstone, pebbly sandstone and conglomerate, siltstone or claystone.
- Permian (P-T): due to the visually similar nature of the materials comprising both the Rewan and Blackwater groups of sediments, it was not possible to readily differentiate between them either from airphoto interpretation or from field observations. Accordingly for the purposes of this study they have been mapped as an undifferentiated composite geological mapping unit.

The occurrence and distribution of the major geological regimes within the project area is shown on Drawing 4.1. This drawing also shows each terrain unit identified by a alpha-numeric symbol which provides a composite expression of geology, landform and soil type. A generalised description of this is given in the Terrain Mapping Unit Reference included with the drawing and a more detailed description is provided in Appendix 1.

4.1.2 Topography and Drainage

The Nogoa River flows across the site in a south-easterly direction and essentially divides the site into two approximately equal parts. The terrain in the northern half of the site comprises mainly mildly dissected gently to moderately sloping and undulating lands which form gentle dissection slopes and outwash plains flanking Boggy Creek. Erosion has occurred below the elevated dissected plateau remnants which occur in the northern and north eastern sectors of the study area.

The dissected plateau remnants are mostly bounded by steep scarpments, with slopes in the order of 33% to 66% or more with local relief up to 40m to 50m between plateau crests and adjacent escarpment footslopes.

Some isolated areas of dissected and eroded low hills and plateau remnants, with irregular steep (28% to 33%) and locally benched marginal slopes occur throughout the northern sector, the most prominent of which occurs in the immediate vicinity of the Ensham homestead. A low range of dissected hilly lands on variably weathered Permo-Triassic shales and lithic sandstone occurs about 3km south-east of Ensham.

In the southern half of the site, with the exception of an extensive broad low rise which occurs in the extreme southern sector, the terrain is essentially flat or very gently sloping. It encompasses the extensive floodplain system of the Nogoa River and its major tributaries which traverse the area in a general south-easterly direction contained within a broad alluvial tract about 4km to 5km wide. The general elevation of the floodplain varies (from east to west) across the site from about 150m to 155m AHD and significant areas are liable to periodic flooding.

4.1.3 Soils

The occurrence and distribution of the major soil groups within the study area are shown on Drawing 4.2. A generalised description of each soil mapping unit is given in the map reference. The soils of the area have been arranged in six major groups with a total of sixteen soil types (variants) as shown in Table 4.1.

The following general descriptions of the major soil groups and variants are based on field observations from excavations and creek bank exposures together with the recovery of intact soil cores from a total of 85 locations throughout the site. The (1.5m x 50mm diameter) soil profile cores were obtained by driving a specially designed thin wall sampling tube into the ground using a jackhammer; a tripod and block and tackle were used to extract the tube and soil core from the ground.

A generalised description of each of the major soil groups recognised 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 300mm 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.

In the study area the soils of this group are 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) - Moderately Shallow Gravelly Sands and Loams

The soils of this group comprise uniform or weakly gradational sands, loamy sands or sandy loams with varying amounts of ferruginous and siliceous gravel or stone included. There appears to be little profile development apart from some organic accumulation at the surface and a slight increase in fines with depth in some of the reddish sandy loam soils. Soil fertility and water storage capacity are low in this soil group.

As shown on Table 4.1, two soil variants have been mapped and are described in more detail in Appendix 2.

TABLE 4.1

SOIL TYPES IN THE ENSHAM PROJECT AREA

MAJOR SOIL GROUP	DOMINANT SOIL TYPE			COMMON GROUP NAME	CLASSIFICATION	
	NO.	BRIEF DESCRIPTION	P.P.F.*		U.S.C.**	
Shallow Rocky Soils	1	Shallow uniform mainly, medium and coarse-textured very rocky soils; rock outcrop common.	Skeletal Soils, Lithosols	Um 1, Uc 1.2	GP, GM, GC	
Moderately Shallow Gravelly Sands and Loams	2.1	Mod. shallow uniform or weakly gradational sand to sandy loam over siliceous gravel, gravelly sand or sandy gravels over dense quartz and siliceous gravel.	Lithosol	Uc 1.21	GP-SP, GM, or SP/GM	
	2.2	Mod. shallow to deep gravelly weakly gradational loamy sand to sandy loam over weathered rock, laterite or gravelly colluvium.	Lithosol	Gn 2.11 Um 5.51	GP-SP/ GC-SC	
Gradational Red and Yellow Earths	3.1	Sand over clayey sand soils; gradational sandy red or yellow earth soils.	Sandy Red/Yellow Earth	Gn 1.2	SM/SC	
	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/Yellow Earth	Gn 2.12 Gn 2.13 Gn 4.11	SC-CL/ CL or CL-CH	
Texture Contrast (Duplex) Soils	4.1	Shallow gravelly brown or reddish brown duplex soils with acidic to alkaline med.-heavy clay subsoils over weathered rock.	Solod; Solodic; Solodized Solonetz	Db 3.11 Db 1.13 Dr 2.13	CL-ML/ CH	
	4.2	Mostly deep sandy to loamy surface duplex soils with brown or reddish brown medium clay subsoils.	Solodic	Dr 2.13	CL-ML/ CL-CH	
	4.3	Mod. to deep sandy to loamy surface duplex soils with yellowish brown silty med. clay subsoils.	Solod	Dy 2.11	SC-CL/ CL-CH	
	4.4	Deep mostly thin loamy surface duplex soils with dark brown or dark reddish brown alkaline med, to heavy clay subsoils.	Solodic	Dd 1.13 Dr 2.13	CL-ML/ CH	
Uniform Fine-Textured (Non-Cracking) Soils	5.1	Mod. shallow stony surface, brown, or reddish brown uniform medium to heavy clay soils over weathered rock.	Lithosol Reddish Prairie Soil	Uf 6.11 Uf 6.12	CL-CH or CH	

TABLE 4.1 (Cont'd)

SOIL TYPES IN THE ENSHAM PROJECT AREA

MAJOR SOIL GROUP	DOMINANT SOIL TYPE		COMMON GROUP NAME	CLASSIFICATION	
	NO.	BRIEF DESCRIPTION		P.P.F.	U.S.C.
Uniform Fine Textured (Non-Cracking) Soils	5.2	Mod. deep mostly uniform dark brown silty light to medium clay soils, with some gravelly lenses included; some occurrences of soil type 4.2 are associated.	Alluvial Soils	Uf 6.21 Uf 6.12 Uf 6.32	CL-CH or CL/CL-CH
	5.3	Deep mostly uniform dark brown, reddish brown or brownish black medium to heavy clay soils (incipient cracking clays); Some occurrences of soil type 4.4 may be associated.	Alluvial Soil	Uf 6.32	CH
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 Texture	Ug 5.32	CH
	6.2	Mod. to deep dark brown uniform med. to heavy clay soils on older alluvial materials	Brown Soils of Heavy Texture	Ug 5.34	CH
	6.3	Deep brownish black or dark grey uniform med. to heavy clay soils on alluvium.	Grey/Brown Soils of Heavy Texture	Ug 5.15 Ug 5.25	CH
	6.4	Gilgaied deep grey uniform med. to heavy clay soils.	Grey Soils of Heavy Texture	Ug 5.25 Ug 5.28	CH

* Principal Profile Form (Northcote, 1971)

** Unified Soil Classification (US Dept of Interior, 1968)

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GR:ra/pl
12 August 1986

Soil Group (3) - Gradational Red and Yellow Earths

These soils occur on the elevated and dissected plateau remnants (Ta 3.5, 5.5) on broadly undulating dissected fans and colluvial aprons (Ta 3.3/5) and on some higher (older) alluvial terraces (Cz 2.6) and drainage-ways (Ta 1.4).

As shown on Table 4.1, two soil variants have been mapped based on colour and texture and are described in more detail in Appendix 2.

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

These soils are characterised by a clear or abrupt change in texture between a generally sandy, silty 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 the broad outwash slopes and plains deposits and on alluvium.

Four soil variants have been mapped within the study area and are described in Appendix 2.

Soil Group (5) - Uniform Fine-Textured (Non-Cracking) Soils

The soils of this group have uniform profiles or weakly gradational texture profile in which the clay content increases slightly with depth. They occur on gentle colluvial and pediment slopes below the dissected escarpments, on undulating plain areas associated with the little weathered Permo-Triassic sedimentary rocks, on some intermediate and lower terraces associated with the major stream systems and in a complex association with cracking clays of the extensive alluvial plains.

Three soil types have been mapped in the study area and are described in Appendix 2.

Soil Group (6) - 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 a common feature associated with some occurrences of these soils.

They occur extensively within the study area and on a variety of parent materials including various sedimentary rocks and unconsolidated clays of the Tertiary weathered zone and alluvium.

Four soil types have been mapped within the study area and are described in Appendix 2.

4.1.4 Chemical Properties and Soil Fertility

In order to assess the soil types which could prove useful or hazardous to the land rehabilitation programme proposed, a number of representative profiles covering most of the important soil mapping units were analysed. A summary tabulation of the results of these analyses is given in Appendix 3. The location of the sampling sites is shown on Drawing 4.2. Comments on the nutritional status of soils submitted for testing, together with some general comments relating to soil improvement are given below.

Soil Acidity (pH)

The range of pH values which could be considered reasonable for the proposed rehabilitation with predominantly native grass based vegetation would be between pH 5 to 8*. Outside these values remedial measures are likely to be necessary to correct pH values to an appropriate level.

With the exception of one strongly acidic subsoil sample tested from Soil Type 4.1 and a few of the subsoil samples from the Cracking Clay and Duplex Soil Groups (Soil Types 6.1, 6.2, 6.4 and 4.1) which are strongly alkaline, the bulk of samples tested were in the moderately acidic to moderately alkaline range.

Major Elements (N, P, K)

Levels of nitrogen of 10ppm, phosphorous of 25ppm and potassium of 100ppm to 150ppm, are the limits below which addition of appropriate fertiliser would be necessary to promote normal growth for grass species. All soils tested are deficient in nitrogen and most soils are deficient in phosphorous. In general, indicated levels of potassium are reasonably satisfactory.

Secondary Elements (S, Ca, Mg)

Levels of sulphur of more than 15ppm, calcium 3,000ppm and magnesium over 800ppm, may, under certain circumstances, present toxicity problems for the establishment of some native grass species.

Approximately one half of the profiles tested, in particular in the Cracking Clay Soils Group, had high levels of sulphur in the deeper subsoil layers.

Levels of calcium were satisfactory in most soils although some of the deeper subsoil samples tested, particularly in the cracking clay Soil Group 6 and the incipient cracking clay soils (Soil Type 5.3) had extremely high levels of calcium present. High to very high levels of magnesium were present in all but one of the profiles tested (Soil Type 3.2 - Red Earth). However structural decline of the soil profile layers is only likely to be a problem where there is an imbalance of calcium to magnesium - see comments on Calcium/Magnesium Ratio below.

* pH values determined using a 1:5 0.01M, CaCl_2 soil/solution mix.

Trace Elements (Cu, Zn, Mn, Fe, B, Mo)

With respect to the trace elements generally, most samples were deficient in zinc and to a lesser extent manganese and copper. Iron, boron and molybdenum were mostly adequate.

Organic Matter

All of the surficial soil profile layers tested had acceptable levels of organic matter present. Predictably the deeper subsoil samples in most profiles had low or very low levels (<2%) of organic matter.

Salinity

Soil salinity is a problem when there is an accumulation of soluble salts in the root zone of the plant sufficient to affect normal growth. Salts may occur naturally in the soil, they may be aided by the application of irrigation water, or be brought into the plant root zone by high groundwater tables or by lateral flow of salty water within the soil mass. High levels of salt in the soil restrict the amount of water available for plant growth even though the soil may appear suitably moist. Total soluble salts concentrations of >500ppm with >300ppm of chloride or EC value (electrical conductivity - 1:5 soil/water solution) of >0.4mS/cm indicate salinity levels which may inhibit plant growth. Analysis of the soil test data indicates that a potential salinity problem exists in the Texture Contrast (Duplex) Soil Group and to a large degree with the subsoil and deeper subsoil layers of the Cracking Clay Soil Group.

Cation Exchange Capacity (CEC)

The amounts and relative proportions of exchangeable cations in soils have important effects on both physical and chemical properties. High CEC values indicate a high capacity for soil colloids to absorb or take up nutrients. On the other hand high levels of exchangeable sodium, for example may cause dispersion and increased swelling of soils, so reducing water movements and affecting aeration, whereas exchangeable calcium flocculates colloids and reduces swelling tendencies (Loveday 1974). Excessively high or low values of one or other of the cations may also result in nutritional disorders and plant growth deficiencies. Exchangeable cations are held in the soil on negatively charged surfaces. The total amount that can be held is designated the "cation exchange capacity" and is an indicator of differing clay mineralogy - kaolinite for example has CEC values of <15m-equiv/100g of soil. Illite clay which is often associated with red earth soils has a medium CEC (15 to 30m-equiv/100g soil, whereas smectite (montmorillonite) has CEC values approaching 80 to 120m-equiv/100g of soil.

A majority of the samples tested have medium low to high CEC values.

Exchangeable Sodium Percentage (ESP)

Exchangeable sodium percentage (ESP) is the ratio (expressed as a percentage) of sodium held on the exchange complex to the total exchange capacity of the clay. Soils with ESP in the range 6% to 14% are considered to be sodic and those with ESP of more than 14 are considered strongly sodic. In an agronomic sense, those soil layers with ESP levels in excess of 10% are normally considered likely to produce nutritional disorders and crop yield reductions. High ESP levels also indicate a potential for dispersive soil conditions to exist which could lead to the formation of a surface crust and reduced permeability of the dispersed soil layers, which in turn can give rise to increased run-off and erosion.

Two test procedures have been employed for the determination of ESP. The standard (Quantum - SGS) method for the determination of exchangeable cations, principally involves the use of ammonium acetate as the displacing solution. The calculated values for ESP based on this method are reported in Appendix 3 - ESP Method (2). However for alkaline soils particularly with free carbonate and/or gypsum present, an alternative method (Tucker 1971) using alcoholic ammonium chloride as the displacing solution is considered more reliable. Accordingly, all samples with pH values of 8 or more were tested by the Tucker method as well. The results of these analyses are reported in Appendix 3 - ESP Method (1). More than half the profiles tested indicated the presence of sodic or strongly sodic soil layers. In particular the Cracking Clay Soils Group (6) and the Texture Contrast Soil Group (4) generally appear to be strongly sodic in the deeper subsoils and either sodic or strongly sodic in the topsoil and/or immediate subsoil layers. The shallow red brown uniform fine textured clay soil (Soil Type 5.1) was sodic in the surficial layer and strongly sodic in the subsoil horizon.

Calcium/Magnesium Ratio (Ca/Mg)

The calcium/magnesium ratio (Ca/Mg) is the relative proportion of the exchangeable calcium and magnesium ions. A high magnesium level relative to calcium has been found to accentuate the dispersive effects of exchangeable sodium which may give rise to the development of poor soil structure. In addition an imbalance in the Ca/Mg ratio may affect plant uptake of the nutrient elements. These adverse conditions may occur where the Ca/Mg ratio is less than 2 - particularly if the value falls below 1.

Most of the subsoil and/or deeper samples in Soil Groups 4 and 6 have Ca/Mg values less than 2. The shallow red brown duplex soil (Soil Type 4.1) and the red brown clay soil (Soil Type 5.1) both overlying rock at shallow depth had Ca/Mg values significantly less than 1.

However where adverse soil structure is liable to inhibit plant growth, then the addition of gypsum plus organic matter will produce a productive response in plant growth by improving the ratio of calcium to magnesium as well as displacing some of the high sodium, so improving internal soil drainage and general structure.

4.1.5 Physical Properties

Plant Available Water (Water Storage Capacity)

The available water range of the soil profile is a measure of the soil moisture available for plant growth. The range is the difference between the available soil moisture content at field capacity and wilting point, and is determined by the effective thickness of the soil profile available for plant growth i.e. depth to rock or to levels of high salinity. No testing has been carried out to determine actual values for the soils within the project area. However a subjective indicative assessment based on experience gained with similar soils within the region has been made for the soils occurring in the project area.

With respect to (estimated) water storage capacity, based on field observations and limited physical and chemical characterisation of typical soils, Soil Types 1, 2.1, 2.2 and 3.1 all rate as "low" due to the generally shallow and gravelly to sandy nature of the soils. Soil Type 3.2 would rate as "low to moderate", due to the somewhat variable but generally higher fines content associated with these profiles.

The shallow red-brown duplex soils and shallow red clay soils (Soil Types 4.1 and 5.1) would be "low" due to the generally shallow depth of soil overlying rock and high levels of salinity and sodicity indicated in the reference sample testing. Soil Types 4.2 to 4.4 rate as "low to moderate" due to the generally thin loamy A horizon overlying a very hard, low permeability B horizon, which may also be strongly sodic and saline.

Soil Types 5.2 and 5.3 would rate as "high" as they are relatively deep soils apparently not significantly affected by salinity or sodicity.

Soil Types 6.1 to 6.4, the cracking clays, rate as "moderate to high" due to depth limitations due to rock or the presence of high levels of salinity and/or sodicity at around 450 - 500mm depth.

Particle Size Characteristics (Soil Texture/Structure)

Soil texture and structure are two key factors influencing the use and productivity of soils for agricultural purposes.

Soil Groups 1 to 3 are characterised by sand or loamy sand to sandy loam surface soils often with considerable gravel or sub-grounded stone included in the surficial soil layer. The subsoils vary with increasing thickness and fines content with a corresponding increase of soil group number from gravels in Group 1 through sands in Group 2 to sandy loams to light clays in Group 3.

The duplex soils of Group 4 are characterised by "hardsetting" sometimes gravelly sandy to silt loam surface soils mostly less than 250mm thick overlying "tough" medium to heavy clay subsoils with massive or coarse columnar structure. Soil Groups 5 and 6 are dominated by clay textures throughout the profile with minor amounts of silt and fine sand included.

Soil Erosion Characteristics

All naturally occurring materials erode to some extent when exposed to the erosive forces of wind and water. The extent to which soil erodes depends mainly on its texture and structure, and the overall steepness of the ground surface. The nature of the ground surface cover, particularly good vegetative cover, can limit the susceptibility to erosion.

Water induced erosion is caused by three mechanisms: rain impact on unprotected soil, concentration of running water in terrain depressions, and dispersion of susceptible clays due to percolating groundwater or from surface water ponding.

The forms of erosion which are of concern to clearing and earthworks operations for mine construction sites are sheet erosion, gullying and tunnelling. Sheet erosion is the disappearance of topsoil in a thin layer of widely spread water runoff rilling. 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 Appendix 1, ratings have been assessed which classify the status of erosion both in the natural (present) state and the potential for erosion of soils when exposed and unprotected due to clearing and/or disturbance due to construction activities. The assessments have been made based on air photo and field observations and consideration of the textural properties, permeability and structural stability of the soil profile layers.

The following criteria have been considered 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 is a gravelly or coarse-grained material and 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 long, gentle, smooth, even slopes, generally <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.

- **Rating M - Moderate**

The materials often lack some binding agent particularly in the topsoil layer, but they are mainly stable in the subsoil layers, ie. 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 steep, 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 gully erosion and/or removal of the natural vegetation.

- **Rating H - High**

The surface soils are shallow to moderately deep and essentially fine-grained non-cohesive sandy to silty soils low in organic matter. They may be susceptible to wind and sheet-wash erosion, or the surface soils are cohesive with low infiltration and prone to rapid surface water runoff with consequent moderate to severe erosion, or 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%, mostly >20%.

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 subjective and is included in Appendix 1 to provide a guideline for site planning and development processes.

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 groundwater.

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 the protective topsoil layer is removed or disturbed.

A test procedure has been devised (Emerson, Seedsman, Tech Memo 15) 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 Appendix 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 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.

A total of 80 soil samples were tested by the modified Emerson Crumb Test method. Analysis of the test results indicates that:

- A total of 30 samples showed a tendency for strong dispersion (Class 1M) these were in the subsoil layers of Soil Types 4.2, 4.4 and 6.4.
- 13 samples indicated moderate dispersion (Class 2M) and these samples were restricted to Soil Types (4.1, 4.2, 4.4, 6.3 and 6.4) mainly in the subsoil or deep subsoil layers.
- 20 samples indicated slight to moderate dispersion (Class 3M) most of which included samples from the topsoil horizons covering a wide range of soil types identified including (2.2, 3.2, 4.1, 4.2, 4.4, 5.2, 6.2 and 6.3).
- The remainder were either non-dispersive or only very slightly dispersive.

It is important to note that of the samples tested which proved to be either non-dispersive or only very slightly dispersive, a significant number of those samples exhibited very rapid slaking on immersion in water in the natural airdry moisture condition. In particular Soil Types 4.3, 5.1 and 5.2 which exhibited this phenomenon, were found to be associated with areas of active and intensive sheet and gully erosion, during the field reconnaissance.

Overburden Characteristics

Fully cored boreholes have been drilled by AQC-Pacific as part of the overall exploration programme for the mining project. A limited number of representative samples have been selected for indicative chemical and physical analysis from three of the boreholes, the locations of which are shown on Drawing 4.2.

In general the materials which overlie and separate the coal seams comprise interbedded sequences of sandstone and mudstone of variable thicknesses with relatively thin siltstone interbeds in places. Representative samples of those materials were selected for testing in particular from the core overlying the coal seams, as pyrite development for example, if present, is more likely to be located in the vicinity of the coal seams.

Results of the chemical and physical analyses of the overburden are shown in Appendix 3.

Apart from the generally low nutrient levels of the overburden materials which are to be expected, one of the most consistent adverse features is the generally high to very high levels of exchangeable sodium (sodicity) obtained. Exchangeable sodium has been widely recognised as a dispersive agent for certain clay minerals and can lead to tunnel or gully erosion, loss of soil structure, reduced permeability or surface crusting.

The potentially dispersive nature of some of the overburden materials is further confirmed by the results of the dispersion testing which indicated moderate to strong levels of dispersion in 4 of the 10 samples tested, which included samples of both mudstone and sandstone sequences.

In addition to the generally high levels of sodicity determined, about one half of the samples tested also indicated moderately high levels of salinity in terms of total soluble salts and chloride which have the potential to affect plant growth if in the root zone. A majority of the materials tested exhibited a high magnesium level relative to calcium. An imbalance of magnesium to calcium can accentuate the dispersive effects of exchangeable sodium present, and in addition may affect plant uptake the nutrient elements.

Pyrite spot tests were carried out on each of the overburden samples to identify the presence of pyritic sulphide which is an indicator of potential acid production. The tests indicated virtually no pyritic sulphide was present and hence acid seepage from spoil piles is unlikely to be a problem.

During the mining operation, regular sampling and testing of the overburden will be undertaken to ensure that strata with dispersive properties or other adverse features are placed within the overburden dumps so that they do not form part of or influence the eventual rehabilitated land surface.

Topsoil Availability

As a result of the reconnaissance field survey work undertaken and from consideration of the soil chemical analyses and dispersion tests carried out, a preliminary assessment of topsoil suitability for rehabilitation purposes has been made. Table 4.2 establishes a basis for an evaluation of some physical and chemical properties of the soils for use as topsoil

TABLE 4.2

TOPSOIL SUITABILITY ASSESSMENT

SOIL PROFILE CHARACTERISTICS					SUITABILITY FOR USE AS TOPSOIL**					COMMENTS
Soil Group	No.	Soil Type	Horizon*	Texture/Physical Properties	Salinity Rating(1)	Sodicity Rating(2)	Alkalinity Rating(3)	Dispersion Rating(4)	Overall Rating(5)	
SHALLOW ROCKY SOILS	1	Skeletal Soil (Um1, Ucl.2)	A-C	Shallow rocky soils with sand to sandy loam matrix.	-	-	-	-	U	Mostly skeletal rocky soils associated with rocky outcrops; not tested.
MODERATELY SHALLOW GRAVELLY SANDS AND LOAMS	2.1	Lithosol (Ucl.21)	A	Loamy sand - sandy loam, frequently stony.	-	-	-	-	M-U	Low water storage capacity; not tested.
			A-C	Sandy gravel - coarse rounded to sub-rounded siliceous & ferruginous gravel.	-	-	-	-	U	Low water storage capacity & excessively gravelly; not tested.
	2.2	Lithosol (Gn2.12)	A	Gravelly sandy loam.	1	1	1	2	M	Low water storage capacity. Mod. hard set surface.
			A-C	Gravelly sandy clay loam.	1	1	1	2	M-U	Excessively gravelly in places.
GRADATIONAL RED AND YELLOW EARTH SOILS	3.1	Sandy Yellow Earth (Gn1.2)	A ₁ -A ₂	Light loamy to light clayey sand, low cohesiveness.	-	-	-	-	M	Low water storage capacity; not tested.
			B-C	Clayey sand - sandy clay, massive structure.	-	-	-	-		Low water storage capacity; not tested.
	3.2	Red Earth (Gn2.13)	A	Sandy loam, mod. hard set surface condition.	1	1	1	2	S-M	Discontinuous occurrence within terrain unit Ta3 ³ / ₆ - sparse surface stone; low-mod. water storage capacity.

TABLE 4.2 (Cont'd)

TOPSOIL SUITABILITY ASSESSMENT

SOIL PROFILE CHARACTERISTICS					SUITABILITY FOR USE AS TOPSOIL**					COMMENTS
Soil Group	No.	Soil Type	Horizon*	Texture/Physical Properties	Salinity Rating(1)	Sodicity Rating(2)	Alkalinity Rating(3)	Dispersion Rating(4)	Overall Rating(5)	
GRADATIONAL RED AND YELLOW EARTH SOILS (Cont'd)	3.2	Red Earth (Gn2.13)	B	Gravelly clay with angular quartz & siliceous gravel.	1	1	1	2	S-M	As above; likely to require some added fertiliser; mod. water storage capacity.
TEXTURE CONTRAST (DUPLEX) SOILS	4.1	Solod (Db3.11)	A	Silty loam weak fine-med. blocky structure.	2	3	1	2	U	Discontinuous occurrence within terrain unit P-T3. ⁷ / ₈ .
			B-C	Med. blocky clay, becoming massive with depth; extremely hard dry consistence.	3	3	3	1 ⁽¹⁾	U	(1) Air dry soil aggregates did not disperse but slaked rapidly when immersed in water.
	4.2	Solodic (Dr2.13)	A	Silty clay loam, mod. hard set surface condition.	1	1	1	2	S-M	Low to moderate water storage capacity.
			Bu	Clay, fine to med. blocky structure, very hard dry consistence.	1	3	1	3	M-U	Subsoils are sodic and dispersive.
			Bl	Clay, fine to med. weak blocky to massive structure, very hard dry consistence.	2	3	2	3	U	Salinity & sodicity increasing with depth.
	4.3	Solod (Dy2.11)	A	Sandy loam, massive structure.	-	-	-	-	M	Of minor occurrence; not tested.
			B	Yellow brown silty mod. clay, coarse blocky structure.	-	-	-	1	M-U	Probably strongly sodic in the subsoil layer; not tested.
	4.4	Solodic (Dr2.13)	A	Dark grey silty clay loam, weak surface crusting.	1	1	1	2	S-M	Occurs within terrain unit 2a2.7.

TABLE 4.2 (Cont'd)

TOPSOIL SUITABILITY ASSESSMENT

SOIL PROFILE CHARACTERISTICS					SUITABILITY FOR USE AS TOPSOIL**					COMMENTS
Soil Group	No.	Soil Type	Horizon*	Texture/Physical Properties	Salinity Rating(1)	Sodicity Rating(2)	Alkalinity Rating(3)	Dispersion Rating(4)	Overall Rating(5)	
TEXTURE CONTRAST (DUPLEX) SOILS (Cont'd)	4.4	Solodic (Dr2.13)	Bu	Dark brown clay, weakly developed structure, very hard when dry.	2	2	1	1	M	Increasing salinity/sodicity with depth.
			B1	As above with early carbonate in pockets, tending to massive structure.	2	2	1	1 ⁽¹⁾	M-U	Mod. high salinity & sodicity increasing with depth; (1) did not disperse but air dry soil aggregates slaked very rapidly when wetted.
UNIFORM FINE-TEXTURED (NON-CRACKING) CLAY SOILS	5.1	Reddish Prairie Soil (Uf6.12)	A	Red brown medium clay, fine to medium blocky structure; dense ferruginous gravelly surface cover.	2	2	1	1 ⁽¹⁾	M	Mod. high salinity & sodicity.
			B	Red brown med.-heavy clay with medium blocky structure.	2	3	1	1 ⁽¹⁾	M-U	High salinity & sodicity. (1) Soils aggregates did not disperse but slaked rapidly when wetted.
	5.2	Alluvial Soil (Uf6.21)	A	Dark brown silty clay, fine blocky structure.	1	1	1	1	S	Suitable topsoil source, high water storage capacity.
			Bu	Dark brown medium clay with well developed pedality.	1	1	1	1	S	Suitable topsoil source high water storage capacity.
			B1	Clay as above with less well defined structure.	1	1	1	1 ⁽¹⁾	S-M ⁽²⁾	(1) Air dry soil aggregates did not disperse but slaked rapidly when immersed in water.

TABLE 4.2 (Cont'd)

TOPSOIL SUITABILITY ASSESSMENT

SOIL PROFILE CHARACTERISTICS					SUITABILITY FOR USE AS TOPSOIL**					COMMENTS
Soil Group	No.	Soil Type	Horizon*	Texture/Physical Properties	Salinity Rating(1)	Sodicity Rating(2)	Alkalinity Rating(3)	Dispersion Rating(4)	Overall Rating(5)	
UNIFORM FINE-TEXTURED (NON-CRACKING) CLAY SOILS (Cont'd)	5.2	Alluvial Soil (Uf6.21)	B1							(2) Suitable topsoil source but upper 500mm (A+Bu) constitutes better quality material.
	5.3	Alluvial Soil (Uf6.32)	A	Brownish black silty medium clay with fine to med. blocky structure.	1	1	1	1	S	Suitable topsoil source.
			Bu	Brownish black med. to heavy clay med. blocky structure, extremely hard dry consistence.	1	1	1	1	S	Suitable topsoil source.
			B-C	Dark brown medium clay with earthy carbonate, tending to massive structure, extremely hard dry consistence.	1 ⁽¹⁾	2	1	1 ⁽²⁾	S-M	Suitable for use as topsoil but upper 500-750mm (A+Bu) is preferable material. (1) Salinity increasing with depth. (2) Slaking with very slight dispersion.
CRACKING CLAY SOILS	6.1	Black Earth (Ug5.32)	A	Black med. to heavy clay, nutty to fine blocky structure; very hard dry consistence.	1	1	1	1	S	Suitable topsoil source but not laterally persistent; occurs in association with Soil Type 4.1 which may have deleterious properties for topsoil use.
			B	Dark brown med. to heavy clay with fine to med. blocky structure; extremely hard dry consistence.	2	2	2	1	M	Mod. high salinity & sodicity; strongly alkaline.

TABLE 4.2 (Cont'd)

TOPSOIL SUITABILITY ASSESSMENT

SOIL PROFILE CHARACTERISTICS					SUITABILITY FOR USE AS TOPSOIL,**					COMMENTS
Soil Group	No.	Soil Type	Horizon*	Texture/Physical Properties	Salinity Rating(1)	Sodicity Rating(2)	Alkalinity Rating(3)	Dispersion Rating(4)	Overall Rating(5)	
CRACKING CLAY SOILS (Cont'd)	6.2	Brown Soil of Heavy Texture (Ug5.34)	A	Brown med.-heavy clay, med. blocky structure, some earthy carbonate.	1	2	1	1	S-M	Mod. highly sodic; upper 300mm (A-Bu) appears acceptable as topsoil source; areas of Soil Type 4.4 occur in association with these soils.
			B	Brown heavy clay weak blocky structure, extremely hard dry consistence.	2	3	1	2-3	M-U	Highly sodic & saline; potential structure problems.
			C	Paler brown med.-heavy clay, highly calcareous massive structure, extremely hard dry consistence.	2	3	2	1	M-U	Highly sodic & saline.
	6.3	Grey Soil of Heavy Texture (Ug5.25)	A	Grey brown, med.-heavy clay fine to med. blocky structure.	1	2	1	1	S	Self mulching surficial soil layer; mod. sodicity but upper 300-400mm probably acceptable as topsoil source.
			Bu	Dark brown med.-heavy clay, medium blocky becoming massive structure with depth.	2	3	1	2-3	M-U	High salinity & sodicity; mod. strongly dispersive.
			Bl	Brown med.-heavy clay, massive structure; extremely stiff in the just moist condition.	2	3	1	3	M-U	High salinity & sodicity strongly dispersive.
	6.4	Grey Soil of Heavy Texture (Ug5.25) (in gilgai depression)	A	Grey-brown heavy clay, coarse blocky structure, extremely stiff to hard in just moist condition.	1	1	1	1	S	Upper 300mm (approx) would constitute a reasonable topsoil source.

TABLE 4.2 (Cont'd)

TOPSOIL SUITABILITY ASSESSMENT

SOIL PROFILE CHARACTERISTICS					SUITABILITY FOR USE AS TOPSOIL**					COMMENTS
Soil Group	No.	Soil Type	Horizon*	Texture/Physical Properties	Salinity Rating(1)	Sodicity Rating(2)	Alkalinity Rating(3)	Dispersion Rating(4)	Overall Rating(5)	
CRACKING CLAY SOILS (Cont'd)	6.4	Grey Soil of Heavy Texture (Ug5.25) (in gilgai depression)	Bu	Brownish grey heavy clay, weak blocky to massive structure; extremely stiff to hard in the just moist state.	1	2 ⁽¹⁾	1	2-3	S-M	(1) Increasing sodicity with depth; mod. - strong dispersion.
			B1	Brown mottled sandy med. heavy clay, massive structure.	1-2	3	1	3	M-U	Mod.-high salinity, high sodicity, strongly dispersive.
	6.4	Grey Soil of Heavy Texture (Ug5.28) (on mound adjacent to gilgai depression)	A	Dark grey-brown med. -heavy clay with med. blocky structure and thin self-mulching topsoil.	1	1	1	1	S	Upper 200-400mm is suitable as a topsoil source.
			Bu	Grey heavy clay, med. blocky structure, extremely hard dry consistence, earthy carbonate included.	1	2	2	1 ⁽¹⁾	M	Mod. sodicity & highly alkaline. (1) did not disperse but air dry aggregates slake when wetted.
			B1	Grey med.-heavy clay, massive structure, extremely stiff in the just moist condition.	2	2	2	1 ⁽¹⁾	M-U	Mod. to high salinity increasing sodicity with depth; highly alkaline. (1) did not disperse but air dry aggregates slake when wetted.

TABLE 4.2 (Cont'd)

TOPSOIL SUITABILITY ASSESSMENTNOTES:-

** Topsoil suitability assessment based on field observations and soil chemical/physical test data given in Appendix 3.

Horizon *

- A - Topsoil horizon
- B - B horizon (generally about 200-500mm+ thick)
- Bu - Upper B horizon (with 600mm of the surface)
- Bl - Lower B horizon (>600mm below the surface)
- C - Parent material, weathered rock.

(1) Salinity Rating (E.C. - 1:5, soi/water solution)

- Rating 1 - E.C. <0.40mS/cm - low to non-saline (chloride (Cl) <300ppm).
- Rating 2 - E.C. 0.40-2.0mS/cm - med. to high salinity.
- Rating 3 - E.C. >2.0mS/cm - Very high salinity.

(2) Sodicity Rating

- Rating 1 - Non Sodic, ESP <6%
- Rating 2 - Sodic, ESP 6-14%
- Rating 3 - Strongly sodic, ESP >14%

(3) Acidity/Alkalinity Rating (pH:- 1:5, 0-01m CaCl₂)

- Rating 1 - Mod. acid to alkaline (pH5.1-8.6).
- Rating 2 - Strongly alkaline (pH>8.0).
- Rating 3 - Strongly acidic (pH≤5).

(4) Dispersion Rating (Emerson Tech. Memo 15)

- Rating 1 - Non-dispersive or very slight dispersion (Class 4/7m).
- Rating 2 - Slightly to mod. dispersive (Class 3m).
- Rating 3 - Strongly dispersive (Class 1, 2m).

(5) Overall Suitability rating

- U - Unsuitable for use as topsoil.
- M - Marginal for use as topsoil.
- S - Satisfactory for use as a topsoil.

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replacement for rehabilitation purposes, and provides a preliminary evaluation of the soils which occur within the project area.

In summary the following general comments can be made with respect to topsoil suitability and availability. However a more detailed assessment will be undertaken in the rehabilitation studies proposed during the initial mining phase.

- The most suitable sources of topsoil for rehabilitation works, in terms of soil properties and extent of occurrence, have been identified within the Soil Mapping Units 5.2, 5.3 together with the upper soil horizons of Mapping Units 6.3 and 6.4.
- The surficial soil layers (250mm to 400mm approx.) of Soil Types 6.1 and 6.2 also appear to be suitable in terms of soil physical and chemical properties, but these soils occur intermingled with the Duplex Soil Types 4.1 and 4.4 respectively, which are of lesser quality and in places are unsuitable for use as topsoil.
- The surficial soil horizons of Soil Types 4.2 and 4.4 generally appear to be satisfactory for topsoil use, the deeper subsoils are however excessively sodic and/or saline. Soil Type 4.3 is of minor occurrence and from visual assessment appears to be of limited value as a topsoil source.
- The Red Earth Soil Type 3.2 is acceptable in terms of physical and chemical properties. However this soil type occurs in association and intermingled with Soil Type 2.1 within Terrain Unit Ta 3.3/5 and more detailed soil mapping would be necessary to differentiate the two soil types.
- Soil Types 1, 2.1, 2.2 and 3.1 are not considered suitable for use as topsoil due to their predominantly coarse texture, stoniness and low water storage capacity.

Land Capability Assessment

Land capability classes have been evaluated for each terrain mapping unit. The capability classes are essentially those defined by the US Department of Agriculture (Klingebiel 1961) and recommended by the Queensland Department of Primary Industry (Rosser et al 1974). The classification contains eight classes based on decreasing adaptability and freedom of choice of land uses. They are explained in Appendix 4.

The classification is normally recorded as a formula indicating various limiting factors present and the degree of limitations attributable to each factor. Fourteen subclasses (limiting factors) are considered and these are described in Appendix 4.

The above classification relates only to dryland agricultural land use. However in view of the existing areas of irrigated land and the presumed potential for further exploitation of the water resources of the Nogoa River system, an assessment of land capability under irrigation has also

been made. Classification for land capability under irrigation requires consideration of somewhat different parameters to those considered for dry land agriculture. The system of land suitability classification proposed for the Emerald irrigation area (McDonald 1986) has been adopted. However this has been modified through consideration of some additional and alternative parameters determined for the land capability classification for the Burdekin River irrigation area.

The basis for the classification adopted which follows a similar format to that of the dry land classification (Rosser et al 1974) is also described in Appendix 4.

The land capability class ratings for both dry land and irrigated land use, based on an assessment of limiting factors, is included with the terrain unit descriptions in Appendix 1.

Drawing 4.3 shows the distribution of land capability classes for dry land agriculture within the project area.

4.1.6 Possible Erosion Effects

Existing Erosion

Appendix 1 provides an assessment of the existing erosion status and the potential for accelerated erosion to occur due to changes to the existing physical environment as a result of the proposed mining/construction activities. Despite the generally flat to gently undulating nature of much of the terrain within the study area, soil erosion in many places is already in a well advanced state.

In particular the areas designated as mapping units Qc 2.6, Qc 5.6 and Cz 2.7/8 and to a slightly lesser extent units Qa 1.6, T-P 2.6, T-P 3.7/8 and T-P 5.6 all exhibit moderate to severe incidence of existing sheet and/or gully erosion. This is due to a combination of factors including drainage/surface runoff conditions, soil physical and chemical properties, clearing activities, and general drought conditions which have prevailed over past years.

Topography

The open cut mining process will alter the topography of the area. The overburden spoil heaps will appear as a series of ridges of unconsolidated soil and rock on what was previously a generally flat to gently undulating landform. Following the progressive rehabilitation of the mining areas, the spoil heaps will be recontoured to present a stable and more undulating landform.

Some localised topographical changes will be created by the construction of the rail loop and the haul roads. In attempting to achieve a balance between cut and fill, some gullies will be filled and some cuts will be made through low hills and rises. However given the essentially low relief of the existing landform, the extent of such earthworks will not be significant.

Clearing

Much of the area to be mined or used for spoil dump sites has previously been cleared and is presently under grazing or cultivation for improved pasture. Accordingly, vegetation clearing operations prior to mining will generally be limited and not likely to cause a significant environmental impact.

Where such clearing is necessary, it will, if possible, be carried out progressively immediately prior to each phase of operation. Every effort will be made to retain some form of crop or grass cover as long as practicable prior to stripping the topsoil layer. Uncontrolled surface water run-off from cultivated surface soils areas and from some of the cracking clay soil areas with self mulching topsoils may give rise to increased sediment load in the stream systems and sheet or rill erosion. As described in Section 4.1.7, adequate measures will be taken to ensure that excessive erosion does not occur.

4.1.7 Erosion Control Measures

The control of erosion and sediment movement throughout the mining area will be necessary both during the construction stage and subsequently during the operating life of the mine. Where access is required for temporary use only, disturbed areas will be lightly ripped and revegetated and restored to a stable condition as soon as possible following the completion of construction. Particular attention will be paid to those areas which contain dispersive soils.

Where access or development is required for a permanent use, the following measures will assist in reducing erosion and sediment movement from disturbed areas.

General Measures

Disturbance of topsoil and vegetation along access routes will be limited to the minimum practicable. Use of selective clearing techniques which cause a minimum of disturbance to surface conditions will be employed where practicable.

On certain sites, diversion channels may be required to control runoff and so reduce the erosion hazard. This will apply above significant areas of disturbance which are exposed to runoff from land upslope.

The outlets of diversion channels and culverts may erode and could require protection. This may be provided by encouraging vegetative growth at these outlets. The outlets will be formed to a broad dish shape before seeding, to minimise the concentration of runoff. Where necessary, rip-rap will be provided at outlets to dissipate the force of water and so reduce erosion.

Service and Access Tracks

Service roads will be graded to a crown and provided with efficient surface drainage to prevent runoff eroding them or adjacent land. All table drains will be stabilised. Where they occur they will be reshaped to a broad dish shaped, seeded and fertilised, to prevent erosion.

In the event that the surficial cracking clay materials are to be used for access road or embankment construction, strict compaction control will be ensured and stabilisation of the surface layers may be necessary to reduce the potential for erosion and tunnelling. The deep subsoil layers (>400mm-600mm) within Soil Groups 4, 5 and 6 may have high levels of exchangeable sodium and may be susceptible to dispersion and erosion. Such soils will not be used on the surface of embankments or in other exposed areas without adequate compaction control or other appropriate surface treatment.

All temporary construction tracks and associated disturbed areas will be ripped, seeded and fertilised when construction is completed. On steep slopes the seeded areas will be protected.

Borrow Pits

For any locations proposed as borrow sources, control of soil erosion on these sites will be introduced to minimise sediment movement onto adjacent land or into streams. The following erosion control management procedures are recommended.

Prior to significant site disturbance, drainage works will be installed to control both external runoff entering the site and the water draining from it. Runoff from land above the site will be diverted around it. This runoff may be intercepted by banks and directed at non-erosive velocity to a safe disposal area, such as grassed waterway, or a pipe can be used to collect it and carry it through the site. Where the catchment above the site is large, stormwater retarding basins may be required to augment these measures.

One or more banks will be located below the site to collect stormwater from it and direct it into a sedimentation basin.

Once borrow pits are established, the following techniques are proposed where necessary as part of on-going site management:

- Disturbance will be restricted to a minimum area consistent with efficient operation of the site.
- Excavation will be designed to minimise the accumulation of water in stagnant pools.
- Banks or channels will be located below areas yielding excessive runoff. These structures will collect the runoff before it erodes bare areas downslope.

- As a first step in stabilisation of part or all of a site, large pieces of debris will be removed. If metal or other inorganic debris is to be buried on-site, it will have a cover of at least 600mm of soil.
- Cut batters which have been created by the excavation will be formed to a stable grade and revegetated. Stabilised chutes or pipe drops may be required to carry water safely down these embankments.

Tailings Dam

The location of the proposed tailings dam mainly encompasses terrain units Qc 2.6 and Qc 5.6 (Soil Types 5.2 and 4.3 respectively). In this area locally intensive gully erosion is occurring. This feature may also suggest that the soils could be somewhat dispersive.

In relation to the water tightness of the foundation of the ponded area, the presence of dispersive soils is not necessarily a bad feature, in that the dispersed clay fraction may tend to clog any soil voids thereby decreasing the overall permeability of the substrate soils. However the presence of dispersive materials within or beneath the tailings dam wall could give rise to piping failures in the dam structure.

Adequate site investigation and soil testing will be undertaken to ensure the long term stability of the tailings dam structure.

Water Storage Dam

The location of the proposed raw water storage dam is mainly within terrain unit P-T 37/8 (Soil Types 4.1 intermingled with 6.1). Preliminary testing of these soil profiles indicated a moderately high ESP and salinity levels for Soil Type 6.1 and a very high ESP and salinity level for Soil Type 4.1. High to very high levels of exchangeable sodium may predispose such soils to dispersion and comments relating to the water tightness of the tailings dam substrate and construction of the containment structure also apply here.

The apparent high salinity and shallow nature of the surficial soils overlying weathered bedrock may have the effect of slightly increasing the salinity of the stored water. This is unlikely to be of any significant consequence.

Boggy Creek Diversion

The proposed diversion of Boggy Creek will be constructed mainly within Terrain Units Cz 2.6 and Cz 2.7 (Soil Types 4.2 and 4.4 respectively). They comprise variably deep clayey older alluvial and slope wash deposits overlying weathered Tertiary sediments or older rock lithologies at variable depths, possibly in the order of 3m-6m or more below the natural surface.

The surficial soils (1m-2m approximately) are likely to include some moderately to highly dispersive soil layers and as such would be

The surficial soils (1m-2m approximately) are likely to include some moderately to highly dispersive soil layers and as such would be considered to constitute potentially erodible soils when exposed and unprotected, and subjected to erosive flood flows. Accordingly the low flow (1.5m/s max.) wide single channel grassed waterway proposed (Munro Johnson & Associates 1986) is appropriate to minimise scouring and erosion for the anticipated flood/flow conditions. Further geotechnical investigation of the proposed diversion channel alignment to define substrate soil/rock characteristics will be undertaken, prior to finalising the channel and bank design. An appropriate bank stabilisation scheme and vegetation planting programme will also be developed.

4.2 Climate

4.2.1 Regional Climate

The region has a sub-tropical sub-humid climate with distinct seasonal patterns in rainfall, humidity and temperature variability. The months of December to March inclusive are the wettest period of the year, receiving some 60% of the annual average rainfall. A typical yearly pattern is of hot wet summers and cool winters with one very dry period around August and September.

4.2.2 Daily and Seasonal Statistics

The nearest weather recording station to the mining lease application area with a significant recording period is at Emerald. Rainfall data only are available from Comet, which is about 10km to the south-east of the area.

The relevant climatic data for the Emerald recording station are summarised in Table 4.3 together with rainfall data from the Comet station.

The temperature data on a monthly basis indicates that the average daily range of maxima is 22.6°C to 34.6°C and the average daily range of minima is 7.0°C to 21.3°C. The hottest period is from November to February with average daily maximum in excess of 33°C. It is not uncommon for temperatures to reach 40°C during the day in these months. The coldest period is during the winter months of June to August when the average daily minimum is in the range 7.0°C to 8.4°C. Frosts may occur during these colder months.

Most of the rainfall occurs during January and February. Average rainfall recorded at Comet during this two month period exceeds 200mm with an average of 11 rain days. Thunderstorms are also more prevalent during these warmer months. The sporadic nature of sometimes high intensity thunderstorms and rain of cyclonic origin means runoff may be quite high as well as producing large year to year variability in rainfall and rain days. The driest period is during August with an average rainfall of 17mm recorded and an average of 2 rain days during this month. The yearly average rainfall is 588mm with an average of 39 rain days per year.

Rainfall probability tables for Emerald are also given in Table 4.3. These give an indication of the higher and lower rainfall probabilities for each month on a one and two month period. The estimated evaporation rate exceeds rainfall for

TABLE 4.3

CLIMATIC AVERAGES - EMERALD

		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Temperature (°C)	Daily Maximum	34.2	33.2	32.0	29.6	25.9	22.8	22.6	24.9	28.3	31.7	33.8	34.6	-
	Daily Minimum	21.3	21.1	19.6	15.6	11.4	8.4	7.0	8.1	11.9	16.1	19.0	20.7	-
Rainfall (mm)	Mean	108	101	71	35	33	34	27	21	24	37	58	89	638
	Median	93	76	56	19	23	21	15	11	10	30	49	79	606
Raindays (no.)	Mean	8	8	6	4	3	3	3	3	3	5	6	7	59
Relative Humidity (%)	9 a.m.	65	69	68	63	63	67	65	59	54	54	56	59	
	3 p.m.	41	46	44	40	41	42	39	33	30	31	32	35	
Cloudy Days	Mean	9	8	8	4	5	5	4	4	3	3	4	6	
* Evaporation (mm)		236.3	190.4	184.5	151.3	124.0	99.2	108.8	139.0	183.2	235.1	254.0	266.1	2171.9
Wind Direction (dominant direction)	9 a.m.	NE-E	NE-SE	E-S	E-S	SE	SE-S	SE-S	SE-S	NE-SE	NE-SE	NE-SE	NE-SE	
	3 p.m.	NE-SE	NE-SE	E-S	E-S	SE-S	SE-S	SE-S	SE-SW	NE-S	NE-SE	NE-SE	NE-SE	

RAINFALL DATA - COMET

Rainfall (mm)	Mean	111	93	60	32	29	29	26	17	21	34	56	80	588
	Median	93	63	44	16	18	19	15	8	11	26	51	68	577
Raindays (no.)	Mean	6	5	4	2	2	2	2	2	2	3	4	5	39

RAINFALL EXPECTATIONS FOR EMERALD (mm)

For the one month period shown.	Maximum Fall in driest 10% of records.	18	12	6	0	0	0	0	0	0	1	6	15	
For the one month period shown.	Minimum Fall in wettest 10% of records.	209	220	152	89	86	93	78	60	73	91	121	188	
For a two month period starting in the month shown.	Maximum Fall in driest 10% of records.	73	47	16	4	9	2	4	3	8	23	44	89	
For a two month period starting in the month shown.	Minimum Fall in wettest 10% of records.	374	332	208	149	138	139	117	110	145	179	266	367	

Source: Bureau of Meteorology

all months of the year. Evaporation exceeds 200mm per month during the period October to January and is lowest during the winter month of June (99mm).

The yearly average pan evaporation rate recorded using a Class A pan is 2,172mm with estimated yearly evaporation of an open water surface of about 2,100mm.

On a yearly basis, humidity reaches its lowest average value during the dryer months of September, October and November with the highest values recorded in February and March.

The direction of the morning winds at Emerald is predominantly north-east to south-east during summer (September to February) tending to be more easterly and south-easterly during winter. Afternoon wind directions are very similar to those of the mornings. Wind speed is generally between 1km/hr and 5km/hr. Wind speeds tend to be strongest in the late winter early summer period.

4.2.3 Special Climatic Conditions

Cyclones

Tropical cyclones influence weather along the Mackay coast on the average once every two years, and any of these cyclones which cross the coast, although they lose much of their destructive intensity, can effect the central highlands with heavy rain.

The period when tropical cyclones are most likely to occur is from December to April, with February and March the more common months. In more recent times cyclones David in 1976 and Althea in 1971, degenerated into rain depressions which resulted in significant flooding in the Central Highlands area. In general though the area is too far west to be regularly adversely affected by tropical cyclones.

Flooding

Following heavy rain, severe flooding is possible in the region, causing traffic dislocations, stock losses and damage to property. Flood records from the St. Aubins recording station, located 5km south of the proposed lease application area where the confluence of the Nogoia and Comet Rivers form the MacKenzie River, reveal that for the 85 year period up to 1960, there were 27 occasions when the flood height of 13.7m (R.L 146.4) was exceeded, the highest being 23.1m (R.L 155.8) in 1916.

However, in more recent times construction of weirs on the Nogoia, Mackenzie and Comet Rivers and in particular the construction of the Fairbairn Dam on the Nogoia River about 17km upstream of Emerald in 1974, appears to have lessened the extent of flooding in the region. A stream flow/flood height relationship analysis of stream flow data for 1966-67 to 1984-85 from recording stations at the Selma Weir (30km upstream of the proposed lease application area on the Nogoia River) and

Drought

It is difficult to give an exact definition of drought as so many factors are involved apart from the failure of seasonal rains, e.g. antecedent weather (especially sub-soil moisture), soil type, the natural resistance of pastures or crops to dry conditions, land management practices etc.

The most obvious guide to the existence of a drought is the low seasonal or annual rainfall total. Annual rainfall totals at Emerald from 1880 to 1984 have been analysed to indicate the frequency of droughts in the past. Short term droughts will not necessarily show up in such an analysis as the absence of rainfall for several months at a critical period in the development of pastures or crops may be masked by heavy falls at other times of the year. Again, frequent light falls which may not assist plant life or increase water supplies to any great extent may add up to an apparently satisfactory total.

However, for extensive, severe droughts, low annual rainfall totals do provide a satisfactory guide. A study of records for the region shows that the following periods of obvious rainfall deficiency at Emerald, 1883 to 1885, 1888, 1892, 1900 to 1903, 1915, 1919, 1926, 1930 to 1932, 1948, 1957, 1965, 1979 and 1982 were all occasions of severe and damaging drought.

Annual rainfall levels of around 400mm or less are generally considered to represent extremely dry conditions, and two or more years with annual rainfall figures around this level and below 500mm per annum is likely to represent drought conditions. An analysis of 75 years of rainfall records from Emerald revealed that 7 years out of the total 75 years had annual rainfall levels less than 400mm while 21 years had total yearly falls less than 500mm.

Dust Storms

Bureau of Meteorology records for Emerald reveal that there were five days between 1957 and 1984 when dust storms were recorded; March 1959, October 1961, February 1962, January 1964 and December 1983. It is expected that dust storms are likely to occur during the driest and windiest periods of the year. Another major influencing factor would be the existence of bare and disturbed ground, and this is likely to occur during dry periods but also when fields are being prepared for the summer and winter crops.

Comparison of the dust storm occurrences and general climatic data for Emerald indicates that these dust storms have not necessarily occurred during either the generally driest or windiest time of the year. However a closer analysis of rainfall data for Emerald reveals that the periods when the dust storms were recorded coincided with unseasonally dry months. Consequently, although dust storms are not expected to be a major occurrence in the area, they may occur during particularly dry periods and at times when it is windy and there are open expanses of disturbed ground.

Frosts

Mean minimum temperatures in the region range from about 7°C in July to about 21.3°C in January. Although day temperatures are relatively high throughout the winter, under prevailing clear skies and stable anti cyclonic conditions of that season, radiational cooling at night is intense, and frosts can be expected throughout the area.

Climatic data for Emerald shows that screen temperatures as low as 2.3°C have occurred as early as May and as late as September at Emerald. As surface temperatures are likely to be several degrees lower than the screen values, the frost risk period for the region is about 5 months, although such low temperatures before June and after August are rare. The period between the average dates of the first and last occurrence with temperatures below 2.3°C is 8 weeks at Emerald (June 21 to August 11).

Between June and August frosts can be expected on average from 3 to 6 days in June and August and from 6 to 9 days in July. July is distinctly the coldest month. Screen temperatures below 0°C can be interpreted generally as an indication of widespread severe frosts. These occur mainly in July but can also be expected in June and August. Frosts are naturally most frequent and severe where the surrounding topography favours the accumulation of cold air within surface depressions.

4.3 Surface Water

4.3.1 Existing Drainage Pattern

The project area lies within the Nogoa River catchment in Central Queensland. The majority of runoff in this catchment is ponded behind the Fairbairn Dam which was completed in 1972 and has a storage capacity of 1.44 million megalitres. The dam supplies water to the Emerald Irrigation Area via distribution channels and releases down the Nogoa River channel. Flow down the Nogoa is "on demand" by the downstream irrigators. Within the 60km between the Fairbairn Dam and the Ensham site are three weirs - the Selma, Town and McCosker, which are located approximately 17km, 31km and 33km downstream of Fairbairn Dam respectively. Details of the drainage system are shown on Drawing 4.4.

Creeks which join the Nogoa River from the north between Emerald and the Ensham site are the Retreat and Bekong Creeks. Boggy Creek joins the Nogoa just to the east of the proposed mine pit.

To the south lies a small catchment associated with Winton Creek which joins the Nogoa within the proposed mine area. Drains from the Emerald Irrigation Area deliver "tail water" to Winton Creek and from there to the Nogoa River. Approximately 10km to the east of the proposed mine site the Comet River joins the Nogoa and the combined flow becomes the Mackenzie River. The Bedford and Bingegang weirs are located on the Mackenzie River 140km and 200km downstream of Fairbairn Dam. Releases from the dam supplement these weirs when required.

4.3.2 Existing Flow Volumes

The Nogoia River downstream of Emerald flows through a broad floodplain. Several small streams including Winton Creek traverse the floodplain. During larger flood events flows break out of the Nogoia River and a series of flood channels develop which link the Nogoia River to Winton Creek. As the flow increases the entire floodplain becomes covered with water. This floodplain reduces to a reasonably confined channel downstream of the mine site.

Since 1972, flow within the Nogoia River upstream of the confluence with Retreat and Bekong Creeks has mainly been controlled by releases from Fairbairn Dam. During the wet season when flows from tributaries supply all requirements, no releases are made from the dam. As part of the Ensham Project investigations a hydrological study to develop flood frequency curves for each of the streams was carried out (Munro Johnson & Associates, 1986).

The adopted peak discharges for the flood frequency curves for each catchment are given in Table 4.4

Table 4.4
Adopted Peak Discharges (m³/s)

Annual Exceedence Probability (%)	Nogoia R (mine site)	Winton Ck	Boggy Ck
50	810	110	83
20	2370	320	240
10	3970	520	390
5	5970	770	580
2	8900	1150	680
1	12060	1580	790
0.1	15150	2050	960
PMF*	21750	--	--

**Probable Maximum Flood*

4.3.3 Flood Characteristics

Munro Johnson & Associates (1986) has undertaken hydraulic modelling of the Nogoia River and Boggy and Winton Creeks to identify their flood flow characteristics. The results of this analysis are as follows.

Nogoa River

The analysis showed that bankfull flow in the Nogoa River was around $3000\text{m}^3/\text{s}$ (around a 10% Annual Exceedance Probability (AEP) event). As flows increased beyond this level breakouts of the river occurred up to approximately $5,000\text{m}^3/\text{s}$ where full floodplain flow was considered to occur.

The "floodplain" model was then used to calculate water surface profiles for flows from $7,000\text{m}^3/\text{s}$ to $30,000\text{m}^3/\text{s}$ (5% AEP to 1% AEP and the Probable Maximum Flood (PMF)). It concluded that the increase in flood level for a large increase in flow is relatively small. This is because the floodplain has a large flood storage volume, and the increase in flood volume between say 1% AEP flow and PMF flow results in only a small increase in flood level.

Boggy Creek

Boggy Creek like most creeks, consists of a fairly well defined main channel with sufficient capacity to handle the more frequent flood flows and a substantial floodplain over which excess flows pass. The main channel of Boggy Creek is quite steep, particularly in the upper reaches, with an average bed slope in the order of 1 in 180.

The creek flows intermittently in response to storms over the catchment and is therefore subject to "flash" floods which typically rise quickly and have a short duration. Because of the steep bed slope, it is expected that flow velocities would be high.

The analysis has indicated maximum average flow velocities in the order of $3\text{m}/\text{s}$. Flood flows are generally well confined and the 1% AEP event generally spreads no further than 500m from the channel.

Winton Creek

Winton Creek is the most significant of the many flow channels traversing the southern floodplain of the Nogoa River in the vicinity of the proposed mine site. Unlike Boggy Creek, Winton Creek has a moderate bed slope (around 1 in 2500) and has a relatively small main channel capacity. Winton Creek joins the Nogoa River just upstream of the confluence with the major anabranch. Because of the flat bed slope of the creek, extensive flooding occurs as a result of backwater effects in the Nogoa River. The bankfull capacity of Winton Creek has been estimated at around $500\text{m}^3/\text{s}$ (approximately a 10% AEP event).

The available survey data shows that the bed invert of Winton Creek is some 2m above the invert of the Nogoa River. This difference in level means that upstream flood levels in Winton Creek are not influenced by levels in the Nogoa River.

4.3.4 Surface Water Quality

The existing surface water quality of the river system has been assessed on data obtained from a number of sources. These include historical data from the Water Resources Commission (WRC) and from project water sampling programmes. The latter have included grab sampling in 1986. Four storm event samplers were installed - three rising stage samplers upstream of the mine area, one each on the Nogoa River and on Boggy and Winton Creeks, and one rising and falling stage sampler downstream of the mine area on the Nogoa River. Details of these data sources are provided in Table 4.5 and the locations of the flood samplers are given on Drawing 4.5.

Table 4.5
Sources of Data - Surface Water Quality Information

Drainage System	Location	Sampling Time	Sampling Technique	Sampling Body
Nogoa River	Fairbairn Dam Outlet	1971-85	Grab Samples	WRC
Nogoa River	U/S Selma Weir	1965-80	Grab Samples	WRC
Theresa Creek	Valeria	1972-85	Grab Samples	WRC
Nogoa River and Winton Creek	Ensham Mine Site	1984	Grab Samples	AQC Pacific Pty Ltd
Nogoa River and Local Tributaries	Ensham Mine	1986	RSS* & FSS*	Hollingsworth Dames & Moore

*RSS = Rising Stage Flood Sampler

*FSS = Falling Stage Flood Sampler

Results of the analyses of the samples from the above data sources are given in Appendix 5. A brief interpretation of these results is given below.

Nogoa River - Fairbairn Dam and Selma Weir

Fifty five samples have been analysed from the Fairbairn Dam outlet. The water can be classified as low salinity (average 163mg/L) dissolved ions neutral water which has low levels of suspended solids (average 22mg/L). Levels of major, minor and trace elements were low. Water would generally be regarded as suitable for the irrigation of all crops, stock and domestic use.

Selma Weir is located 17km downstream of Fairbairn Dam and has a storage capacity of 1,180Ml. Results from the 11 water samples taken show water of similar quality to that of Fairbairn Dam. This would be expected.

Theresa Creek - Valeria Gauging Station

Forty four samples have been analysed for this drainage system. The results are more variable than the Nogoa River because of the absence of any large storages within the catchment. Water has lower dissolved ions and higher suspended solids during high flow periods with water quality deteriorating and suspended solids load decreasing as flow drops away.

Water quality varies from being suitable for irrigation of all crops, domestic and stock use to being suitable for irrigation of all but low salt tolerant crops, suitable for domestic use subject to certain conditions and all stock.

Nogoa River and Winton Creek - Ensham Mine Site Grab Samples

Samples were from the Nogoa River and Winton Creek. The waters were of low salinity (138mg/L to 205mg/L) and slightly alkaline with low levels of suspended material (44mg/L to 68mg/L).

Nogoa River - Ensham Mine Flood Samples (February 1986)

Waters were low in dissolved solids (184mg/L to 226mg/L) and suspended matter (1mg/L to 108mg/L). All samples were slightly alkaline. All major, minor and trace elements were low in concentration or below detection limit.

This water was thought to have been "backup" from the flooding Comet River to the south. The low level of suspended solids and the lack of samples from the upstream site (No. 2) would support this conclusion.

Ensham Mine Site - Flood Samples (March 1986)

- **Nogoa River**

Dissolved matter was low varying between 88mg/L and 156mg/L. Suspended material was high varying between 1,330mg/L and 12,500mg/L. Peaks of 12,000mg/L were recorded at both Sites 1 and 2

during the rising stages of the flood. The peak in suspended load would be expected to correspond approximately with the flood wave peak. During the falling stages of the flood, levels of suspended load fell to about 2,500mg/L.

Levels of N and P and minor trace elements were all low in concentration or below the detection limit. With the exception of suspended load, this water would be suitable for all purposes.

- **Boggy Creek**

The only sample obtained had a dissolved matter concentration of 55mg/L and a suspended sediment load of 15,800mg/L. Fe with a concentration of 12.8mg/L was the only ion which had a concentration which was not low or below detection limits with the exception of suspended load and dissolved iron, this water would be suitable for all purposes.

- **Winton Creek**

Dissolved ion levels were low (64mg/L) with moderate suspended solids levels of 630mg/L from the only sample taken. Fe levels were high at 2.94mg/L. With the exception of Fe and suspended solids, this water would be suitable for all purposes.

4.3.5 Current Usage of Surface Water

The Nogoa River from Fairbairn Dam to the Comet River junction is within the Emerald Irrigation Area (refer Drawing 4.4) and withdrawals from the river are regulated under the Water Act. Within the regulated area, water supply is guaranteed, water metres are installed, and water used is paid for. Between the Comet confluence and the Bingegang Weir, water supply is unregulated. Here waterworks licenses limit the amount of irrigation area for each landholder. Water supply is not guaranteed and not paid for. Water consumption and use on these drainage systems is summarised in Table 4.6.

4.3.6 Industrial Area Waste Water Management Systems

The general philosophy of water management for the project is to reuse as much water as possible on site and to minimise losses of surface water to the external environment. One of the main advantages of the chosen location for the industrial area is that all surface drainage can be diverted to settling ponds and eventually to a raw water balancing dam adjacent the ROM haul road loop. Waste water which cannot be readily reused is allowed to evaporate in storage ponds.

Site drainage of this area is shown on Drawing 4.6.

Table 4.6
Annual Surface Water Consumption and Use (ML)

Location	Irrigation	Stock & Domestic	Urban	Industrial	Total
Fairbairn Dam to Mine Site	12,200	160	4,300	1,885	18,545
Mine Site to Nogoa/Comet Confluence	5,000				5,000
Nogoa/Comet Confluence to Bingegang Weir	8,360 ^a	<i>b</i>			8,360
Bedford Weir					11437 ^c
Bingegang Weir					10257 ^c
Total					53 599

- a It has been assumed that the grain and fodder crops grown require 5ML/ha/yr for the 1,672ha approved by water works license.*
- b Pumping for stock and domestic use will occur because of the small quantities consumed it has been ignored.*
- c Allocations are mainly to mining companies for mine water use and urban use in towns servicing the mines. These towns include Blackwater, Bluff, Tieri, Dysart and Middlemount.*

Surface Runoff Water

A raw water storage dam will be constructed downstream of the industrial area. This raw water dam will hold all reclaimed water, plus all infrastructure coal plant area runoff. The design provides for a side channel spillway for overflow to Boggy Creek. The dam volume at full supply level will be 110ML, however the live storage capacity will be 80ML. The full supply level will be RL172.5m with a 0.9m freeboard for retention of rainfall runoff. Live storage is sufficient for one month's demand.

Runoff water from the product coal stockpile area, coal loadout area and the northern side of the infrastructure area will be detained initially in the siltation dam. This dam will allow for coal fines from these areas to settle

out prior to the runoff being discharged to the raw water dam. This siltation dam will be designed with a low level/low volume discharge to ensure that it empties after each storm event to provide efficient capacity to retain the water from follow-up storms. It will be regularly cleaned of settle fines to ensure that adequate storage and settling capacity is available.

The siltation dam will discharge to a drainage channel which, with the additional of runoff from the industrial area, the raw coal handling area, and the wash plant, will flow to the raw water pond. Supernatant water from the tailings dam will also be pumped to the raw water dam.

The coarse reject dump will be surrounded by a bund to collect runoff or seepage water. Runoff from the active dumping areas will run by a siltation dam into the raw water pond. This siltation dam will provide for the settlement of suspended coal particles to improve the quality of the raw water pond in a manner of the similar to the siltation dam downstream of the product coal stockpile.

The dump will be worked in stages with dumping occurring in one area only at any one time. After dumping in each section is completed, that section will be sealed with compacted overburden to reduce infiltration area will be discharged via a siltation dam to Boggy Creek.

Pit Water Evaporation Ponds

At the junction of the pit ramps with the haul road, evaporation dams will be built into which pit water will be pumped. The dams will be designed to accept groundwater inflow into the pit as well as direct in-pit precipitation for the 1 in 100 year 24 hour design storm. Further investigations are required before the groundwater inflow can be estimated. However as shown on Drawing 4.24, there is sufficient room available between the mine pit and the haul road to ensure that the ponds can be made to a size sufficient to accommodate the likely inflows. Under normal circumstances the water will be allowed to evaporate from the ponds and road water will be taken from the raw water dam contained within the haul road loop. On occasions when the inflow exceeds evaporation, the water level of the ponds will be reduced by using the water for road watering.

Oil and Grease

Within the industrial area, areas where oils and grease are likely to be spilt or stored will be isolated so that the first flush runoff flows through a treatment unit. This unit will consist of an inclined plate separator to remove oil. It will ensure high levels of removal in a small treatment volume. The oil fraction will rise to the top of the chamber and can be skimmed off and stored in a sump where further separation from water can occur. The oil can then be collected by tanker or in drums for subsequent safe disposal.

Sewerage System

Early in the construction phase, a package sewage treatment plant will be installed. The plant which will be designed to cater for the full construction force will consist of 2 treatment units which will discharge effluent into a pond providing 3 days retention prior to overflowing to the tailings dam.

The same system will be used for the operational phase and will have adequate capacity to meet such requirements. It will treat all sewage from the industrial area except for the train loading station which, because of the more distant location and small workforce, will be serviced by a local septic tank and absorption trench.

Tailing Dam

The tailings dam will have the capacity at full supply to hold 2,300ML. This will be sufficient to hold slimes for 17 years of mine operations. In addition, freeboard capacity will be available at the end of 17 years which will be sufficient to allow for a 1 in 100 year 24 hour storm before overflow occurs through the natural saddle adjacent to the southern end of the dam wall.

The tailings dam wall will be built of selected overburden from the initial mining operation. It will be a fully engineered structure built to the requirements of the Water Resources Commission for a water storage dam.

The dam is classed as a "referable dam" under the Water Act and will require a waterworks license.

Adequate space is available for the construction of a further tailings dam to allow mining to continue after the initial 15 year design period.

4.3.7 Site Water Balance

Two conceptual water balances have been prepared for the industrial area; a dry day and a wet day for a 1 in 100 year 24 hour storm. These balances are shown on Drawing 4.7. Details of calculations appear in Appendix 6.

Dry Day

All available water will be reclaimed for the tailings dam, with additional water requirement being made up from the Nogoia River bore. Under the dry day situation, 3,654kL/day will be required from this bore. This will be distributed as shown on Drawing 4.7.

Wet Day

Under the wet day scenario of a 1 in 100 year 24 hour storm, water will be supplied from inflows to the raw water storage only, with no water being made up from the Nogoia River bores.

Rainfall and runoff to the raw water storage will be approximately 32,800kL, which will be in excess of the domestic usage of 70kL and the process plant water requirement of 3,300kL.

The excess inflow to the raw water storage will build up within the storage's freeboard capacity, which will be more than adequate at 490,000kL. Thus even if the pond was full to its design depth, there would still be sufficient capacity to retain the 1 in 100 year 24 hour storm.

Water will not be reclaimed from the tailings pond on a wet day. The total inflow of 63,705kL to the tailings pond, comprising process water together with rainfall and water runoff will build up within the pond's freeboard capacity which at 360,000kL when the pond is full after 17 years production, will have more than adequate capacity for containment of the runoff.

4.3.8 Effects of Project on Surface Water Quality

Industrial Area Drainage

Given the water management system discussed in Section 4.3.6, the operation of the mine as proposed will not have any significantly detrimental effects on the surface water quality of the area.

In an extreme event there may be a discharge from the raw water dam. However this would only occur on a rare occasion such as if the dam was at its full design depth and a storm greater than the 1 in 100 year 24 hour storm was to occur. In such a situation the discharge would be via an emergency spillway designed to protect the dam from general overtopping and would flow to Boggy Creek. In this case the runoff from the mine area would be relatively clean because the major pollutant load would have been carried in the first flush and retained in the raw water dam. Furthermore Boggy Creek and probably the Nogoia River would both be in flood and would contain water with a turbidity and suspended load at least as high as that of the discharge water.

High turbidity, particularly in the Nogoia River is likely to originate to a significant extent from the large areas of cleared agricultural land in the catchment. Given the raw water dam as proposed, it is likely that the effect of minesite drainage discharged during an extreme storm event would be much less than the effect of runoff from the upstream agricultural areas.

Mine Area Drainage

As part of the mining activities, actions such as the removal and disposal of vegetation, stripping of overburden, and recontouring of spoil dumps, will generate significant amounts of nutrients and loose particulate matter which could produce detrimental effects on the low flow creek systems and aquatic life.

To prevent such occurrences, after the initial preparation phases have begun, runoff from preliminary operations such as clearing, stripping etc. will be directed through a properly designed drainage system incorporating settlement ponds. This action will greatly reduce the amount of suspended solids entering the natural water courses and, in time, should impose little impact on the freshwater system. Consequently, the drainage systems will be established early in the construction programme to reduce the effects of siteworks on the overall hydrological system.

During the mining phase, the ongoing process of overburden stripping and stockpiling will continue the potential for increased sediment discharge to the drainage system. However, disturbed areas and overburden spoil piles will be progressively recontoured and revegetated (refer Section 4.8). The recontouring will be aimed at reducing slopes and providing a system of drainage paths and retention basins to control runoff velocities. Revegetation will stabilise the spoil surface against erosion. Consequently, given efficient and progressive rehabilitation as proposed, silt laden runoff from the overburden spoil piles will be limited to those areas which are currently being worked and awaiting rehabilitation.

In general, retention ponds will be located so as to collect both the silt laden surface runoff and leachates percolating through the overburden. These ponds will allow settlement of suspended solids prior to discharge and, as leachates may deteriorate in quality over a number of years, the ponds will be retained after revegetation so as to dilute leachates with surface runoff.

It is not the aim of the ponds to store water, and provision will be made either with a decant pipe or a low flow/low level discharge pipe to draw down most of the full storage so as to provide retention capacity for follow-up storms.

The settling ponds will be designed on the 1 in 10 year 24 hour storm which has an estimated rainfall intensity of 6.25mm per hour. Based on a runoff coefficient of 0.7, the design storm will produce a surface runoff of 1ML/ha. The ponds will be designed to retain this runoff volume.

At flows greater than the design storm, drainage water would overflow the pond embankment through a suitably designed spillway and enter the natural drainage system. It is likely that should this occur, Boggy Creek would be in flood and a situation similar to that described above for the raw water pond discharge would arise. No significantly detrimental effects are expected.

4.3.9 Boggy Creek Diversion

At approximately Year 5, approval to divert Boggy Creek will be sought in accordance with Part II of the Water Act. The proposed location of the diversion is shown in Drawing 3.3. Design criteria applied to this diversion are that scour of the channel and downstream sediment deposition will not increase and that flood levels will not be affected as a result of the work.

The recommended design for the diversion channel incorporates a low flow channel along the north-west side of the mine with a single channel design taking up minimal width through the mine itself.

Preliminary design for the low flow channel provides for a bed width of 5m, side slopes of 1V:3H and a depth of 5m which is approximately the same as the channel section of the existing creek. Along the north-western boundary of the mine, the channel will be bounded on one side by the mine levee, while on the other side flow is not constrained therefore flood flows can spread out.

The design of the single channel flow through the mine area has been based on a 1% AEP flood flow with a suggested maximum velocity (average) of 1.5m/s. The maximum velocities under existing conditions are of the order of 3m/s. However, the existing channel has a well vegetated bed bank and floodplain, compared with the proposed man-made diversion channel. Therefore, velocities in excess of 1.5m/s could be considered erosive in the diversion channel, and hence the suggested maximum is considered reasonable. These design parameters have been selected with regard to the potentially erosive nature of the soils in the area of the diversion as discussed in Section 4.1.7.

At the downstream end of the channel, the earth will be formed as necessary for transition between the channel and the natural creek bed to ensure existing flow conditions are maintained. A drop structure placed just upstream of where the channel terminates will dissipate excess energy before the natural stream bed is reached.

An analysis of channels with varying bed widths and side slopes was carried out to determine the required depth of flow and thus the top width. This analysis indicated that because of the restricted area available for siting the diversion channel, the preferred design parameters were a bed width of 50m, a flow depth of 7.5m, and a top width of 95m.

4.3.10 Nogoia River Floodplain

Within the 15 year mine plan examined in this study there will be no mining in the floodplain of the Nogoia River. One small exception will be pit B on the southern side of the river and pit C on the northern side both of which are on the edge of the floodplain. They will be bunded to protect them from floodwater ingress. A mathematical model of this bunding (Munro Johnson & Associates 1986) has indicated that it will not significantly affect existing flood conditions with the increased water surface levels and maximum velocities falling within general Queensland Water Resources Commission guidelines.

4.3.11 Water Quality Monitoring

A monitoring programme of Nogoia River water upstream and downstream of the site will be undertaken during the construction phase and in the early years of the operational phase. The objective of this programme will be to identify if the project is affecting the mine's water quality. The sampling will include regular grab sampling as well as storm event sampling. The programme will be agreed with the Department of Environment and Heritage before being implemented.

4.4 Groundwater

4.4.1 Existing Resources

The regional geology within the area of the mine has been described in Section 4.1.1.

River Alluvium

The extent of the recent alluvium is shown on Drawing 4.9. This groundwater resource is not developed and there are no licensed bores on the alluvium in the general area of the project.

Investigations carried out on the mine site have shown that the recent alluvium associated with the Nogoia River floodplain has a thickness of 15m to 20m over much of the area. The uppermost part of the alluvium is generally clay while the lower part consists of clean sand and gravel with a depth of around 10m.

Groundwater levels are relatively uniform with an average depth of less than 5m above the base of the alluvium. Water levels in the alluvium and Nogoia River are approximately the same. This fact in combination with the falling gradient away from the river and the occurrence of clean sands and gravels in the Nogoia River bed suggest that the alluvial aquifers are recharged from flow within the Nogoia River.

Permeability and specific yield of the recent sand and gravel aquifer determined from a pumping test were 130m/day and 0.1 respectively.

Quality of water within the alluvium was tested in a water sample bore shown on Drawing 4.9. Twelve samples were taken at different depths during the drilling of the water bore. The variation in conductivity after the first sample was less than 4%. All samples were then bulked and the results of the analysis of this composite sample are reproduced in Page A7-1 in Appendix 7.

The dissolved ions within the samples were measured at 417mg/L. Predominant ions for all samples were Na and HCO₃. Based on the analysis it is good quality water although there would be some restrictions on its use for irrigation.

Permian and Triassic Formation

No hydrogeological investigations have been carried out within these formations. However exploration drilling encountered small to moderate water flows in the coal seams. This indicated that the coal seams were the main aquifers within the Permian and Traissic Formations at this location.

Under recent alluvium of the Nogoa River, the coal seams are in direct contact with the basal sand and gravel aquifers. Water levels measured in exploration holes suggest that the alluvial aquifers and coal seams are interconnected in this area.

Water quality within the coal seams is variable but generally poor. Details of quality are summarised in Tables 7.B and 7.C in Appendix 7 and sample locations are shown on Drawing 4.9. Total dissolved ion concentrations vary between 376mg/L and 20,120mg/L with an average value of approximately 11,500mg/L. Principal ions are Na and Cl. Many minor trace elements have high concentrations.

4.4.2 Effects of the Project on Groundwater Resources

Water Supply

As discussed in Section 3.14, it is intended to use water from the plant area runoff and from the mine pit as well as recirculating the supernatant water from the tailings dam. However, this is unlikely to provide sufficient water under all conditions. When additional water is required it will be drawn from a bore to be installed adjacent to the Nogoa River. This bore will be located in the river alluvium. As discussed above, there is a direct link between the alluvium aquifer and the Nogoa River. Any withdrawal from this aquifer will be readily recharged by the river. Given the regulated flow in the river from the Faibairn Dam, the occasional withdrawal of water from this aquifer is unlikely to have any significantly effect on the aquifer quality or capacity. The bore will be constructed and used in accordance with the requirements of the Water Resources Commission.

Floodplain Mining

As has been detailed elsewhere in this report the mine is being planned for an initial life of fifteen years. During that time a minor amount of alluvium on the southern edge of the floodplain will be removed after placing a clay cut-off trench around the excavation. The effect of mining in this pit on groundwater movement down the floodplain will be minimal. Water removed from the alluvium will be pumped into the raw water supply system for the mine.

Mining in the Permian Triassic Formations

In the underlying Triassic and Permian strata outside of the floodplain, small to moderate water flows were encountered in the coal seams during airflush drilling of exploration boreholes. This indicated that the coal seams are the main aquifers in these strata. Water levels measured in exploration boreholes are similar to alluvial groundwater levels, which suggests that the alluvium and coal seams are an interconnected part of the alluvial groundwater system. These preliminary observations indicate that only minor flows would be expected from the coal seams into the mine pit.

Due to its poor quality (refer Appendix 7) seepage from the coal seams into the pits will be pumped into evaporation ponds located between trunk and ramp haul roads. Once the final site for the ponds has been selected, the seepage characteristics of the pond bases will be determined and appropriate anti-seepage measures incorporated as necessary into the design. As discussed in Section 4.3.6, provision will be made to use this water for road watering on occasions when the rate of evaporation does not equal the inflow rates.

4.5 Noise

4.5.1 Background Noise Levels

The mine site is located in a sparsely inhabited rural area, in which the major activity is grain cropping and cattle grazing. Properties in the area are relatively large and homesteads fairly widely dispersed with little influence upon the noise climate of neighbours. The two main sources of noise in the area are the Capricorn Highway and the railway line, but because of relatively low traffic volumes, neither represents a significant noise source.

Emerald, which is approximately 45km from the mine industrial site, will be the major service centre for the construction and operations phases of the mine and the housing area for the mine workforce. Major noise sources in the town are railway movements at the station which is in the centre of the town and vehicular traffic. The remainder of the town generally experiences levels of noise usually associated with a country urban community.

To define the existing noise climate onto which noises generated by the proposed development would be superimposed, a survey of background noise levels was undertaken. A Bruel and Kjaer model 2225 noise level meter was used, with all measurements being made using an A-scale frequency weighting to approximate to the "loudness" heard by the human ear. Instantaneous readings were taken manually at 10 second intervals until sufficient readings were obtained to determine the noise level which was exceeded 10% of the time (L10) with a 95% confidence of 3dB or better. Following this, five one-minute equivalent continuous noise levels (Leq), were recorded and the average calculated. This is a measure of the constant noise level which, over a given period of time, transmits to the receiver the same amount of acoustic energy as an actual time-varying sound.

Fine weather prevailed throughout the recording period with calm to light winds. Day and night time readings were taken on the 24 and 25 January 1986 at the proposed mine industrial site and in the area of Emerald proposed to be developed for mine housing.

The noise levels recorded are presented on Drawing 4.12 as plots of the percentage of time that a given sound level is equalled or exceeded. The noise level which was exceeded 90% of the time (L90) and the noise level which was exceeded 10% of the time (L10) have been calculated. The L90 noise level is commonly accepted as an indicator of the ambient background noise level which exists when no significant noise source is present. The Leq noise level has also been calculated. These background levels are given in Table 4.7.

Table 4.7
Existing Background Noise Levels (dB(A))

Site & Time	Noise Level (dB(A))			Sources
	L10	L90	Leq	
5.30am	41	35	38	truck on highway & birds
4.30pm	37	29	35	vehicles at dump
9.30pm	35	27	31	crickets& rustling leaves
6.00am	35	29	32	birds
4.30pm	37	29	33	--
9.00pm	33	25	30	crickets& rustling leaves

The proposed new housing area is on the current outskirts of Emerald, on the opposite side of the Nogoa River from the main town area and in the vicinity of the existing rubbish dump. The major noise sources in this area were the distant sound of heavy transports on the Capricorn Highway and singing birds in the morning, vehicles accessing the dumps during the day and crickets and rustling tree leaves during the night. The noise survey at the proposed mine site revealed a typical rural situation with very low noise levels with slight intermittent increases by the rustling of wind-blown tree leaves and bird calls, particularly in the morning and at night. At various times of the year there is likely to be slight increases in daytime noise levels in the general area of the proposed mine brought about by the operation of cultivation and harvesting equipment.

4.5.2 Noise Effects During Construction Phase

Major construction activity at the mine site is likely to extend over a period of about 5 years. Construction noise sources will include dozers, backhoes, end-loaders, cranes, rock drills, hammering and grinding. At various stages of the construction phase, commissioning of various items of plant will occur. In some cases the full extent of any acoustical treatment associated with such plant may not be complete and temporary high noise levels may be experienced from trial runs of such equipment. However it is assumed that the general noise levels generated from construction equipment and mobile plant will be similar to those likely for the operation stage. These levels and their impact are outlined in the following Section.

Construction of the majority of mine housing in Emerald will be undertaken during the Years -1 and 1 with the remainder of the housing provided as and when required over the next 6 years. Activities associated with the development of the subdivision and the initial housing will result in noise levels above that which would normally be expected in an urban environment. However, because the housing area is in a sparsely populated area, well removed from the main residential areas of Emerald, the housing construction activities are not expected to cause any significant problems. Although on-going periodic construction of housing in the subdivision will occur within an increasingly inhabited environment, the small number of houses to be constructed over relatively short periods of time, should ensure that there is no significant noise nuisance for the residents of the subdivision.

4.5.3 Noise Effects During Operational Phase

Mine Noise

Most noise will originate from the mine services area, trucking roads and loading areas. Associated with these activities will be drills, dozers, graders, trucks etc. These will be scattered across the site, and in many cases will be within the mine pit where noise levels will be significantly attenuated by the depth of the pit.

Noise levels will fluctuate as items of plant stop and start, move about, and vary their power output. Because of these variations in noise levels at different times and places, it is impossible to accurately predict noise levels on and around the site. It has therefore been assumed that the noise levels would be comparable to those for a variety of "typical" earthmoving and associated equipment, operating as a point source at any given location.

On the basis of these "typical" levels, it is possible to arrive at likely noise level estimates for various distances from the site. Table 4.8 shows typical noise levels representative of heavy earthmoving equipment. Table 4.9 estimates the attenuation of a noise level of 90dB(A) at 30m which can be considered as an approximate average maximum of the sources given in Table 4.8. In estimating these noise levels, an excess attenuation of 0.2dB(A) per 100 metres has been made for open unvegetated ground

due to ground absorption. For vegetated areas where the average source height is less than 2 metres, an excess attenuation of 2dB(A) per 100m has been assumed.

The nearest residences outside the proposed mine lease area are the homesteads of "St. Aubins" and "Currimundi" and the township of Comet. Their distances from the likely nearest mining activities are 3.2km, 3.5km and 10.4km respectively. As can be seen from Table 4.9, Comet is well outside the audible distance of the mine, although under unfavourable conditions (inversion and wind from the direction of the mine) blasting noise might be heard in the town.

Table 4.8
Typical Noise Levels

Source	Typical Noise Level at 30m (dB(A))
Bulldozer ripping	80-90
Scraper at full load	83-92
Loader	73-77
Truck hauling earth	77-82
Rock drill	85-92
Air compressor	65-77
Blasting	90-130
Mobile Crusher	80-90
Conveyor	70-75
Conveyor transfer point	73-75
Coal preparation	75-80

Table 4.9
Estimated Equivalent Noise Levels (Leq)
at Varying Distances from the Mine

Distance	Estimated Equivalent Noise Levels (dB(A))	
	(a)	(b)
30	90	90
500	56	65
1000	40	58
2000	14	50
3000	--	44
4000	--	40
5000	--	36
10000	--	20

- (a) Over vegetated ground with average source height of about 2m.
 (b) Over unvegetated ground with average source height of about 2m.

A comparison of the existing and predicted noise levels outlined in Tables 4.7 and 4.9, reveals that it is possible that mine associated noise could be audible at the "Curramundi" and "St. Aubins" homesteads. It should be noted however that the circumstances outlined in Table 4.9 are a "worst case" situation and do not take account of the significant attenuation affects of the mining activities gradually descending into the mine pit. Therefore, it is assumed that while some mine associated noise may be audible at the two homesteads, it will mainly be during the initial stages of mining, after which time it is expected that the majority of the mining noise will be contained within the mine pit.

Blasting will occur several times each week only in daylight hours and will result in quite high noise levels. This noise will be heard at much greater distances than the general mining noises but will be of short duration. Infrequent large blasts, if well designed, generally have less impact than a greater number of small blasts fired at irregular intervals. Provided that residents within the audible distance of the mine sources are given adequate warning of the blasting programme, no cause for complaint should arise. To reduce annoyance the company will attempt to programme the blasting for the same hours of the day on nominated days of the week. It is not expected that noise from the site will be in conflict with existing land users in the area, and effects on any stock or wildlife should be minimal.

Vehicular Noise

Increased traffic noise will result from supply and haulage vehicles and from employees travelling by car to and from the mine site. The volume of traffic will vary throughout the construction and operation phase, having an effect on the site and adjacent rural areas, and within Emerald.

Vehicular noise in and around the site will be relatively low compared with the higher background noise levels which would result from the mining activity. Although the area immediately surrounding the mine site is sparsely inhabited, the proposed mine access road from the Capricorn Highway will run within 1,800m of "St. Aubins" and 3km of "Currimundi".

Table 4.10 estimates the attenuation of a likely maximum traffic noise level on the access road of 67dB(A) at 10m. This noise level was calculated using an expected maximum flow of 200 vehicles per hour which could occur at the change of shifts at the mine.

As is evident from the above table, even where there is no vegetation or landforms to attenuate noise, the likely maximum level of traffic noise emanating from the access road is not expected to be audible at either the "St. Aubins" or "Currimundi".

Isolated rural residents close to the Capricorn Highway may be affected to a small degree by increased traffic from Emerald. During the initial

construction period, heavy trucks will form a larger part of this traffic. Estimates of likely increased traffic volumes are given in Section 5.7.

Table 4.10
Estimated Equivalent Noise Levels (Leq)
at Varying Distances from the Access Road

Distance (m)	Estimated Equivalent Noise Levels (dB(A))	
	(a)	(b)
10	67	67
500	23	32
1,000	7	25
1,800	--	18
3,000	--	12

(a) *Over vegetated ground with average source height of about 2m.*

(b) *Over unvegetated ground with average source height of about 2m.*

In general, the increased noise levels in Emerald will be due to passenger vehicles, and not trucks associated with the mine. Most traffic from the housing area to the mine will not pass through the main urban area of Emerald and consequently is not expected to create a significant noise problem for the town.

Train Noise

It has been assumed that at a production rate of around 3.6Mtpa, an average of 14 unit train trips would be required each week. Each train would consist of four electric locomotives, 108 bottom-dump wagons and a locomotive remote control unit, and would haul 5,400t of coal.

Noise associated with the loading of coal trains and the movement of these trains around the mine rail loop was dealt with in the consideration of general mine noise in Section 4.5.3. With respect to the noise associated with the movement of these coal trains along the rail route from the mine to the port, the resultant railway noise has also been calculated.

It should be noted that the only new rail which is being constructed as part of this project is the 15.4km spur line to link with the Gregory Mine

railway line. Consequently the only area exposed to train noise for the first time as a result of this project will be in the vicinity of the spur. In this area there are no residents who will be affected. The balance of the rail line to be used is an existing coal haulage line. The impact of the average of two train trips per day from the Ensham project in addition to the trains already using this line each day (refer Table 4.11) will be a relatively minor additional effect.

Train noise has been calculated using the method recommended by the UK Noise Advisory Council, which was outlined by Roberts (1986) with reference to freight train movements in Western Australia.

The following parameters have been assumed in calculating train noise:

- maximum speed 60km/hr
- wagon length 15.6m
- wagon capacity 50 tonne (coal)
- 4 movements per day (2 loaded, 2 empty)

A maximum (1 second) sound pressure level of 81 dB(A) was assumed at a distance of 30 metres from the track, this level being associated with rail/wheel sources which are predominant over motor noise from the electric locomotives. In reality, there will be some variance from this level, with a tendency for empty trains to generate more noise, on average, than loaded trains (Roberts, 1986).

Table 4.11 outlines the predicted noise levels at various distances from the track, assuming a tangent track with constant train speed, and attenuation of noise over soft ground, but not influenced by terrain or dense vegetation. The given noise levels are L_{eq} (24hr), which represents the equivalent continuous sound level over a 24 hour period, and which has been shown to best quantify the effects of rail noise on adjacent communities.

Table 4.11
Estimated Noise Levels Due to Train Movements

Distance from Track (m)	L_{eq} (24hr) dB(A)	Resultant L_{eq} dB(A)
30	58	61
100	51	54
250	44	47
500	36	39
1,000	24	27
1,500	14	17
2,000	7	10

The resultant L_{eq} in Table 4.11, obtained by adding 3dB(A) to the predicted $L_{eq}(24hr)$, applies to areas where the proposed rail movements are added to existing traffic, and is an approximate measure which assumes that the proposed traffic will generate a similar L_{eq} to existing traffic. In areas where existing rail traffic noise is already greater than the predicted $L_{eq}(24hr)$, the incremental noise level caused by this proposal will be less than 3dB(A). In areas where there is little or no noise presently from trains, the predicted levels will correspond to the $L_{eq}(24hr)$ values in Table 4.11.

Authorities generally consider that an $L_{eq}(24 hr)$ level of 50 to 55 dB(A) is an acceptable upper limit for train noise. Such levels would be exceeded only within 100 to 200 metres of the track. In areas where the existing level of $L_{eq}(24 hr)$ might be higher, the proposal will lead to an increase of less than 3dB(A).

The applicability of normal noise assessment criteria to rural areas may be questioned, and it is possibly more realistic to adopt an acceptable level of 40 to 45 dB(A). This suggests that in areas not already subject to rail noise, the proposed rail traffic may be capable of causing some annoyance within 350 metres of the track. The actual impact will depend substantially on existing ambient noise levels at any potentially sensitive receptor sites.

Operator Noise

An equivalent continuous level for an 8 hour working day of 85 to 90dB(A) is considered to be the threshold of intensity likely to cause hearing damage. Higher levels may be acceptable for shorter periods. Table 4.12 below provides noise levels associated with the operator-position of plant and machinery in use on existing open-cut mines.

Table 4.12
Operator Noise Levels for Various Plants

Specific Machine	Function	Noise Level dB(A)
Cat D9H	Bulldozer - air conditioned	88
A/C HD41	Bulldozer - air conditioned	92
F/A HD41	Bulldozer - air conditioned	95
Cat 12E	Grader	88
Cat 14G	Grader	85
Euc CH120	Coal Hauler	93
Euc R170	Coal Hauler	85
Wabco 100	Coal Hauler	88
Wabco	Water Truck	85
P & H 1600	Face Shovel	86
Marion 182M	Face Shovel	75
Mayhew 1000	Coal Drill	93
Jacro 200	Coal Drill	92
BE 45R	Overburden Drill	89
BE 60R	Overburden Drill	83
Cat 631B	Scraper - open	98
Cat 631B	Scraper - air conditioned	96
Cat 633	Scraper - open	96
Cat 633C	Scraper - air conditioned	94
Cat 657B	Scraper - open	100
Cat 657B	Scraper - air conditioned	91

Ear protectors and/or sound proof cabins will be considered where necessary and noise reduction barriers may be used to screen workers from excessively noisy areas at the site. Direct reduction of noise from all plant, fixed and mobile, will be sought by the selection of quiet running plant; by using, where necessary, vibration isolation, acoustic enclosure and baffling; by providing silencers on air-operated equipment; and by using preventative maintenance on all plant. Particular attention will be paid to areas subject to impulsive metal-on-metal noise such as maintenance areas where hammering may cause levels likely to cause hearing damage. At no time will operators be subject to noise levels in excess of 115dB(A) even for short periods of time. In accordance with the requirements of the Department of Environment and Heritage, plant noise will be monitored at several key sites on a regular three monthly basis once the mine has commenced operation. The plant will be

surveyed at this time to determine any deterioration in the condition of equipment which may lead to increased noise levels, and to determine areas requiring ear protection to safeguard hearing.

4.5.4 Noise Monitoring

During the construction phase and in the early years of the operational phase a noise monitoring programme will be introduced. The objective of this programme will be to monitor the noise effects of the project on existing noise sensitive uses such as nearby residences. Details of the programme will be agreed to with the Department of Environment and Heritage before being implemented.

4.6 Air Quality

4.6.1 Introduction

Mining and associated activities at Ensham will cause changes in air quality in the surrounding area. The most significant alterations to air quality will be due to dust, in the forms of suspended particulate matter and dust deposition or fallout. Disturbance to soil and rocks, and the handling and processing of materials will generate dust, which will be dispersed from the various sources by the atmospheric processes of advection and diffusion. The influence of gravity will cause dust particles to settle out of the air, with heavier particles settling closest to their sources.

4.6.2 Air Quality Standards

Maximum standards for the levels of various emissions in residential situations have been laid down by a number of environmental agencies around the world. As the Department of Environment and Heritage has not established standards specifically for Queensland, it is common to refer to guidelines set down by authorities elsewhere in assessing the significance of air quality impacts. The standards most relevant to the proposed operation are those dealing with dust fallout and the concentration of total suspended particulates (TSP).

Dust Fallout

A variety of maximum allowable standards has been set by regulatory authorities for inert dust fallout rates. The United States Environmental Protection Agency (USEPA) standard is equivalent to 150mg/m²/day. However, the Department of Environment and Heritage reports that levels in excess of 120 to 130mg/m²/day over the period of one month are likely to generate complaints. Fallout of inert dust particles at high rates leads to a loss of amenity, and may necessitate the frequent cleaning of affected surfaces.

Total Suspended Particulate Concentration

The USEPA secondary standards (i.e. the most stringent standards, designed for the preservation of public health and amenity) for suspended particulate concentration are:

Annual Coverage	60 $\mu\text{g}/\text{m}^3$
24 hour average	150 $\mu\text{g}/\text{m}^3$

A standard that is useful for assessing short term increases in TSP has been established in the Soviet Union. This standard refers to an averaging period of 20 minutes:

20 minute maximum TSP 500 $\mu\text{g}/\text{m}^3$

4.6.3 Existing Air Quality

No on-site measurements of air quality at Ensham have been made, and so the existing air quality must be estimated by comparison with similar situations. It is assumed that the air quality in the vicinity is within the range typical of rural areas of Queensland where some cultivation occurs. Given the extent of cultivation in the area, background dust levels are likely to be relatively high at certain times of the year. On this basis, the existing annual average TSP could be approximately 40 $\mu\text{g}/\text{m}^3$, and the annual average dust fallout rate could be around 70mg/m²/day.

4.6.4 Air Quality Model

The widely used Gaussian steady state diffusion equation (Pasquill, 1974) has been used as the basis of the mathematical modelling procedure to predict impacts on air quality.

The model predicts increases of pollutant levels above background and is formulated to use multiple emission sources with the computation performed on a grid of receptors.

A modification to the basic equation has been made to incorporate the process of particle deposition. This has been achieved by the inclusion of a term which calculates the fall velocity of particles of a given density and diameter, as per Ledbetter (1972).

The absence of data normally acquired prior to modelling air quality has necessitated the adoption of the following assumptions:

- for annual average calculations, neutral atmospheric stability has been assumed, as per Turner (1970)
- area and line sources have been represented by a series of point sources

- no account has been taken of the effects of topography and vegetation on the dispersion processes. Generally these effects reduce impacts to levels below those predicted by the model.

On balance, the adoption of these assumptions is likely to yield conservative results, i.e., there is likely to be a tendency for the model to overestimate rather than underestimate air quality impacts.

4.6.5. Meteorological Data

No meteorological data are available for Ensham. The nearest meteorological station for which the Bureau of Meteorology has wind data is Emerald, about 45km to the west. Data derived from 0900 and 1500 observations are available. These do not provide a great deal of information about the diurnal variations in wind speed and direction that are experienced in the area.

The available wind data are summarised in Table 4.13.

Table 4.13
Annual Average Wind Speed and Direction - Emerald
(Based on surface observation, 0900 and 1500)

Direction	Speed (km/h)				
	1-5	6-10	11-20	> 20	All
N	3.6	2.3	0.4	0.1	6.4
NE	9.9	5.7	1.3	0.5	17.4
E	7.8	5.6	1.6	0.4	15.4
SE	9.6	9.1	3.2	1.7	23.6
S	7.3	7.0	1.6	0.4	16.3
SW	3.3	2.6	1.1	0.4	7.4
W	1.5	0.8	0.3	0.1	2.7
NW	3.5	1.7	0.5	<0.1%	5.7
Total	46.5	34.8	10.0	3.6	94.9
Calm 5.1%					

A meteorological parameter of importance to the modelling of diffusion is the stability of the lower levels of the atmosphere. In this case, there are no

stability data available and it has been assumed that neutral stability will be an adequate approximation of actual conditions when averaged over time.

4.6.6 Emissions Data

Dust Emission Sources

Potential sources of dust can be identified for the pre-mining, coal processing and handling activities. Specific aspects of the operation that have potential for dust generation are:

- **Clearing and topsoil removal**

In preparation for mining, clearing of vegetation and removal of topsoil will generate dust, from the effects of machinery and wind.

- **Blasting**

Blasting will be carried out to break up deeper overburden prior to removal, and each blast will raise significant amounts of dust, causing transient peaks in dust emission. However, blasting is expected to be conducted only one day per week, and will therefore not be a major contributor to overall dust levels.

Available data indicate that emission of about 1kg of particulate matter per 1,000t of material blasted can be expected. This assumption yields a maximum once-weekly emission of about 700kg, equivalent over one hour to 194g/s, and a long-term average of 1.2g/s.

- **Exposed surfaces**

In preparation for mining, pit areas are to be progressively stripped of overburden. Under windy conditions, dust can be raised from the pre-stripped areas and overburden heaps. Dust generation from exposed surfaces will be reduced by phasing the clearing and stripping in conjunction with the mining programme so that excessive areas of exposed ground are not left standing for long periods. The progressive overburden restoration following mining operations will minimise the amount of raw overburden exposed to wind action.

Based on data from Dean and Train (1984) it might be expected that at Ensham exposed areas will produce particulates due to wind action at an average rate of about 0.2g/s/ha. The emission rate at any particular time will depend upon moisture content, particle size and distribution and wind speed.

Worst case emissions from exposed areas have been assumed to occur under conditions of strong wind, when the energy available for entrainment of particles is greatest. There is little written about the short-term variation of emissions with wind speed, and so the assumption has been made that a wind speed of 15m/s (30 knots approximately) will generate emissions at 100 times the long term average rate. The increase of emissions with wind speed is known to increase very rapidly with increasing wind speed once it exceeds the minimum entrainment velocity for the range of particle types and sizes present.

- **Drilling**

Dust generation from the drilling of overburden is expected to be about 0.6kg per hole, corresponding to an average rate of approximately 1g/s.

- **Machinery and vehicles**

The movement of trucks, earthmoving equipment and other machinery over mine pit areas and haul roads will generate dust. Watering of roads will reduce emissions, its effectiveness being determined by the frequency of application. Vehicle movement should produce about 2kg of emissions per kilometre travelled.

Truck loading in the pit areas should generate approximately 20g per tonne of coal and 10g per tonne of overburden.

Dragline operations in overburden and coal seams should produce in the vicinity of 10g/s as material is disturbed and transferred.

Scrapers are each likely to generate dust at a rate of about 4g/s.

- **Truck Dumping Station**

This will be provided for receipt of ROM coal from rear-dump trucks. The dumping is likely to produce 6g of dust per tonne of coal, at an average rate of 0.6g/s.

- **Coal Processing and Handling Area**

The processing plant is a potential dust source due to the reclaim of coal from the ROM stockpiles, conveying of raw and product coal, crushing and stacking.

Provision will be made at points of size reduction and material transfer for the application of dedusting sprays.

Water sprays will be assisted by chemical agents for greater effectiveness of dust suppression where necessary.

Dust can be generated by wind blowing across coal on conveyors and by material falling off the return side. Conveyors will be equipped with wind shields and transfer points will be enclosed.

Some dust can be expected from the handling of the coal during stacking and reclaiming from both the ROM and product stockpiles, and the loading of rail wagons.

Wind action can pick up fines from stockpiles and working areas and disperse them downwind. The rate of dust generation will depend on wind velocity, particle sizes and moisture content. For coal fines 75 to 105 μ m in diameter, the pick up velocity is approximately 6.3m/s (Djamhouz and Ghonein, 1974).

The coal processing and handling plant area, excluding stockpiles, is likely to produce emissions at an average rate of about 25g/s, and a maximum rate of 40g/s. The mean rate of generation from the product stockpiles should be around 1g/s, and from the smaller stockpiles around 0.1g/s. The maximum rate of emission from the stockpiles is difficult to estimate, since there is very little published data on the increase of emissions with increasing wind speed. However, it has been assumed that for the purposes of estimating maximum conditions, the emission rate at a wind speed of 10 m/s will be 20 times the long term average.

- **Burning**

Burning of cleared vegetation on occasions will generate smoke and ash. The area of cleared vegetation will be approximately 220ha each year for 15 years. The burning will only be undertaken during periods of suitable atmospheric conditions when the wind is blowing away from inhabited areas. Because such smoke generation will be a relatively infrequent event, it should not cause any serious impacts.

- **Dust Characteristics**

Predictions of dust fallout and concentration are influenced by the particle size distribution and density used in the computations.

USEPA data indicate a mean particle size of 20 μ m, and indications from the Hunter Valley are that the mean size may be less than 20 μ m. An assumed particle size distribution is given in Table 4.14.

Table 4.14
Dust Particle Size Distribution*

Diameter (um)	% By Mass
5	20
10	20
20	20
30	15
40	15
60	10

**Assumed density values are 2.6 for earth dust and 1.4 for coal.*

- **Other Emission Sources**

Emissions other than coal and earth dust will arise from the mining activity in the form of gaseous exhaust emissions from trucks, scrapers and other machinery and vehicles with internal combustion engines. These will generate carbon monoxide (CO), oxides of nitrogen (NO_x), hydrocarbons (HC) and particulate matter. However, owing to the relatively small number of machines and vehicles operating in the mining and processing areas, the concentration of such pollutants will not be of any concern.

Spontaneous heating of coal stockpiles can occur, producing fires that may emit considerable quantities of sulphur dioxide (SO₂), NO_x and particulates. Ensham coal has been identified as possibly being susceptible to heating, and so precautions will be taken to reduce the probability of it occurring, principally by ensuring rapid turnover of the stockpiles. It is unlikely, therefore, that a stockpile fire would occur. In such an event, however, the plume would rise due to buoyancy and thus ground level effects would be limited to some degree. Considering previous estimates of gas concentrations arising from fire in coal stockpiles (Gutteridge, Haskins and Davey, 1976), no deleterious effects are expected at the distance of nearby residences, and any effects on vegetation would be confined to the immediate vicinity of the stockpile area.

4.6.7 Air Quality Estimation Procedure

Averaging Periods

The air quality model was used to predict the following:

- maximum annual TSP concentration
- maximum annual dust fallout
- maximum one hour TSP concentration
- maximum 24 hour TSP concentration
- maximum 24 hour dust fallout

All predictions were of increases in concentration or fallout above background levels.

Model Input

For the case of annual average calculations, the model was run using 13 point sources representing the various emission sources described in Section 4.6.6. The rate of emission for each source was set to the long term average, taking into account downtime and other temporal variations where applicable.

Because the areas of activity at the mine will be changing over time as the various pits are worked, the modelling of annual average dust levels was performed several times, with the "mobile" sources placed in a number of different positions. This allowed the predicted annual dust levels for any location around the mine to be determined for the period of greatest impact. That is, the likely maximum annual levels were obtained, using the long term average wind data as the meteorological input.

The modelling of short term (ie. 1 hour and 24 hour maximum) dust levels involved a number of simulations to determine a worst case condition.

For the 1 hour period, there appeared to be two different types of condition that might lead to a worst case, viz, a blast cloud dispersing slowly under stable low windspeed conditions, and wind generated dust from exposed earth and stockpiles during very windy dry conditions.

Over the 24 hour period, the major consideration was the effect of wind blown dust during windy conditions. The calculation for this period used a different approach than for the 1 hour maximum. It was assumed that for the 24 hour maximum, the wind direction over that period would vary uniformly within a 45 degree sector. For the 1 hour maximum the prediction was based on the assumption that the wind direction would be constant, with the receptor directly downwind.

4.6.8 Results and Discussion

Maximum Annual TSP Concentration

Drawing 4.13 shows the increase in annual TSP due to mining. Plotted values should be added to the background level to yield the actual TSP at any point. Very high values, locally over $500\mu\text{g}/\text{m}^3$, are confined virtually to the pit and processing areas. Assuming a background level of $30\mu\text{g}/\text{m}^3$, and referring to the annual standard of $60\mu\text{g}/\text{m}^3$, it is apparent that the predicted $30\mu\text{g}/\text{m}^3$ isoline marks the limit of increases that under the most stringent criteria may be classed as unacceptable for residential purposes.

The only residences that are occupied at present and within the predicted $30\mu\text{g}/\text{m}^3$ limit are "Ensham" and "Duckponds" both of which will be vacated prior to mining commencing. "Currimundi" and "St. Aubins", approximately 3.5km south-east of the southern mine pit, will be affected marginally, with an increase of approximately $5\mu\text{g}/\text{m}^3$.

The residents of Comet may experience an increase of about 5% in annual TSP concentration, making the impact of the mine virtually undetectable.

Maximum Annual Dust Fallout

The pattern of annual dust fallout in Drawing 4.14 is similar to that of TSP concentration. The critical value in terms of preserving residential amenity is $100\text{mg}/\text{m}^2/\text{day}$, since the assumed a background of $30\text{mg}/\text{m}^2/\text{day}$ must be added. Dust fallout is expected to exceed the acceptable residential criterion only in close proximity to the mine. There will be no significant effects at either "Currimundi" or "St. Aubins".

Maximum 24 Hour TSP Concentration

Drawing 4.15 indicates that under worst case conditions, the USEPA 24 hour standard of $150\mu\text{g}/\text{m}^3$ may be exceeded up to 7km from the mine if the $30\mu\text{g}/\text{m}^3$ background level is applied. However, under such conditions, other dust sources may also be active, and thus the background TSP may be higher than average. This would have the effect of extending the area over which worst case values might exceed the standard.

The results of this model run should be assessed bearing in mind that the relationship between wind speed and emissions has been approximated only broadly in the absence of more definitive data.

It would appear from Drawing 4.15 that Comet township will lie outside the area in which the 24 hour standard may be exceeded in the worst circumstances, although "Currimundi" and "St. Aubins"

may occasionally experience short term concentrations higher than the recommended standard. Such occasions may arise only when all dust generating activities are operating in the mine pit nearest to the homesteads and the wind is blowing from either the north or north west. As can be seen from Table 4.13 such winds are expected only 12.1% of the time.

Maximum 24 Hour Dust Fallout

No standards exist for 24 hour fallout rate, since this parameter is not routinely measured over periods of less than 1 month. Some specific studies have indicated that loss of amenity may occur in residential areas if a 24 hour fallout rate of $500\text{mg}/\text{m}^2/\text{day}$ is exceeded. In view of this, it would appear from Drawing 4.16 that the area of possible adverse effects under worst case conditions is similar to that for 24 hour TSP maximum concentration.

Maximum 1 hour TSP Concentration

It was determined from a series of simulations that the maximum 1 hour effect on air quality would arise from a large blast cloud dispersing in a light wind. The worst case situation of a light wind and stable thermal stratification (unlikely to occur between 0900 and 1700 in winter, and 0600 and 1900 in summer) is plotted in Drawing 4.17. As distance from the mine increases, the probability of such values being experienced even in the worst case decreases, as the requirement would be for an improbably long duration of such meteorological conditions for the plume to be transported to the receptor point. Another mitigating effect is the vertical wind shear that is usually present in stable conditions. This would enhance lateral spreading of the cloud and reduce the maximum ground level TSP concentration.

As in the case of the 24 hour maximum simulations, there is considerable uncertainty in the estimates of dust emission associated with a blast cloud, and the plotted values should be taken as a guide only.

From Drawing 4.17, it would appear that in the worst case a blast cloud may lead to 1 hour concentrations in excess of the $500\mu\text{g}/\text{m}^3$ short term standard over a distance of up to 5km downwind which would include "Currimundi" and "St. Aubins". The more probable situation is that during times when mine blasting is likely (ie. daylight hours) neutral stability and light wind can be expected. Calculations of dust dispersion in these circumstances indicate that concentrations in excess of $500\mu\text{g}/\text{m}^3$ would be limited to within 3km of the mine area. In such a case the above homesteads would experience levels below the $500\mu\text{g}/\text{m}^3$ standard. The worst case TSP at Comet is not likely to be in excess of the standard in either case.

Maximum 1 Hour Dust Fallout

Drawing 4.18 indicates the increase of 1 hour dust fallout in the same manner as Drawing 4.17. No standards for 1 hour fallout exist, but there is observational evidence suggesting that at least $1000\text{mg}/\text{m}^2/\text{day}$ equivalent is necessary over this period for dust to become a nuisance in residential areas. The downwind effects of a blast cloud in excess of that standard would therefore be limited to 3km in the worst case. Using the more likely situation of neutral stability in the calculation, this reduces to 1.5km. In either event, neither of the nearest homesteads will experience fallout levels from the mine in excess of $1000\text{mg}/\text{m}^2/\text{day}$.

4.6.9 Conclusion

Mining of coal at Ensham will produce increases in the levels of TSP and dust fallout around the mine. The principal sources of dust will be the workings and movements of earthmoving machinery and trucks, the blasting of overburden and the processing and handling of coal in the plant area.

The maximum effects of these sources on a yearly, daily and hourly basis have been estimated by the use of an air quality model with the ability to simulate the dispersion of dust under a range of meteorological conditions. Although no on-site data were available, it was possible to generate results using various assumptions about the source strengths and, where relevant, their possible variation with wind speed.

The maximum annual levels of TSP and fallout should not create adverse effects at any inhabited site once mining commences. Minimal increases in dust will occur at Comet.

Over the short term it is likely that worst case effects will come from two different causes operating on different time scales. The maximum 24 hour impact is most likely to arise from dry windy conditions generating large amounts of dust from exposed dusty surfaces. The highest 1 hour levels are likely to arise from the transient effect of a blast cloud dispersing slowly in light wind conditions.

The extent of 24 hour and 1 hour effects is difficult to gauge because the data required to make an accurate prediction are lacking both from the site and from the literature on the subject. However in the rare event of the extreme worst atmospheric conditions, normally accepted short term standards at the two nearest residences may be exceeded. Nevertheless, it would appear that the worst case effects in atmospheric conditions which can be expected to occur in the area are unlikely to result in normally accepted standards being exceeded at the nearest residences.

4.6.10 Dust Monitoring

A monitoring programme of background and project generated dust levels will be introduced prior to and following implementation of the project. This programme will attempt to identify the significant natural variations in dust levels over a period of time and to relate these to the dust levels which will be measured during the construction and operational phases. Details of the programme will be agreed with the Department of Environment and Heritage prior to implementation.

4.7 Biology

4.7.1 Existing Vegetation

Ninety percent of the Ensham study area has been cleared for grazing and the cultivation of crops. The major sites of remaining natural vegetation are stony rises, hillslopes, crests, scarps and plateaus where the shallow to skeletal rocky soils support a variety of woodland and forest communities. Such vegetated terrain borders the north-western, northern and north-eastern boundaries of the area and occurs around Ensham Homestead. Natural vegetation also lines the channels and stream terraces of the Nogoa River and major creeks including Boggy Creek and Winton Creek.

South of the Nogoa River there is extensive cultivation, particularly on the alluvial plains, whereas north of the Nogoa River most of the vegetation has been cleared for grazing.

Mapping of the vegetation was done initially from aerial photography, followed by a ground survey. Community boundaries were verified and classified according to structure and floristic composition. Woodlands are open tree communities with sparse to dense grass cover. A shrub layer may be present. Eucalypts are usually the most common tree species. Forests are more closed tree communities, sometimes dominated by a single species such as lancewood.

The vegetation communities identified have been mapped as shown on Drawing 4.19 and are described below. A complete list of species identified is given in Appendix 8.

Narrow Leaved Ironbark - Bloodwood Woodland

This community is found on mid and upper hillslopes, hillcrests and plateaus 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*), large fruited bloodwood (*E. polycarpa*). The ghost gum (*E. papuana*) is frequently 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.

Small trees and shrubs commonly include red ash (*Alphitonia excelsa*), quinine bush (*Alstonia constricta*), black thorn (*Bursaria incana*), Leichhart 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 (*Bothriochloa decipiens*), desert blue grass (*B. ewartiana*), barbed wire grass (*Cymbopogon refractus*), leafy nineawn (*Enneapogon* spp., *E. lindleyanus*, *E. polyphyllus*), love grass (*Eragrostis sororia*), mountain wanderrie (*Eriachne mucronata*), black spear grass (*Heteropogon contortus*) and kangaroo grass (*Themedia triandra*).

Silver Leaved Ironbark - Bloodwood - Ghost Gum Grassy Woodland

This community is found on low rises on shallow skeletal and texture contrast soils. Silver leaved ironbark (*E. melanophloia*), red bloodwood and ghost gum are the most commonly occurring eucalypt species; willow wattle (*Acacia salicina*) is also present. Shrubs and small trees are sparsely scattered and include dead finish (*Archidendropsis basaltica*), Leichhart bean (*Cassia brewsteri*), Denhamia oleaster, boonaree (*Heterodendron oleifolium*), white Bauhinia (*Lysiphyllum hookeri*) and yellowwood (*Terminalia oblongata*).

The dominant grasses include *Bothriochloa* spp. - forest blue grass (*B. bladhii*), pitted blue grass (*B. decipiens*), Queensland blue grass (*Dichanthium sericeum*), black spear grass and kangaroo grass. *Aristida* spp. and *Enneapogon* spp. may also be present.

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 ground cover of grasses including hooky grass (*Ancistrachne uncinulata*), wire grass (*Aristida caput-medusae*), *Calypochloa gracillima*, love grass (*Eragrostis* spp.) and *Paspalidium distans*. Forbs 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. It commonly represents the demarcation line of clearing for grazing. Dense regrowth of brigalow (*Acacia harpophylla*) and saplings of mountain yapunyah occur around the periphery. At higher elevations lancewood replaces brigalow.

There is a shrub layer of false sandalwood (*Eremophila mitchellii*), wilga, *Capparis* spp., currant bush and Leichhart bean. Yellowwood may also be present.

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

Brigalow - Blackbutt Shrubby Open Forest

This community is of limited distribution because of clearing, and is restricted to sites at the base of vegetated hill slopes and an isolated lowland area towards the north of the study area. The community occurs on texture contrast soils and merges with the brigalow - mountain yapanyah open forest on hill slopes. Blackbutt (*Eucalyptus cambageana*) is often an emergent tree in the brigalow association. Poplar box (*E. populnea*) may also be present. There is a moderate shrub layer of false sandalwood, wilga, yellowwood and currant bush.

Additional tree and shrub species at the lowland site included bottle tree (*Brachychiton rupestris*), red Bauhinia (*Lysiphyllum carronii*) whitewood (*Atalaya hemiglauca*), and *Capparis lasiantha*.

Ground cover grasses include wire grass (*Aristida* spp.), nine-awn (*Enneapogon* spp.), curly windmill grass, love grass, black spear grass, *Paspalidium* spp. and *Sporobolus* spp. A variety of forbes were found at the lowland site including old man saltbush (*Atriplex nummularia*), berry cotton bush (*Enchylaena tomentosa*), *Einadia* spp., pig weed (*Portulaca oleracea*), roly poly (*Salsola kali*), *Sclerolaena* spp., and *Sida* spp.

Brigalow - Poplar Box Mixed Low Woodland

Again, this lowland community was of limited distribution due to clearing. Although brigalow is predominant, other tree species frequently occurring include poplar box (*Eucalyptus populnea*), yellowwood, whitewood, red Bauhinia and bottle tree. Small trees and shrubs include false sandalwood, wilga, emu apple (*Owenia acidula*) dead finish, boonaree, *Canthium vacciniifolium*, splitjack, *Capparis lasiantha*, and currant bush.

There is a sparse ground cover of grasses including buffel grass (*Cenchrus ciliatus*), nine-awn, curly wind mill grass, love grass, *Paspalidium* spp. and *Sporobolus* spp. Forbes include those mentioned for the lowland brigalow - blackbutt community.

Small isolated clumps of brigalow, often in association with yellow-wood, wilga, false sandalwood, currant bush, have been left as shade trees around dams.

Burrow's Wattle Low Open Mallee Forest

Burrow's wattle (*Acacia burrowii*) was extremely localised and found on the uppermost steep slopes and hill crests of the rocky Permian outcrops west of Ensham. The trees have a mallee habit, there was no shrub layer and very sparse, if any, ground cover.

Fringing Forest and Woodland Communities

These communities are associated with water courses - stream channels, channel benches and adjacent terraces. Several distinct tree associations were identified, however due to their rather limited and often localised distribution, they have not been mapped separately.

Trees of the stream channels include coolibah (*Eucalyptus microtheca*), blue gum (*E. tereticornis*), river red gum (*E. camaldulensis*) black teatree (*Melaleuca bracteata*) and river oak (*Casuarina cunninghamii*).

Trees of channel benches and terraces may include coolibah, Moreton Bay ash, silver leaved iron bark, poplar gum, yellowwood, brigalow, willow wattle, white wood, Leichhardt bean, and red Bauhinia.

Most fringing communities are mixed stands. However a single species may become locally abundant, for example Moreton Bay ash in areas not subject to flooding such as relict levees. Pure stands of coolibah are rare and are confined to channel benches subject to intermittent flooding. More frequently, coolibah occurs in association with yellowwood and other non eucalypt trees and shrubs listed above. Yellow wood is the dominant species in such mixed shrub woodlands.

A good variety of grasses are associated with fringing communities. Awnless barnyard grass (*Echinochloa colonum*) and spiny mud grass (*Pseudoraphis spinescens*) are restricted to permanently wet sites and are found growing at the water's edges.

Other grass species preferring wet or damp situations include weeping love grass (*Eragrostis parviflora*), *Leptochloa* spp. - umbrella cane grass (*L. digitata*) and *L. neesii* and panic grass (*Panicum larcomianum*). More widespread species amongst the

fringing communities include forest blue grass, *Calypochloa gracillima*, buffel grass (*Cenchrus ciliaris*), *Chloris* spp. - windmill grass (*C. divaricata*), tall chloris (*C. ventricosa*), Queensland blue grass, curly windmill grass, clustered love grass (*Eragrostis elongata*), brigalow grass (*P. caespitosum*), shot grass (*P. globoideum*), Warrego summer grass (*P. jubiflorum*) and *Sporobolus* spp.

Sedges include *Cyperus* spp. (*C. bifax* - downs nutgrass, *C. gunnii*, *C. gracilis*, *C. tuberosus*). Forbs include wandering jew (*Commelina cyanea*) and pig weed (*Portulaca oleracea*).

Mixed Woodlands

Mixed woodlands occur on the shallow rocky soils, lithosols and texture contrast soils of the low rises and footslopes around Ensham Homestead.

The composition of the communities is highly variable with brigalow and yellowwood both being locally abundant and often forming a more dense closed community. Other common trees and shrubs include ironwood (*Acacia excelsa*), Leichharts bean, red Bauhinia, whitewood, bottle tree, scrub boonaree (*Heterodendron diversifolium*), false sandalwood and wilga. *Canthium* spp., weeping pittosporum (*Pittosporum phyllicoides*), vine tree (*Ventilago viminalis*), ebony (*Diospyros ferra*), peach bush (*Eretia membranifolia*) and emu apple (*Owenia acidula*) all components of vine thicket, are also found. Eucalypts present include silver leaved ironbark, ghostgum and poplar box.

A variety of grasses are represented and include spear grass, pitted blue grass, buffel grass, tall windmill grass, Queensland blue grass, nine awn, curly windmill grass, *Paspalidum* spp, and *Sporobolus* spp.

Semi Evergreen Vine Thicket - Low Closed Forest

This community also known as softwood scrub is of limited development and distribution occurring on rocky scarps and steep stoney slopes. A good example of this community occurs at the southern end of the tertiary outcrop east of Ensham Homestead.

The community has low tree/tall shrub and low shrub layers that are floristically diverse and variable. Vines are frequent. Species frequently occurring include: *Acalypha eremorum*, *Alectryon connatus*, red ash, quinine bush, broom bush (*Apophyllum anomalum*), blackthorn, *Canthium* spp. (*C. odoratum*, *C. oleifolium*), split jack, currant bush, wallaby apple (*Citrobatus spinescens*) *Croton insularis*, *C. phebaliodes*, *Denhamia oleaster*, *D. pittosporoides*, *Diplospora ixoroides*, ebony (*Diospyros ferrea*), peach bush, *Erythroxylum australe*, *Flindersia dissosperma*, wilga, scrub boonaree, red Bauhinia, *Notolea microcarpa*, emu apple, quinine

berry and vine tree. Vines include *Cissus opaca*, *Jasminium* spp., and caustic vine (*Sarcostemma asutrale*).

Taller trees associated with the community included Burrow's wattle, brigalow, whitewood, bottle tree, belah (*Casuarina cristata*), and yellowwood.

The ground layer is very sparse and is composed of only a few species of forbes and grasses. Hooky grass and *Enteropogon* spp. were most frequent.

Elements of this semi evergreen vine thicket often become prominent in the understorey of the narrow leaved ironbark - bloodwood woodland and the Acacia-mountain yapunyah forests and are components of mixed woodland communities.

Cultivated Open Space

This land is used for cropping. A few scattered eucalypt trees and the occasional bottle tree may remain. Isolated clumps of Moreton Bay ash and poplar gum are present where the land was probably grazed prior to cultivation.

Grazing and/or Disturbed Land

This land is used mainly for the production of beef. The grazing land east of the track leading to Duckponds is scattered with bottle trees and the occasional poplar gum. North of the Nogo River the brigalow scrub has been extensively cleared apart from isolated clumps adjacent to dams.

Regrowth appears to be a problem in many areas. Currant bush (*Carissa ovata*) is a dominant regrowth species as are other thorny species including *Capparis* spp and broom brush and brigalow. Very few paddocks of pure grassland (usually buffel grass) were found. Various stages of regrowth occur on most paddocks ranging from a few low shrubs of current bush and brigalow to tall shrubland containing a variety of species such as - ironwood (*Acacia excelsa*), dead fish, whitewood, false sandalwood, wilga and *Maytenus cunninghamii*. Some paddocks with tall shrubland have been burnt and recleared.

4.7.2 Significance of Vegetation Types

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.

Due to the past clearing of land for grazing and cultivation of crops, no large significant stands of natural vegetation remain on the flatter sections of the study area. The vegetation map produced by Story (1967) indicates that these areas would have been vegetated by grassy eucalypt woodlands, brigalow scrub and mixed shrub woodland.

On the steeper rocky terrain which is unsuitable for crops or pasture, communities of ironbark - bloodwood woodland, lancewood - mountain yapunyah open forests and semi evergreen vine thicket remain. These communities occur north of the Nogoia River. Mixed softwood shrub woodland remains in the vicinity of Ensham Homestead although cattle tracks through this area indicate some grazing of the natural vegetation.

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. Although such communities occur within the proposed mine site, it is not considered that these communities are of significant conservation value due to their small size and human disturbance. Similar pockets of semi evergreen vine thicket and areas of brigalow-mountain yapunyah and brigalow-yellowwood mixed woodland would be expected to occur elsewhere in the region.

4.7.3 Effects on the Vegetation

The mine site and plant areas are located for the most part on land already cleared for agricultural purposes and minimal clearing of native vegetation will be necessary. However clearing of vegetation beyond the proposed mining lease will be necessary for the rail and powerline corridors.

Depending on the extent of the ultimate development of the mine, it may be that some of the fringing riverbank vegetation and the communities on Ensham Hill will also be cleared. But as can be seen from Drawing 3.3 neither of these areas will be mined in the first 15 year mine plan.

Table 4.15 shows the approximate areas of each vegetation type which may be removed from the proposed lease area. Although all of the mixed woodland and semi-evergreen vine thicket could be removed, the conservation significance of these pockets of vegetation is low. Depending on the results of field trials, seeds from these natural communities may be used to rehabilitate disturbed areas thus ensuring an eventual return of the pre-mining vegetation types in the area.

4.7.4 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.

- **Open Space**

Cultivation - crops/stubble

Grazing Land - grass, regrowth, scattered trees.

TABLE 4.15

EXTENT OF VEGETATION TO BE CLEARED

Vegetation Types*	A	B	C	D	E	F	G	H	I	J	K	L	Total
Total Existing Area (ha)	438	90	548	131	27	54	3	671	144	9	3216	3983	9314
Pit Area (ha)	49	-	56	40	8	25	0	300	144	9	1064	1006	2701
Plant Site (ha)	-	10	-	16	-	-	-	15	-	-	66	444	551
Total Clearing (ha)	49	10	56	56	8	25	-	315	144	9	1130	1450	3252
Proportion to be Cleared (%)	11.2	11.1	10.2	42.7	29.6	46.3	-	46.9	100	100	35.1	36.4	34.9

* Refer to Section 4.7.1 and Drawing 4.19.

- A Narrow Leaved Ironbark - Bloodwood Woodland
- B Silver Leaved Ironbark - Bloodwood - Ghost Gum Grassy Woodland
- C Lancewood - Mountain Yapunyah Open Forest
- D Brigalow - Mountain Yapunyah Open Forest
- E Brigalow - Blackbutt Shrubby Open Forest
- F Brigalow - Poplar Box Mixed Low Woodland
- G Burrow's Wattle Low Open Mallee Forest
- H Fringing Forest & Woodland Communities
- I Mixed Woodland
- J Semi Evergreen Vine Thicket
- K Cultivated Open Space
- L Grazing and/or Disturbed Land

- **Wooded Areas**

Woodland
Forest.

- **Farm Dams.**

Forty bird species were observed during the survey (Appendix 8). Particular mention should be given to the occurrence of large numbers of brolgas - flocks of up to 20 were observed feeding amongst the sorghum stubble, but as many as 200 birds have been seen (pers. comm.). Their population numbers have increased with the increased cultivation in the area. Similarly the population of bustards (plain turkey) has increased - up to 4 birds were observed feeding in the grazing pastures south of Duckponds. Other ground feeding birds that were commonly seen included the ground pigeon, pale headed rosella, and cockateil.

Special mention should also be given to the dams which provide a valuable habitat for water birds. The dam adjacent to the brigalow-blackbutt patch in the north west of the study area is both a feeding and breeding habitat for several species including the pink eared duck, grass whistling duck, little grebe and white necked heron (parents with young were observed). The dam in the extreme south west corner may similarly serve as both feeding and breeding habitats.

The only marsupials observed were the grey kangaroo (*Macropus dorsalis*) and the dingo (*Canis familiaris*). The identification of scats indicated the presence of the echidna (*Tachyglossus aculeatus*) and bushtail possum (*Trichosurus vulpecula*). Gordon (1984) has produced a species list for the native mammalian fauna of the brigalow belt and indicates their distribution according to habitat type. It is quite likely that many of the species listed would occur in the area.

Exotic fauna include the rabbit (*Oryctolagus cuniculus*) which was common in both woodland and open space habitats and the feral pig (*Sus scorfa*) and the fox (*Vulpes vulpes*).

Of the reptiles, skinks were common on the stony hillslopes and ridges. Only one species could be identified *Ctenotus leonhardii*. No amphibians were observed.

Aquatic

There are several freshwater ecosystems in the study area including farm dams, swamps, Duckponds Lagoon, Boggy Creek, Winton Creek and the Nogoa River. At the time of the field study the Nogoa River and its major tributaries contained flowing but turbid water. In the larger pools of the Nogoa River swirls

produced by the spotted barramundi or saratoga (*Scleropogon leichardti*) were observed. Fish weighing up to 3kg have been caught in the area (pers. comm.). The saratoga is well adapted to living in billabongs in times of drought.

Sampling for invertebrate benthos and nekton was not undertaken, however whirligig beetles and pond skaters were seen on the surface of pools.

Aquatic organisms in farm dams would provide a food source for some waterbirds.

4.7.5 Significance of Fauna

Gordon (1984) indicates that within the brigalow belt several native mammals have declined in numbers and distribution or may even be extinct, as a result of the clearing of native vegetation and settlement. Two endangered species listed include the Queensland Hairy Nosed Wombat (*Lasiiorhinus 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.

The presence of numerous water birds on the two large dams, at the periphery of the mining area, suggests that these are significant nesting, feeding and shelter sites. However farm dams are relatively common features of the area and the dams within the study area have no significant features which would distinguish them as being a more suitable habitat than other farm dams elsewhere in the region.

4.7.6 Effects on the 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 will 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.

The two large dams which provide breeding sites for a diversity of water birds are not within the areas to be disturbed for the mine and plant areas however noise disturbance may cause the more timid species to seek feeding and nesting sites elsewhere.

Aquatic

The effects of mining on the aquatic ecosystems of the Nogoia River and Boggy Creek should be minimal. All input groundwater and rainfall runoff will be pumped into evaporation ponds and runoff water from the plant site will enter a raw water storage dam. Runoff from the coal washing and crushing area, stockpiles and spoil heaps may contain pollutants deleterious to aquatic ecosystems, however this water will be detained in the raw water dam. It is possible that discharge to local watercourses may occur following an extended period of intense rainfall, however dilution should be such that deleterious effects will not occur. Further details of the water quality aspects are given in Section 4.3.

It is unlikely that disturbance to the Nogoia River due to bridge building and temporary diversions will affect the movements of the saratoga.

4.8 Rehabilitation

4.8.1 Introduction

A general discussion on the rehabilitation strategy proposed for the project is given in Appendix 11. The broad objectives of the strategy can be summarised as follows:

- to provide a rehabilitated landform which is stabilized against accelerated erosion above natural rates and is non-polluting to the contiguous non-lease areas
- to establish a vegetation cover over the rehabilitated landform which is able to recover from natural agents of disturbance such as drought, storms and fire and man-made disturbances likely to occur from selected land uses such as overgrazing sufficiently quickly to maintain stabilization against erosion.

At this time, the proposals for rehabilitation have been investigated in sufficient detail to ensure that the works can be constructed within the limits of the site and will satisfy the broad requirements of the rehabilitation strategy as well as various specific requirements of the Mines Department. Detailed design of the proposed rehabilitation works and their implementation into mining operations will need to be finalized once the detailed mine plan is completed. The detailed mine plan will incorporate and consider the impacts of rehabilitation operations.

4.8.2 Mine Operation

Drawing 3.3 shows the mine site while Drawing 3.2 shows the strip layout for the fifteen year life of the mine at a production of 3.6 million tonnes per annum. The mine extends over areas on both the north and south banks of the Nogoia River. On the north bank, the mine has a total length

of 8.5km and maximum width of 1.2km. On the south bank, the length of the mine is 4.5km with a maximum width of 1.3km.

The development of prestripping and progression of mining is shown in Drawing 3.2. Topsoil will be removed from the areas to be mined prior to removal of prestrip and overburden material and stockpiled. A total quantity of topsoil of some 2 million cubic metres minimum will be required to cover the rehabilitated areas to a minimum depth of 150mm. The location of stockpile sites will be determined during detail of the mine planning phase. The stockpiles will be located away from water courses and be contoured and grassed to minimize erosion. Sedimentation dams will be provided to reduce sediment load in runoff from the topsoil stockpiles prior to discharge into streams.

Prestripping operations will be carried out where the overburden depth exceeds 45m, the maximum depth of dragline operations. Overburden removed by dragline will be placed into the previously mined strip. Prestrip will be removed by truck and shovel and generally placed into the valleys in the spoil areas. However, as described later, the prestrip material may be strategically placed during the mine operation for use in recontouring the spoil areas to achieve the required landform for rehabilitation works.

The nominated strip width is 65m, and the general topography of the spoil areas during mining will be a series of ridges and valleys at 65m spacing, running approximately north - south, intersected by the haul ramps into the high wall area. The estimated maximum angle of repose of the material in the spoil piles is 37°. The estimated volume of overburden material (including prestrip) is approximately 550 million cubic metres, including a swell allowance of 30%.

4.8.3 Final Landform and Drainage

Post-mining Land Use

The Strategy Report (refer Appendix 11) recommends that the land use of the rehabilitated mine area should be non-agricultural, with revegetation to encourage the return of native flora. The primary reasons for selecting this land use option are that recontouring the spoil piles to grades suitable for cropping or grazing enterprises (maximum slopes of 4% and 8% respectively) will not be economical and that development of commercial forest (requiring recontouring to maximum slopes of 17%) is not viable.

Recontouring Requirements

The maximum gradients of landforms which will allow conventional machinery (i.e. a small dozer) to recontour and rip the spoil areas is 24%. However, current practice is for maximum slopes to be approximately 17%, with an upper limit of 20% where steeper slopes are required to construct drainage systems which will operate effectively. As the gradient increases, the slope length

between graded contour banks to prevent erosion is reduced significantly over the requirements for flatter slopes.

For waterways, particularly as these are generally constructed in relatively easily eroded materials, current practice suggests slopes be limited to a maximum grade of 2%. This will result in flow velocities which may be considered non-scouring once vegetation is re-established and would result in only moderate erosion of the waterway prior to full establishment of vegetation. Any erosion of the waterways would be repaired as part of rehabilitation maintenance during mining operations.

Drainage Concept

Within the limits of maximum landform and waterway gradients, a drainage scheme for the recontoured spoil areas has been developed. The rehabilitation scheme involves drainage of the entire mined area, including the spoil areas, external contributing catchments and the final void which is intended to be left open. The most significant drainage feature for the Ensham Coal Project is the drainage of the spoil area and this aspect is discussed below. The other aspects of drainage of the rehabilitated mine area are discussed later in this report.

There are two alternatives for spoil area drainage with current industry acceptance. The first alternative involves a system of lateral waterways running within each spoil valley and draining into a collector waterway. This collector waterway is typically located in the centre of each spoil area (bounded at each end by a haul ramp), but may be located towards one end of the spoil area. The collector drain is graded from the spoil valley adjacent to the final void towards the initial box-cut area. At the toe of the recontoured spoil area, the runoff is collected into a drain running parallel to the spoil valleys and discharged via the ramps into the final void.

Obviously, this scheme will be most practical in mines where the overburden depth is relatively small and the coal seam is dipping slowly. In cases where the seam depth is relatively large, it is not practical to drain the entire spoil area by a central waterway system. An alternative is to pond all runoff from the area into small, non-discharging storages constructed in the spoil valleys. The water level in these storages would fluctuate due to rainfall and evaporation. However, because of the typically high evaporation rates in Central Queensland and the small catchment area of each storage, these storages would typically be empty for extensive periods.

The drainage scheme proposed for the recontoured spoil areas at Ensham involves a mix of these two alternative approaches. The depth of the coal seam does not allow a central collector waterway system to be constructed over the whole spoil area. In the areas

which cannot be drained, runoff will be ponded within the spoil area. These areas are typically located in the spoil areas generated from the first three to five mining strips. Drawing 4.21, Pit "D" Drainage Plan shows the proposed drainage scheme for Pit "D" on the north side of the river, whilst Drawing 4.22, Drainage Plan Pit "B" shows the proposed drainage scheme on the south side of the river. The features of this scheme are noted below.

- Landforms are graded generally at 17%. However, where a steeper gradient will allow the extension of a collector waterway and thereby improve the overall drainage design, a maximum slope of 20% may be used.
- At the final void, the high wall will be blasted to provide a face with a maximum slope of 50%. Blasted material will be thrown into the final void. In addition, the spoil areas adjacent to the final void will be reworked to provide a maximum slope of 20%.
- Along the haul ramps, the spoil areas will be regraded to 17% slopes. The ramp slope will remain at the dip of the coal seam (maximum 5 degrees at Ensham). Graded contour banks will be constructed at a maximum 2% grade along the face of the final void and around the face along the haul ramp to discharge into the haul ramp (which drains into the final void).
- A channel running diagonally across this face from natural ground level will convey collected water into a drain running along the toe of the spoil area into the ramp to be discharged into the final void.
- From the upstream end of the diagonal drain, a central collector drain will be constructed at a maximum grade of 2% through the spoil area. Where the levels of the spoil valleys permit (after recontouring), each spoil valley will be recontoured to provide a lateral drain discharging into the collector drain. In instances where the invert of the collector drain is above the floor of the spoil valley, some pondage of water will occur prior to discharge into the waterway. This is considered an ideal situation since this ponded water will reduce the amount of runoff required to be carried by the waterway and will act as a sediment trap. In these cases, the spoil valleys will be recontoured to provide a maximum depth of pondage of 2m.
- In cases where the invert of the collector drain rises significantly above the floor of the spoil valleys, prestrip material will be dumped into the valleys and the spoil piles recontoured to form a 'plateau' with graded contours to direct runoff into the head of the collector drain. In these areas, which typically occur towards the final void, slopes of

the lateral and main collector waterways can be maintained below the 2% maximum.

- In the areas towards the toe of the spoil areas where the spoil valleys cannot be regraded to discharge into the collector drain (i.e. the invert of the collector drain is above the valley floor), internal pondages will be constructed. These ponds would be constructed so that each pond will overflow during large storm events into the adjacent pond until the overflows can be directed into a valley with a lateral connection into the collector waterway. Specific features of the design of these internal pond systems are discussed below.

Differential settlement of spoil in the rehabilitated areas may alter grades of graded contour banks and waterways. If this settlement occurs during the mine life repairs to graded banks and waterways will be made to ensure that stability is maintained and that the vegetation becomes fully established. After completion of mining, any damage to the graded banks will have negligible impact on stability as the role for the graded banks has been replaced by the vegetation cover. Damage to waterways has a more significant impact. However, in this proposal, the waterways are designed to operate relatively infrequently and only directly drain a small part of the rehabilitated area. Overall stability of the rehabilitated area is expected to be maintained by allowing the vegetation time to repair disturbances.

Drainage Plan

Drawing 4.23, and 4.24, show the proposed drainage plan for the rehabilitated mine areas for the Ensham Project. Apart from one small catchment above the final void at the northern end of Pit "D", all external catchments drain away from the toe of the spoil areas and the high wall. Therefore, the only drainage to be considered in the recontouring of the mine area is generally confined to the spoil areas. The only other feature of external catchment drainage is the Boggy Creek Diversion which runs along the high wall of Pit "E" and through the corridor between Pits "D" and "E". This channel will be designed to convey the flood flow from a specific storm event (e.g. a 1 in 100 year storm). For larger flows, the diversion channel will overtop and flow will discharge into the final void.

Drawing 4.24 also shows where sedimentation dams will be constructed during mining operations to collect runoff from the partially rehabilitated spoil areas prior to discharge into natural watercourses.

Drawing 4.21 and 4.22 show a typical cross-section through the spoil areas. Based on current mine planning data, the extent of the recontoured spoil areas has been determined to ensure that the final landform can be constructed within the limits of the mine area and that the concepts for drainage described above can be implemented. These figures indicate that the recontoured spoil areas can be constructed within the following limitations:

- all rehabilitation works will be located within the proposed lease boundaries.
- all rehabilitation works will fall within artificial surface features such as haul roads and powerlines
- the mine plan allows the proposed rehabilitation works to proceed.

Detailed design of the drainage scheme will be completed as part of the detailed mine planning phase which will include the interaction between rehabilitation and mining operations.

Collector Waterways

A large portion of the mine area can be drained by a system of waterways, as shown on Drawing 4.24. These waterways will be constructed within the grade limits discussed. However, the collector waterways will have slope lengths of up to 1.0km and it will be required that rock weirs of 1m maximum height be constructed at intervals along the waterways to break the flow in order to minimize the risk of scour and to control sediment discharge.

Internal Pondages

The design of the internal pondage system as proposed differs from the concepts currently in vogue in the industry by attempting to minimize the risk of failure during overflows from the ponds. From hydrological work already undertaken, these internal pondages will be subjected to overflows during larger storm events. These overflows could lead, ultimately, to the formation of large gullies in the spoil valleys and the generation of significant erosion hazard if adequate measures are not taken to prevent failure. The concept proposed for Ensham is to dam the spoil valleys at both ends (i.e. adjacent to the ramp at one end and the central waterway at the other) with fill material of sufficient lateral extent (say 100m) to prevent piping failure of the dam and of sufficient height to prevent overtopping at the valley ends.

A "spillway", or emergency overflow section would be formed by breaching the ridge between the spoil valleys. This spillway would be lower than the dam walls at the ends of the valley and of such width to maintain low flow velocity over the spillway and hence

reduce the potential for erosion of the spillway. The internal pondages would be arranged to overflow from one to another towards the final void until the overflow from the final pond can be discharged into a lateral spillway draining into the central collector waterway. The spillways will be staggered in lateral location to prevent channeling of flow from one spillway to the next and constructed at such elevations that the energy to be dissipated across the spillways during overflow will not erode the spillway channel.

Preliminary hydrological investigations of both long term rainfall data and short duration storm rainfall data has indicated that internal pondages are expected to overtop relatively infrequently (in the order of once every 20 years on average). In the intervening periods between "wet" seasons it is expected that evaporation will exceed rainfall (on average) and that the internal ponds may be dry for periods of up to 10 years. Applying the concept described for operation of internal pondages with spillways, it is feasible to design the required heights of end walls and spillway levels so that overtopping will only occur for storm events of a specified magnitude (e.g. a 1 in 50 year storm event).

Final Void Pondage

The final void has a contributing catchment generally limited to the rehabilitated spoil areas, except for a small external catchment at the northern end of Pit "D". Available daily rainfall data in the area and results of storage behaviour analyses conducted by Blain Johnson Pty Ltd previously for sites in the region (near Blackwater) have been reviewed to evaluate the storage behaviour of the final void.

From the 90 years of rainfall data available, a trend of extensive 'dry' periods followed by one to three months of heavy rainfall is evident. Evaporation in the area is much greater than rainfall on average and because of the volume of runoff expected from the relatively small catchment area compared with the volume of the final void, it is predicted that the final void may be dry for extended periods of time. From the review undertaken for this study, it is not considered likely that the final void pondage will fill to overflowing.

Erosion Control

The primary natural disturbance which will endanger the long term stability of the rehabilitated landforms is erosion. The minimization of erosion potential has been of primary concern in the formulation of the rehabilitation proposal. The use of maximum gradients for recontoured slopes and waterways, construction of graded contour banks to limit slope lengths and rock weirs in collector waterways are the primary erosion prevention measures.

These measures will be supplemented by the re-vegetation of the recontoured areas. Ultimately, the vegetation cover will be the primary erosion control mechanism. The purpose of the re-vegetation is to provide stability to the slopes to control sheet erosion. A key element of the mine operation will be the maintenance and cultivation of treated spoil areas to ensure full establishment of the vegetation prior to cessation of mining activities.

Drainage Control During Mining

Recontouring activities will proceed in parallel with the mining operation. Prior to completion of the mine, runoff from the recontoured spoil areas which discharged towards the toe of the spoil will need to be diverted into sedimentation dams before discharging into natural streams.

Drawing 4.24 shows the proposed locations of these sedimentation dams. The required sizes and overflow requirements will be determined from hydrological analyses completed during the detailed mine planning phase.

4.8.4 Revegetation

It is proposed to revegetate the recontoured mine areas with grass and native tree and shrub species. The recontoured areas will be covered to a minimum depth of 150mm with topsoil and planted with grass, acacia and eucalyptus seeds. The seedlings will be supplemented with plantings of eucalyptus seedlings.

The establishment of grass coverage is important in the early stages of the rehabilitation works, as this will be the principal form of stabilization against erosion. As the tree and shrub species grow, the role of the grass in erosion control will be relinquished to these flora.

The spreading of topsoil, application of fertilizer and maintenance of the vegetation will conform to the established guidelines. In the early years of mine operation, trials of various plant species will be conducted to determine the most suitable varieties for the site.

4.8.5 Rehabilitation Management

A number of rehabilitation management objectives and principles have been incorporated in the engineering of the Ensham Coal Project. These objectives and principles have been approved and accepted by the joint venture partners. The objectives and principles are set out below.

- The Ensham Coal Project has a stated rehabilitation policy: To conduct necessary rehabilitation measures to return all disturbed land to a cover of native trees and shrubs with an understorey of grass.

- The Project will employ a full time Mine Rehabilitation Officer responsible for implementing this policy.
- The proposals in this report are to be engineered in detail in parallel with detailed mine planning during the mine project. Any significant mine planning changes will also require a review of rehabilitation plans.
- The engineering of the Project has included all machinery and resources, both company owned and contractor supplied necessary to conduct rehabilitation.

4.9 Future Possible Floodplain Mining

At some time in the future beyond the initial 15 year mine plan, it may be proposed to mine within the floodplain of the Nogoia River to maximise the volume of coal extraction. One way in which this could take place is by the construction of a series of isolated bunded mining blocks. Such mining could take place in the area shown on Drawing 4.8.

4.9.1 Surface Water Effects

The mathematical model used to assess the effects of pits "B" and "C" on flood flows (Munro Johnson & Associates, 1986), was modified to include the proposed mining block surrounded by flood levees in various positions across the floodplain. A number of alternative designs were considered with an initial block width of 500m being modelled and this was increased in 200m steps to 1,100m.

Within the general guidelines of the Water Resources Commission, the model analysis concluded that for all flow conditions and the full range of widths of pits studied, increased flow velocity is not a controlling factor. However, based on the assessment of increased flood levels upstream, a maximum mine block width of 600m was recommended. This is also a convenient width of "block" to fit in with the overall concept of mining across the floodplain. This width of block would result in an increase in flood level of 100mm at the upstream boundary of the open cut area. This is considered acceptable. The increase in flood levels and the maximum velocities for the 600m block width are shown in Table 4.16.

Table 4.16
Flood Effects from Floodplain Mining

Probability of Flood	Increase in Flood Level (m)		Maximum Flow Velocity (m/s)		
	With Levee Around Pits B & C Without Block	With 600m Block	Existing Conditions	Levee Pits B & C Without Block	With 600m Block
5%	0.05	0.05	0.58	0.59	0.66
2%	0.05	0.07	0.58	0.61	0.70
1%	0.06	0.09	0.60	0.64	0.73
MF*	0.08	0.10	0.69	0.78	0.89

* *Probable Maximum Flood*
Source: Munro Johnson & Associates, 1986

Details of the construction and mining of the 600m wide block in the floodplain are given on Drawings 4.10 and 4.11. The proposed method will require the overburden from the initial strip to be stored outside the floodplain and to be returned to fill the last strip of the final block. All other strips will be filled by overburden from the successive strip in the conventional manner except that it will be dumped in such a manner that it does not interrupt the existing aquifer. Any excess overburden as a result of bulking will be disposed of outside the floodplain to ensure that the post mine ground level is the same as that which existed prior to mining commencing.

4.9.2 Groundwater Effects

Numerical modelling has been carried out for the various options for mining coal under the alluvium after the fifteen year initial mine life. Results show that the minimal interference with groundwater flow would occur using clay cut-off trenches to isolate each mining pit as it is constructed. As the recent alluvium in the area has a minimum width of a little less than 3km, virtually no impact on the existing groundwater flow regime would be expected during the mining process by the blocking of the groundwater flow by the groundwater cut-off barrier around each mining block.

During mining, the overburden from successive cuts will be dumped in a sequence designed to reconstruct the original stratigraphic profile. As each

block is mined out, the cut-off barrier will be removed and the alluvium reinstated to enable the pre-existing groundwater flow to be reinstated.

The volume of groundwater to be removed from each pit is estimated to be between 140 and 220ML/day based on a specific yield of 0.1 and an average depth of saturated material of 4 to 6m. Inflow rates into the pit when first opened have been calculated to be between about 3 and 6m³/day for each metre of trench (Munro, Johnson & Associates 1986). Maximum inflow will then reduce to 0.8ML/day over a 600m cut assuming the first cut is located adjacent to a clay cut-off trench.

It is proposed to dewater each pit using a sump pump, with the pumped water being used in mining operations when required. This water will be discharged to evaporation dams as described in Section 4.3.6.

4.9.3 Nogoa River Diversion

To achieve maximum extraction of the coal, diversion of the existing river channel will be necessary. A detailed investigation into re-routing the river has not been undertaken at this stage, as the tonnage required for a 15 year operation of the mine is contained in the pits outside the floodplain. However, as part of the overall feasibility study report for the proposed Ensham Coal Project, the possible diversion was addressed. Outlined below are the statutory regulations associated with approval of major diversion works, relevant design criteria, and the approach to design of the diversion.

Statutory Requirements

It is considered that diversion of the Nogoa River would require approval under Section 73A of the Water Act because of the magnitude of the works and not a waterworks license as described for the Boggy Creek diversion.

It is noted that the Water Act is currently under review and the area of stream diversion is being considered in that review. Therefore, the mechanism for approval of the proposed diversion of the Nogoa River may be different at the time the works are implemented and the statutory requirements will be re-addressed at that time.

In addition, the advice of the Department of Environment and Heritage will be sought with respect to adverse environmental impacts associated with the proposed diversion and included with the other design considerations.

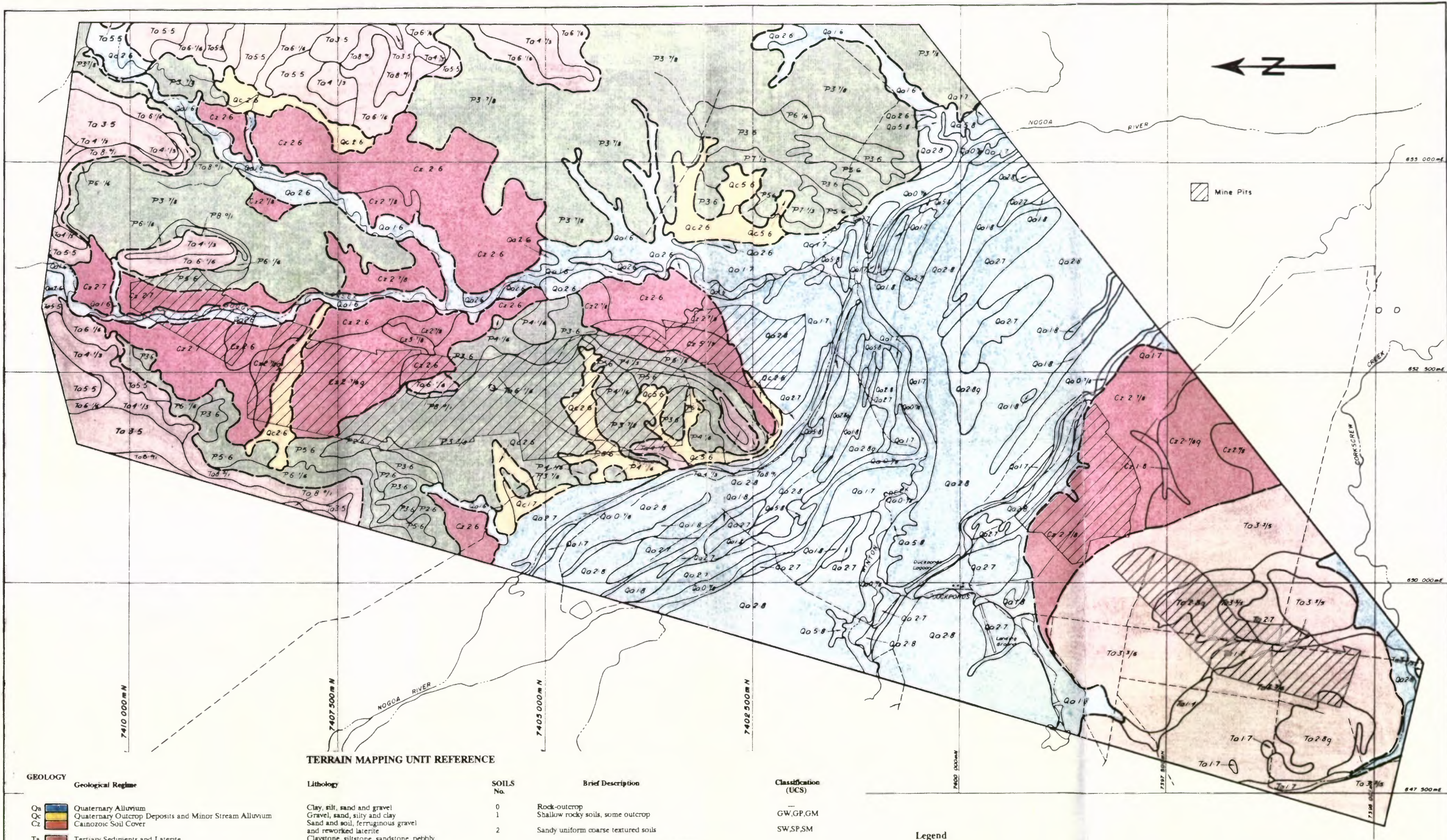
Design Aspects

A brief assessment of the detailed investigations which are appropriate in a hydraulic study of river diversions has been made (Munro Johnson & Associate, 1986). The various aspects considered are summarised as:

- the development of diversion alternatives considering hydraulic aspects
- the effects of flooding on upstream and downstream developments
- scour of the diversion channel
- sediment movement and deposition
- passing of low flow and meeting riparian requirements
- consequences of flooding above levee height (based on design flood).

The principal considerations in the design would be scour of the channel and consequent increased sediment deposition and flooding effects both upstream and downstream.

In the specific case of diversion of the Nogoia River, the model indicates that the diversion channel would provide a similar bankfull capacity as the existing stream channel. The floodplain would remain essentially unaltered except for a protective levee around the isolated mine pit. The scheme for diversion is expected to result in minimal adverse impact under "floodplain" flow conditions. However more detailed design will be undertaken at the appropriate time before any decisions are made.



TERRAIN MAPPING UNIT REFERENCE

GEOLOGY

Geological Regime

- Qa Quaternary Alluvium
- Qc Quaternary Outcrop Deposits and Minor Stream Alluvium
- Cz Cainozoic Soil Cover
- Ta Tertiary Sediments and Latelite
- P Upper Permian/Lower Triassic, Undifferentiated:- Burngrove and Rewan Formations

Lithology

- Clay, silt, sand and gravel
- Gravel, sand, silty and clay
- Sand and soil, ferruginous gravel and reworked laterite
- Claystone, siltstone, sandstone, pebbly sandstone, gravel, laterite
- Carbonaceous mudstone, interbedded mudstone and fine lithic sandstone, carbonaceous lithic and feldspathic sandstone

SOILS

- 0 Rock-outcrop
- 1 Shallow rocky soils, some outcrop
- 2 Sandy uniform coarse textured soils
- 3 Gravelly sand to clayey sands, uniform or weakly gradational soils
- 4 Sandy to silty coarse to medium textured soils - sandy loams, silty clay loams etc. mostly uniform or weakly gradational profile
- 5 Mostly, gradational locally uniform medium-textured (sandy to clay loam) surficial soils grading to finer textured light or light - medium clay subsoils
- 6 Uniform, gradational or duplex soils with medium clay or sandy clay subsoils.
- 7 Uniform, gradational or duplex soils with medium to heavy clay subsoils.
- 8 Cracking clay soils

Classification (UCS)

- GW,GP,GM
- SW,SP,SM
- GM-SC or SM-SC
- ML-CL or SC/CL-ML
- SC-CL, CL or SC/CL
- SC-CL/CL-CH or CL-CH
- SC to CL-ML/CH
- CH

LANDFORM

No.	Surface Form	Slope Range (%)
0	Stream channels and banks of major streams and braided stream systems:	-
1	Drainage flats and depressions; poorly drained, floodprone	<1
2	Alluvial plain and gentle outwash slopes, valley floors, prior levees and stream terraces; near flat or very gently sloping	<2
3	Undulating plain, broad low rises and interfluvies	Up to 5 (mostly 1-3)
4	Low rises, eroded plateau crestal areas and benched marginal slopes around the plateau margins	Up to 12 (mostly 3-5)
5	Gentle to mod. steep footslopes and outwash slopes	5-12
6	Mod. steep mostly middle and lower hillslopes, dissected footslopes	12-35
7	Mod. to steep dissected and eroded ridge and hill slopes	25-33
8	Steep escarpment, ridge and hill slopes	33-66
9	Very steep escarpment slopes	>66 (locally sub-vertical)

Example

Geology	Terrain Mapping Unit Symbol	Soils
Ta	3	5

Notes: (1) Suffix "g" indicates intensive gully development is evident from the air photos or from ground observations.
(2) For more detailed descriptions of Terrain Mapping Units - refer to Report Text - Appendix A

Legend

- Geological Regime Boundary
- Terrain Unit Boundary and Symbol

0 500 1000 1500 2000 2500metres

ENSHAM COAL PROJECT



HOLLINGSWORTH DAMES & MOORE

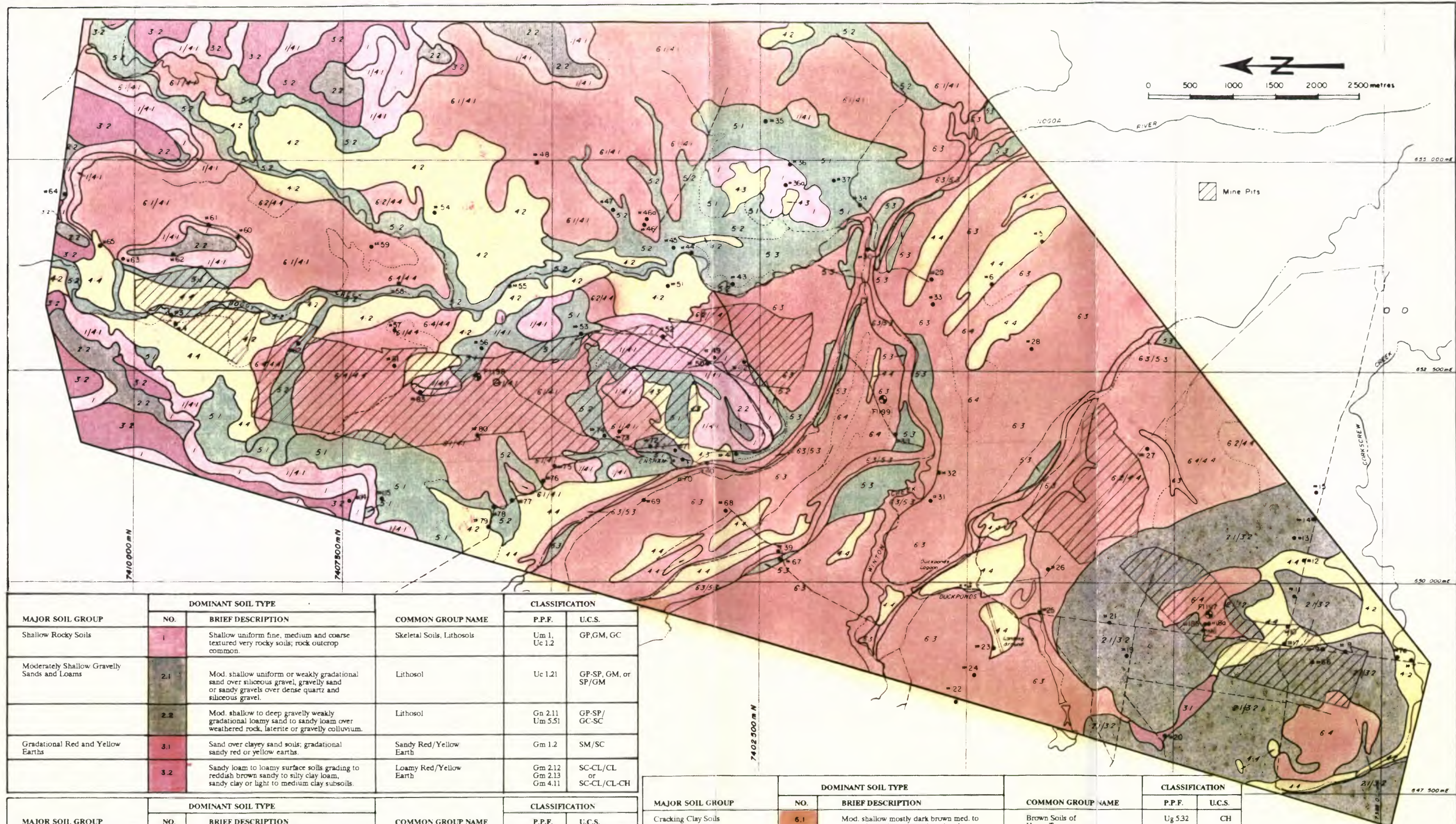
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TERRAIN UNITS

DATE MARCH, 1990

DRG. APPR'D.

DRG. NO. 4.1



MAJOR SOIL GROUP	DOMINANT SOIL TYPE		COMMON GROUP NAME	CLASSIFICATION	
	NO.	BRIEF DESCRIPTION		P.P.F.	U.C.S.
Shallow Rocky Soils	1	Shallow uniform fine, medium and coarse textured very rocky soils; rock outcrop common.	Skeletal Soils, Lithosols	Um 1, Uc 1.2	GP,GM, GC
Moderately Shallow Gravelly Sands and Loams	2.1	Mod. shallow uniform or weakly gradational sand over siliceous gravel, gravelly sand or sandy gravels over dense quartz and siliceous gravel.	Lithosol	Uc 1.21	GP-SP, GM, or SP/GM
	2.2	Mod. shallow to deep gravelly weakly gradational loamy sand to sandy loam over weathered rock, laterite or gravelly colluvium.	Lithosol	Gn 2.11 Um 5.51	GP-SP/ GC-SC
Gradational Red and Yellow Earths	3.1	Sand over clayey sand soils; gradational sandy red or yellow earths.	Sandy Red/Yellow Earth	Gm 1.2	SM/SC
	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/Yellow Earth	Gm 2.12 Gm 2.13 Gm 4.11	SC-CL/CL or SC-CL/CL-CH

MAJOR SOIL GROUP	DOMINANT SOIL TYPE		COMMON GROUP NAME	CLASSIFICATION	
	NO.	BRIEF DESCRIPTION		P.P.F.	U.C.S.
Texture Contrast (Duplex) Soils	4.1	Shallow gravelly brown to reddish brown duplex soils with an alkaline med. - heavy clay subsoils over weathered rock.	Solodic, Solodized Solonetz	Db 3.13 Db 1.13 Dr 2.13	CL-ML/CH
	4.2	Mostly deep sandy to loamy surface duplex soils with brown or reddish brown medium clay subsoils.	Solodic	Dr 2.13 Db 1.13	CL-ML/CL-CH
	4.3	Mod. shallow stony surface brown or reddish brown soils.	Solod	Dr 2.11	SC-CL/CL-CH
	4.4	Deep mostly thin loamy surface duplex soils with dark brown or dark reddish brown alkaline med. to heavy clay subsoils.	Solodic	Db 1.13 Dr 2.13	CL-ML/CH
Uniform Fine-Textured (Non-Cracking) Soils	5.1	Mod. shallow surface brown or reddish brown uniform medium to heavy clay soils over weathered rock.	Lithosol, Reddish Prairie Soil	Uf 6.11 Uf 6.12	CL-CH or CH
	5.2	Mod. deep mostly uniform dark brown silty light to medium clay soils, with some gravelly lenses included; some occurrences of soil type 4.2 are associated.	Alluvial Soils	Uf 6.21 Uf 6.12 Uf 6.32	CL-CH or CL/CL-CH
	5.3	Deep mostly uniform dark brown, reddish brown or brownish black medium to heavy clay soils (incipient cracking clay); some occurrences of soil type 4.4 may be associated.	Alluvial Soils	Uf 6.32	CH

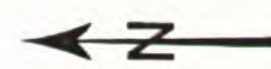
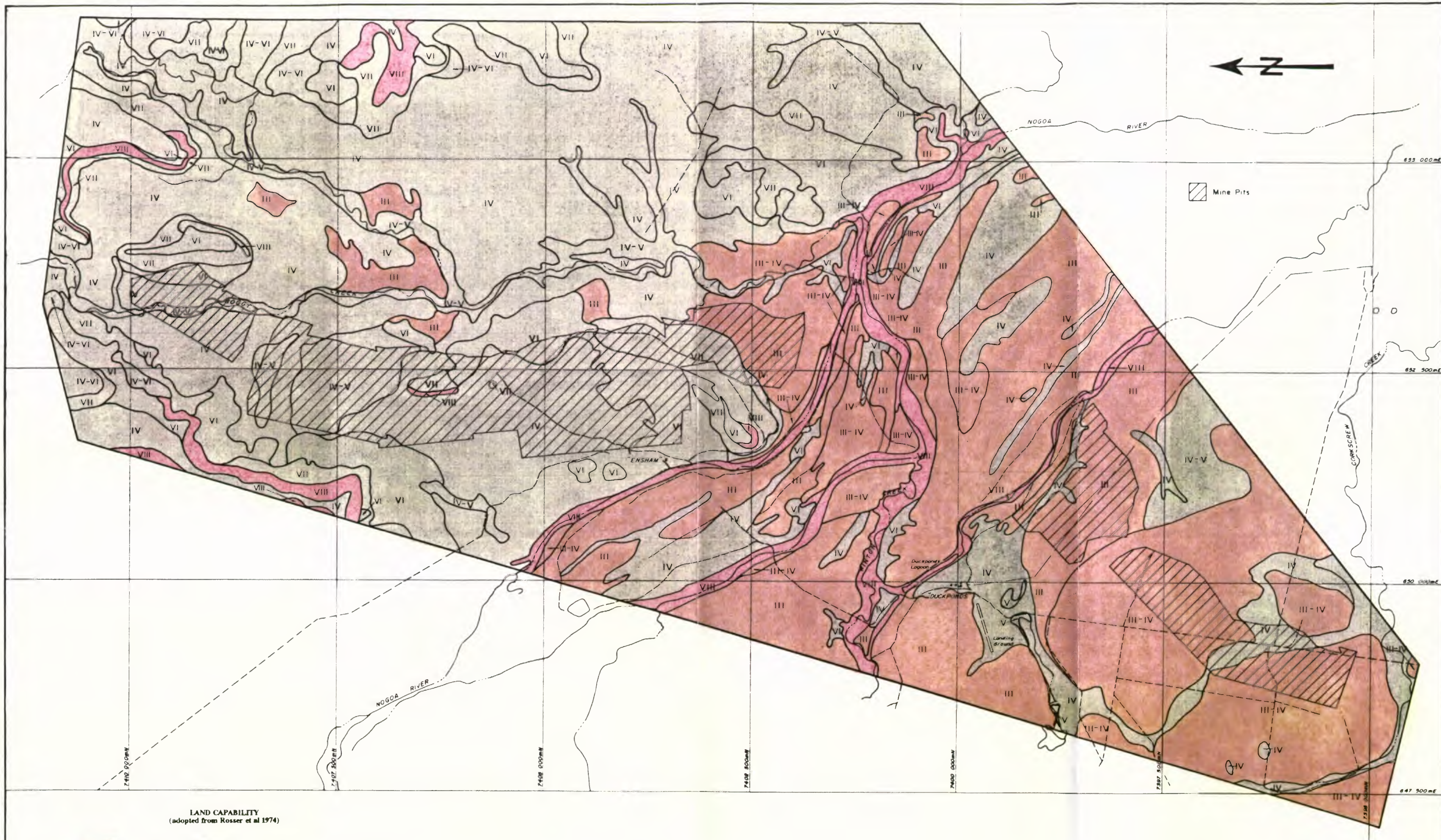
MAJOR SOIL GROUP	DOMINANT SOIL TYPE		COMMON GROUP NAME	CLASSIFICATION	
	NO.	BRIEF DESCRIPTION		P.P.F.	U.C.S.
Cracking Clay Soils	6.1	Mod. shallow mostly dark brown med. to heavy clay soils over weathered rock; considerable surficial stone may be present.	Brown Soils of Heavy Texture, Black Earth	Ug 5.32	CH
	6.2	Mod. to deep dark brown uniform med. to heavy clay soils on older alluvial materials.	Brown Soils of Heavy Texture	Ug 5.34	CH
	6.3	Deep brownish black or dark grey uniform med. to heavy clay soils on alluvium.	Grey-Brown Soils of Heavy Texture	Ug 5.15 Ug 5.25	CH
	6.4	Gilgaied, deep grey uniform med. to heavy clay soils.	Grey Soils of Heavy Texture	Ug 5.25 Ug 5.28	CH

Legend

- #4 Soil Sample Location Number
- F1197 Overburden Sample Location
- (2) Major Soil Group Boundary
- 2.2 Soil Group Variant

ENSHAM COAL PROJECT

HOLLINGSWORTH DAMES & MOORE			
TITLE		SOILS	
DATE	MARCH, 1990	DRG. APPR'D.	DRG. NO. 4.2



Mine Pits

LAND CAPABILITY
(adopted from Rosser et al 1974)

Land Class	Description
I	Land suitable for all agricultural and pastoral uses with few if any limitations.
II	Land suitable for agricultural uses but with slight restrictions with respect to; crop/productivity, use of machinery for cultivation or soil conservation constraints.
III	Land suitable for agricultural uses but with moderate restrictions with respect to; crop/productivity, cultivation or soil conservation restraints.
IV	Land primarily suited to pastoral use but which may be used for occasional cultivation/cropping with careful management.
V	Land which would be arable but has limitations which unless removed, make cultivation impractical/uneconomic.
VI	Land which is not suitable for cultivation but is well suited to pastoral use - pasture improvement using machinery is practicable.
VII	Land which is not suitable for cultivation but on which pastoral use is possible - pasture involving use of machinery is not practicable.
VIII	Land with such severe limitations that it is unsuited for cultivation or grazing.

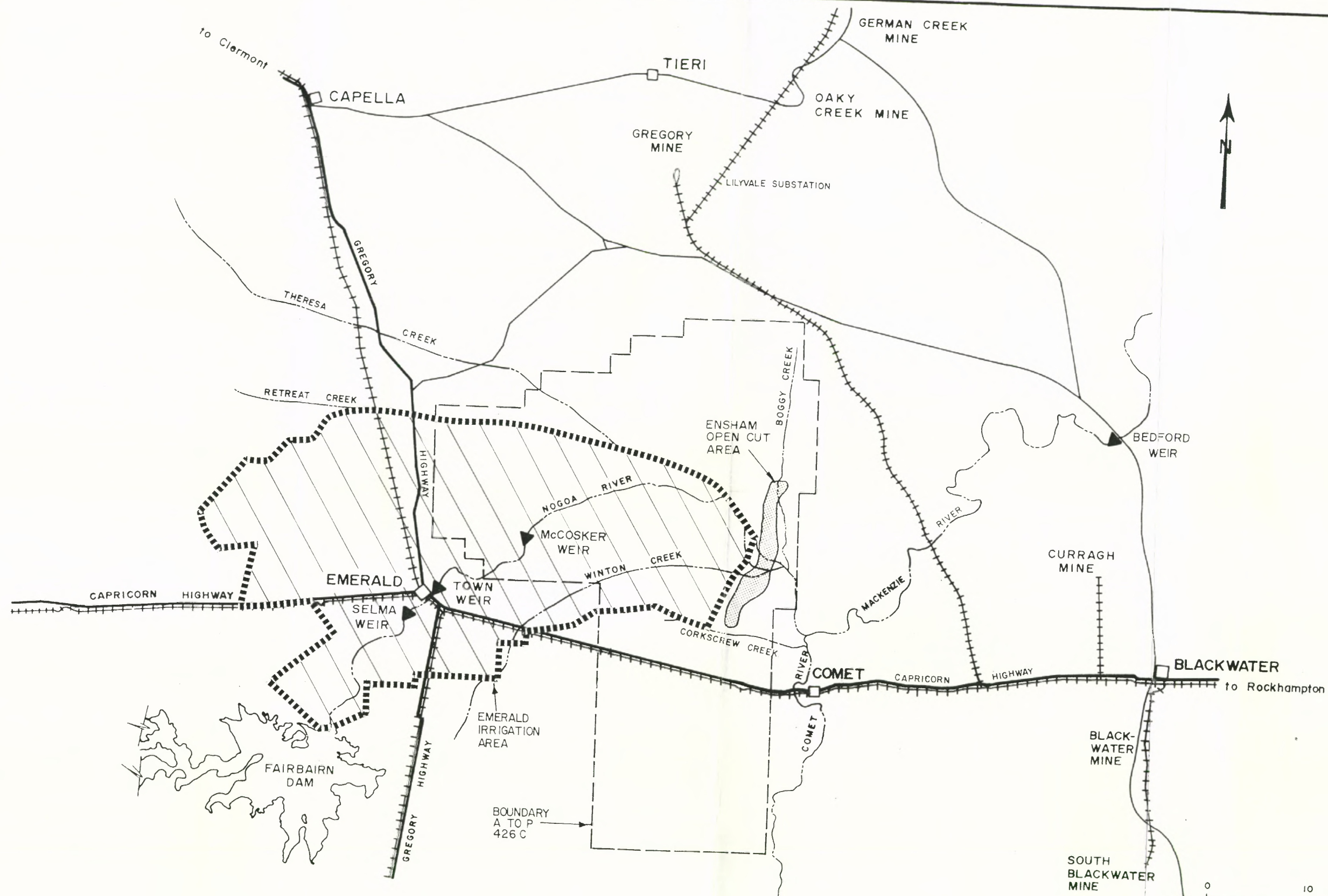


ENSHAM COAL PROJECT

HOLLINGSWORTH DAMES & MOORE

TITLE **LAND CAPABILITY**

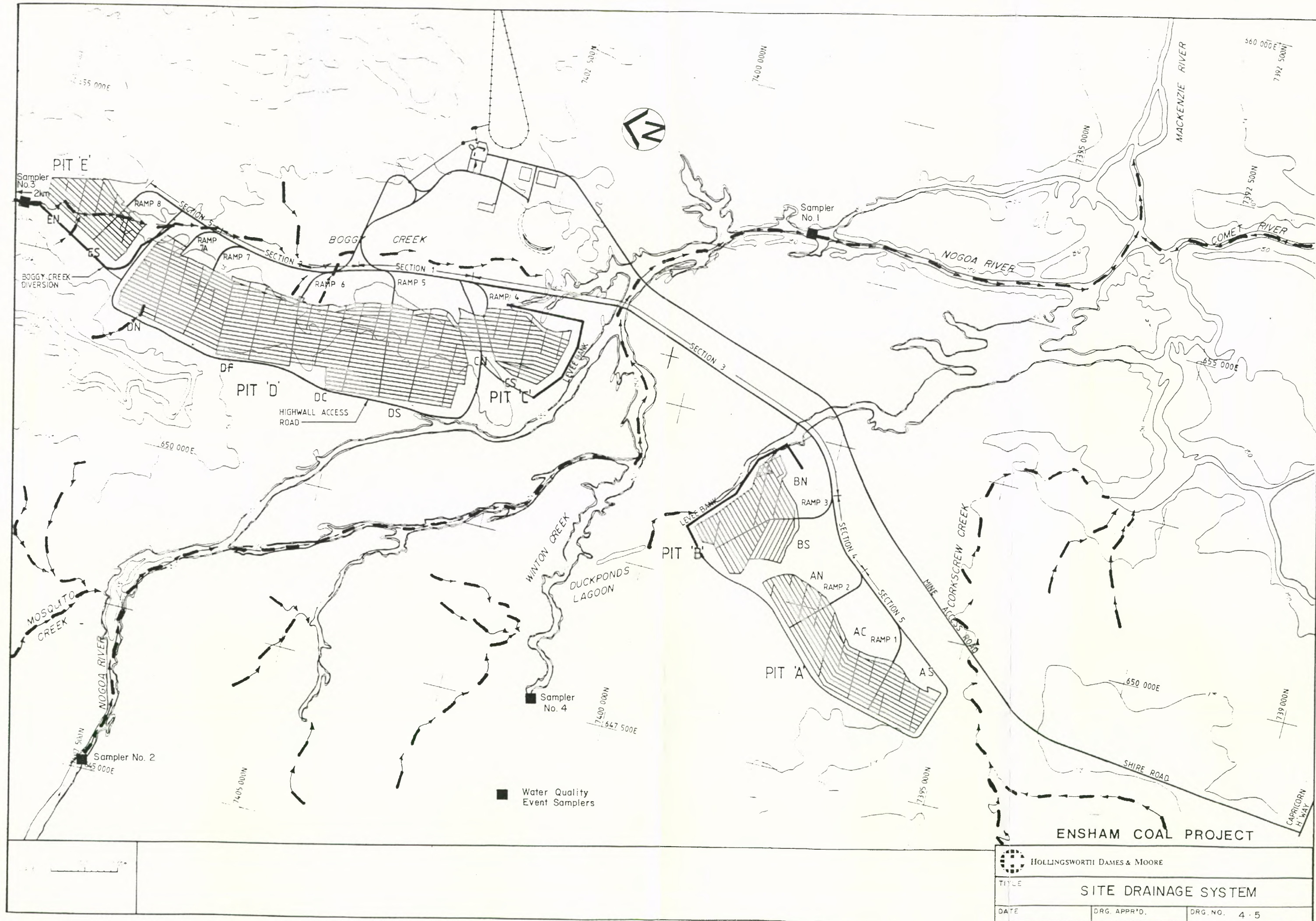
DATE **MARCH, 1990** ORG. APPR'D. ORG. NO. **4.3**

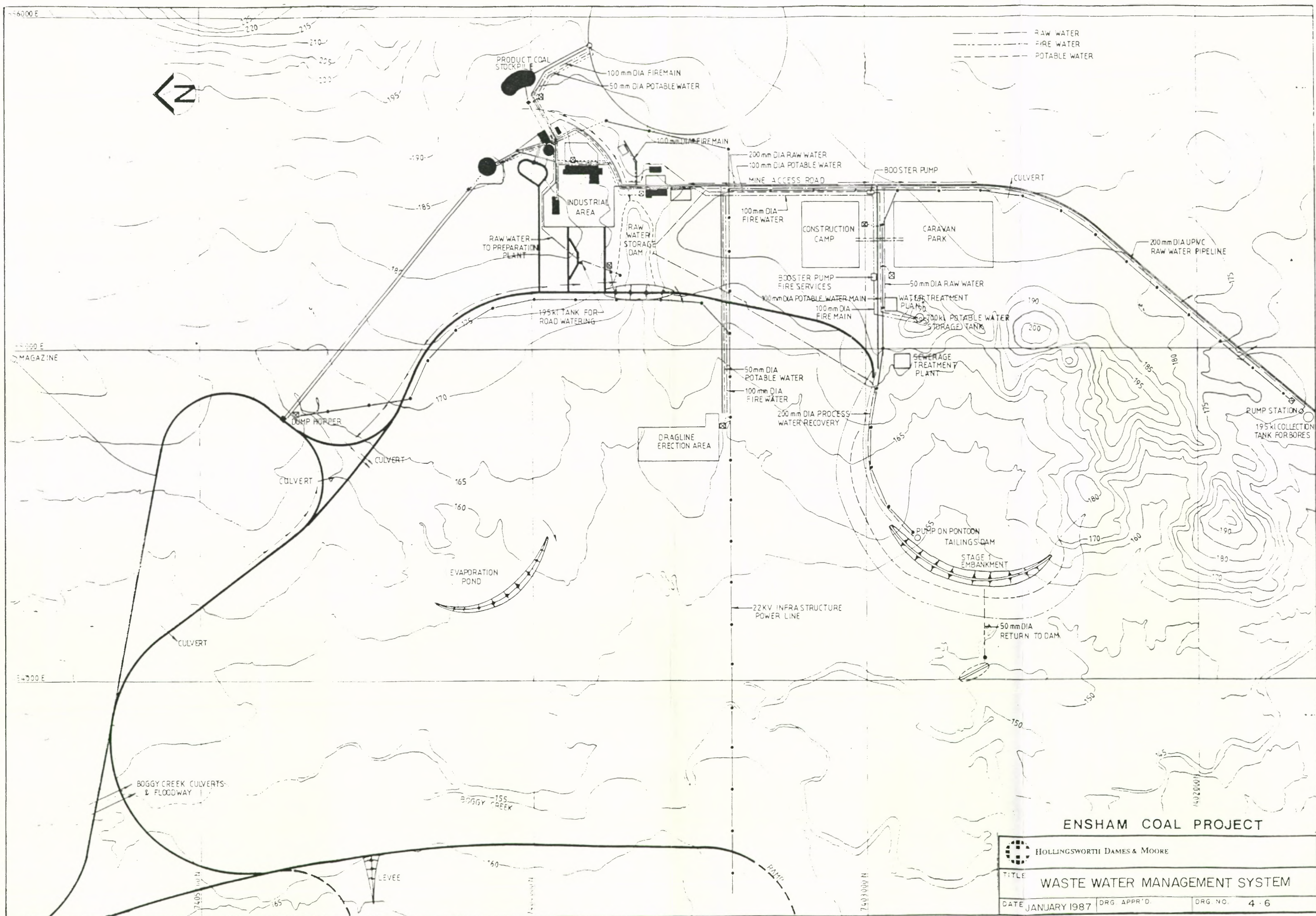


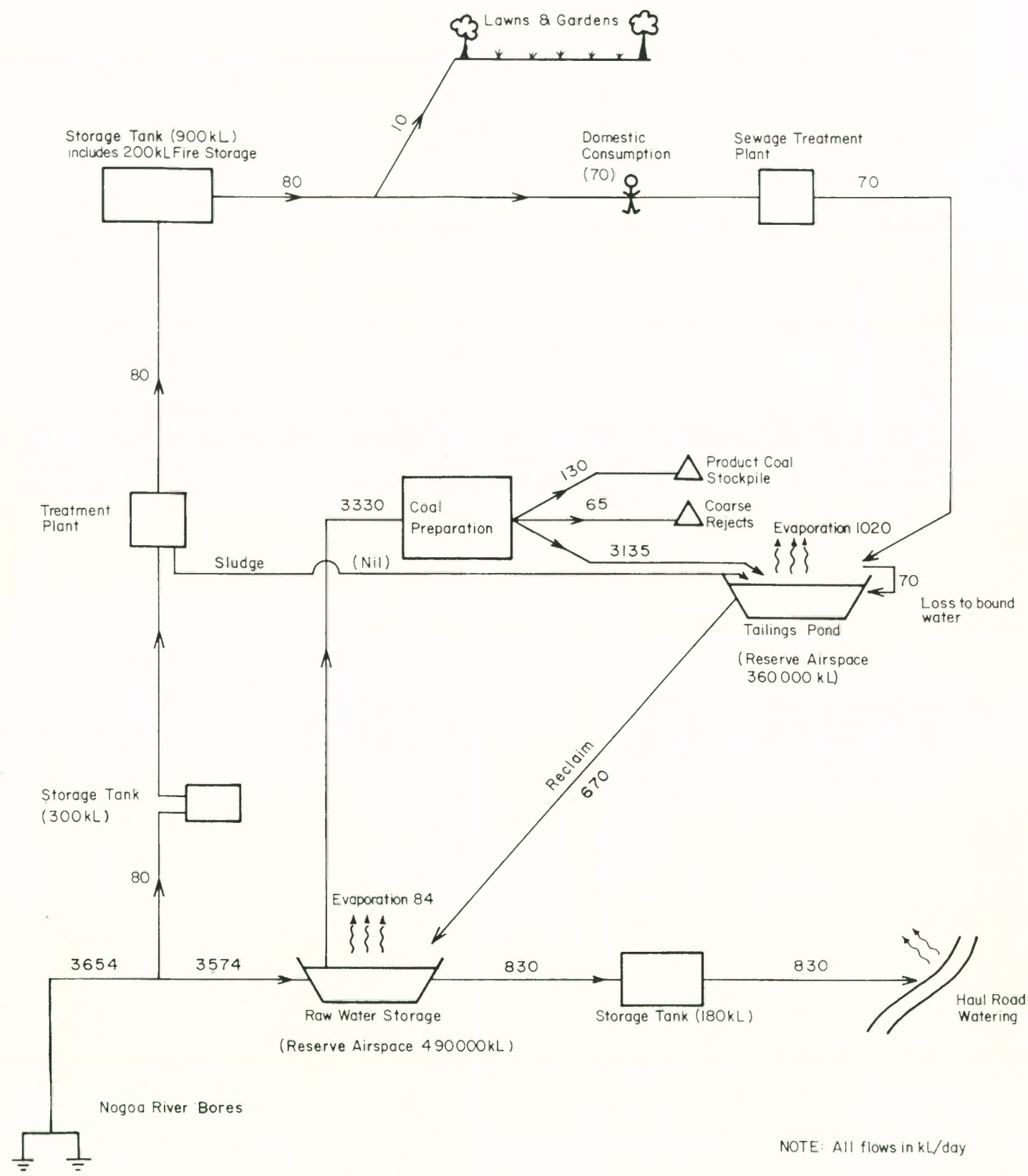
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ENSHAM COAL PROJECT

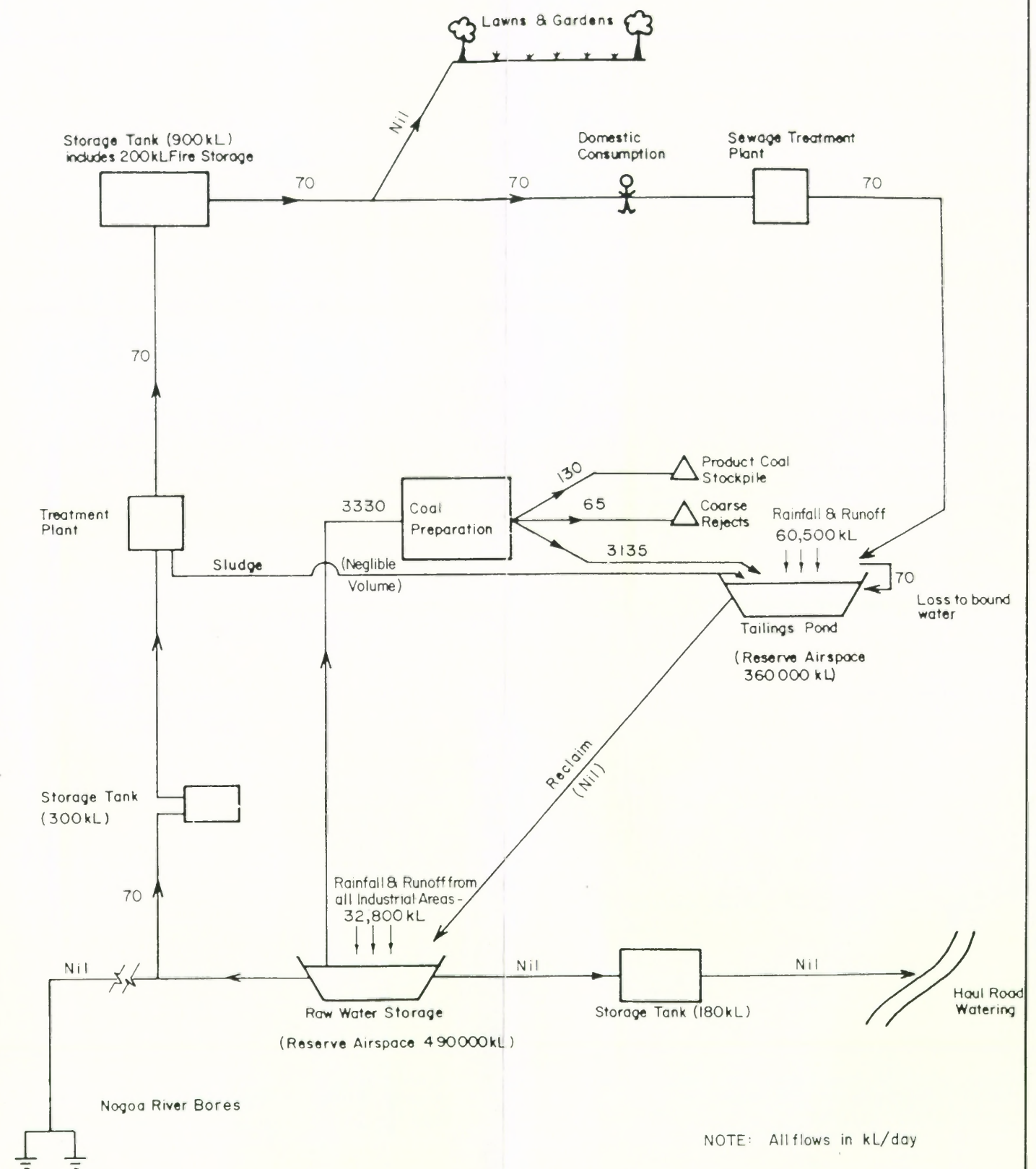
 HOLLINGSWORTH DAMES & MOORE			
TITLE REGIONAL DRAINAGE SYSTEM			
DATE JANUARY 1987	DRG. APPR'D <i>cmf</i>	DRG. NO.	4.4







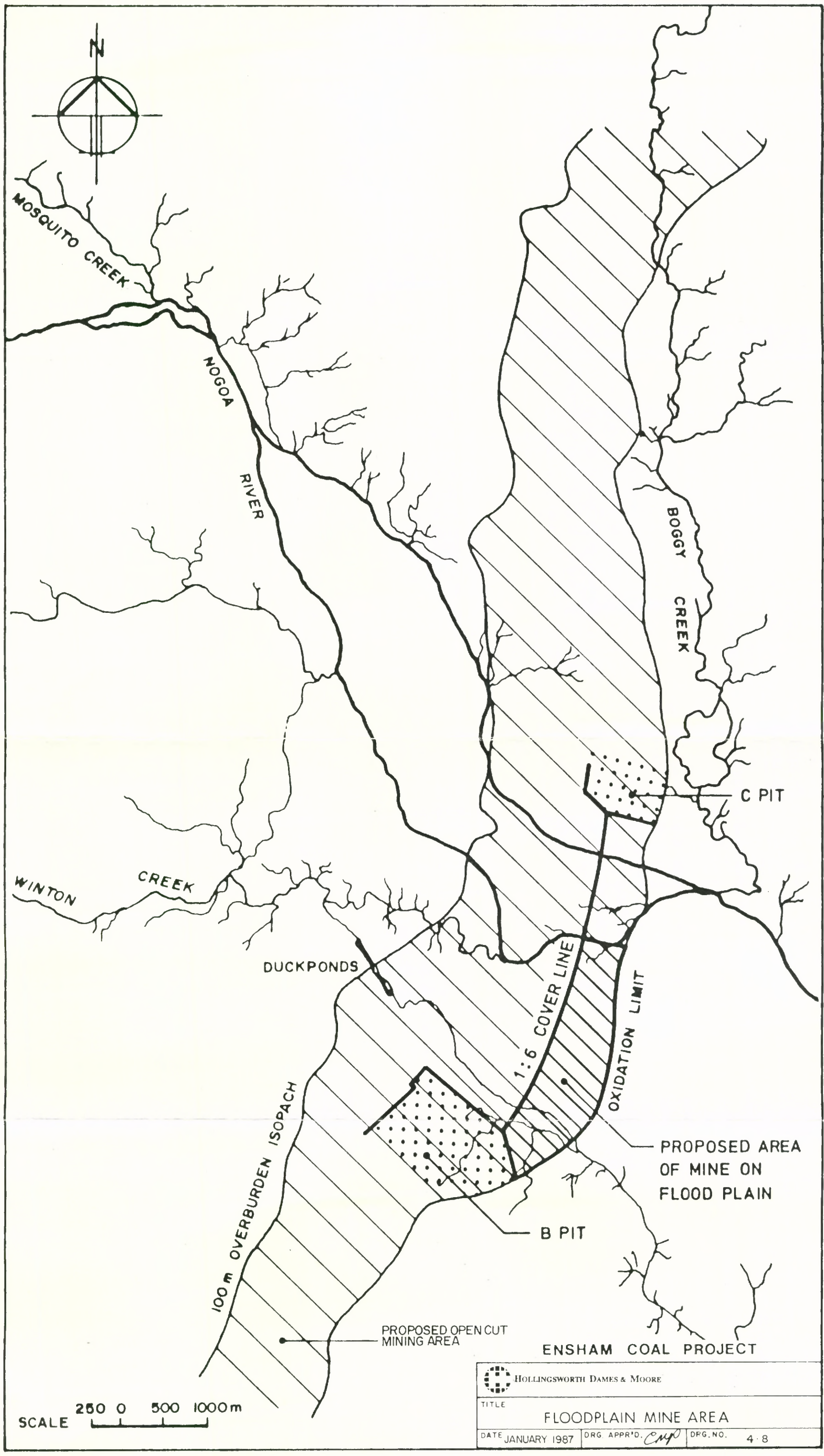
DRY DAY



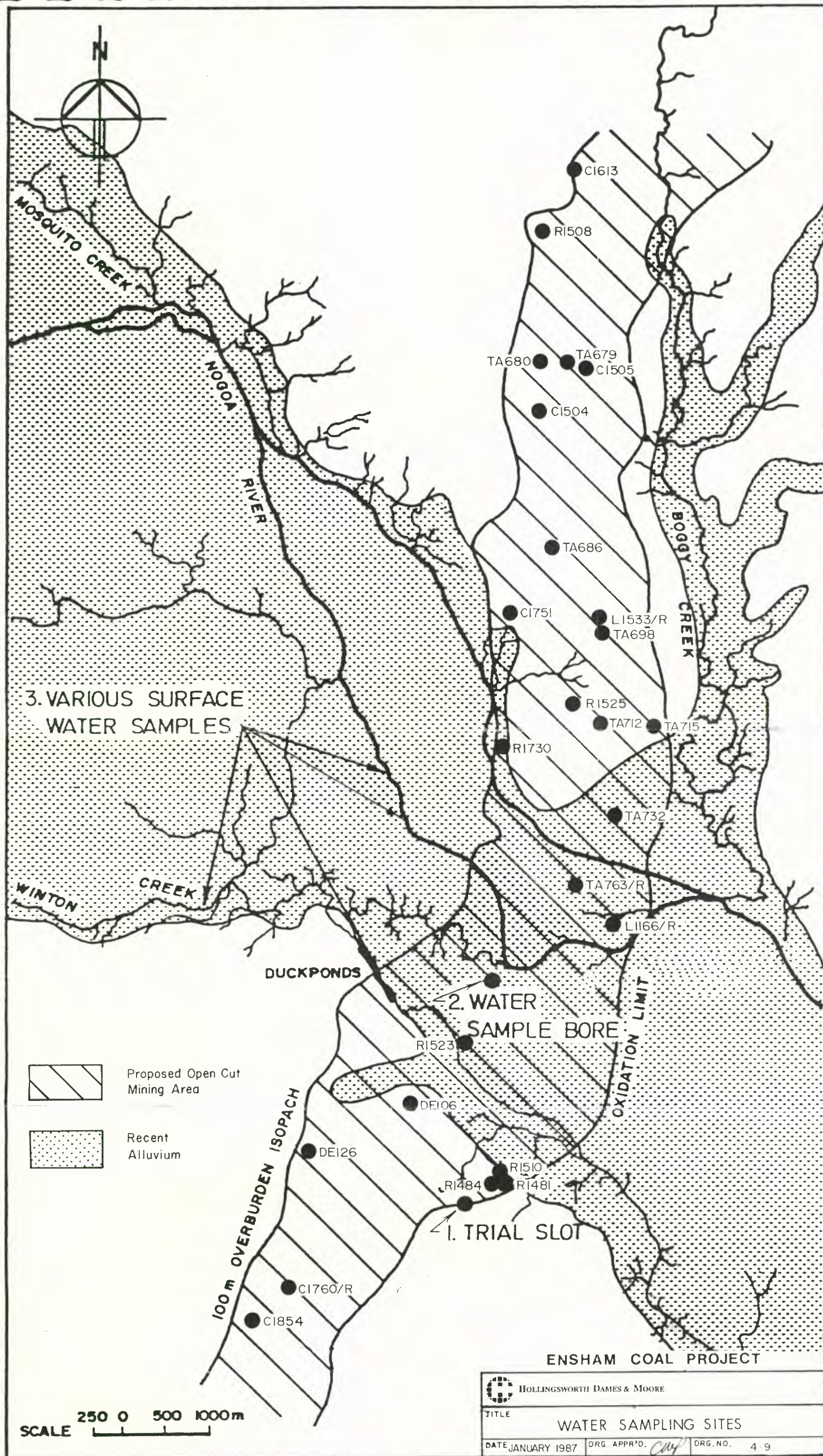
WET DAY

ENSHAM COAL PROJECT

HOLLINGSWORTH DAMES & MOORE		
TITLE		
WATER BALANCE		
DATE JANUARY 1987	DRG. APPR'D. <i>cap</i>	DRG. NO. 4-7



 HOLLINGSWORTH DAMES & MOORE			
TITLE FLOODPLAIN MINE AREA			
DATE JANUARY 1987	DRG. APPR'D. <i>CMP</i>	DRG. NO.	4-8



3. VARIOUS SURFACE
WATER SAMPLES

2. WATER
SAMPLE BORE

1. TRIAL SLOT

-  Proposed Open Cut Mining Area
-  Recent Alluvium

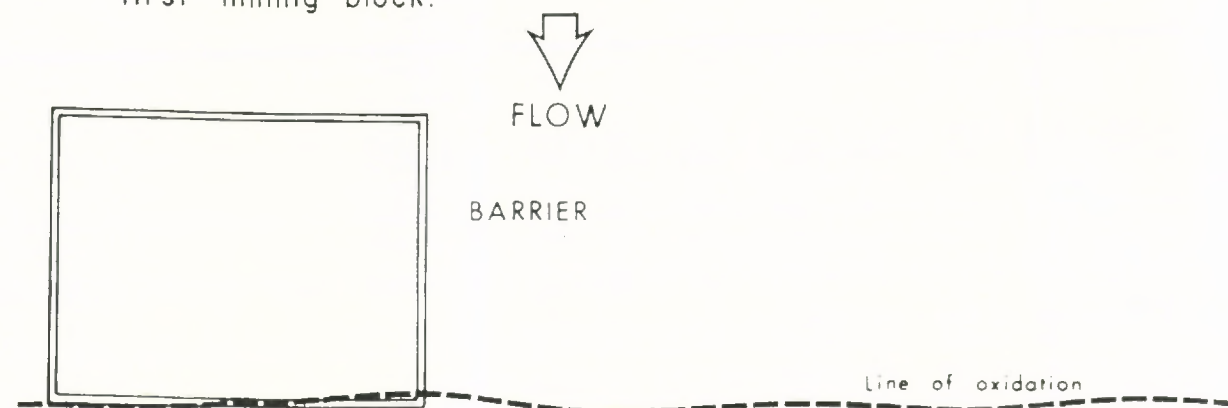
100 m OVERBURDEN ISOPACH

OXIDATION LIMIT

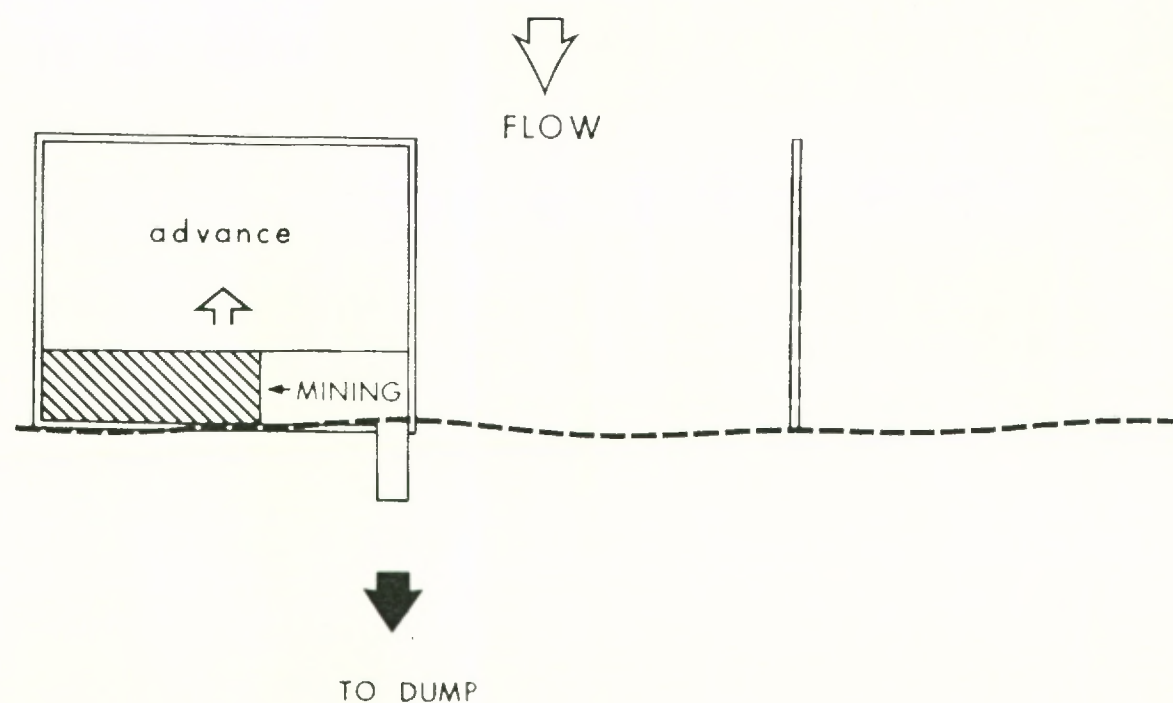
ENSHAM COAL PROJECT

 HOLLINGSWORTH DAMES & MOORE			
TITLE WATER SAMPLING SITES			
DATE JANUARY 1987	ORG. APPR'D. <i>CMH</i>	DRG. NO. 4-9	

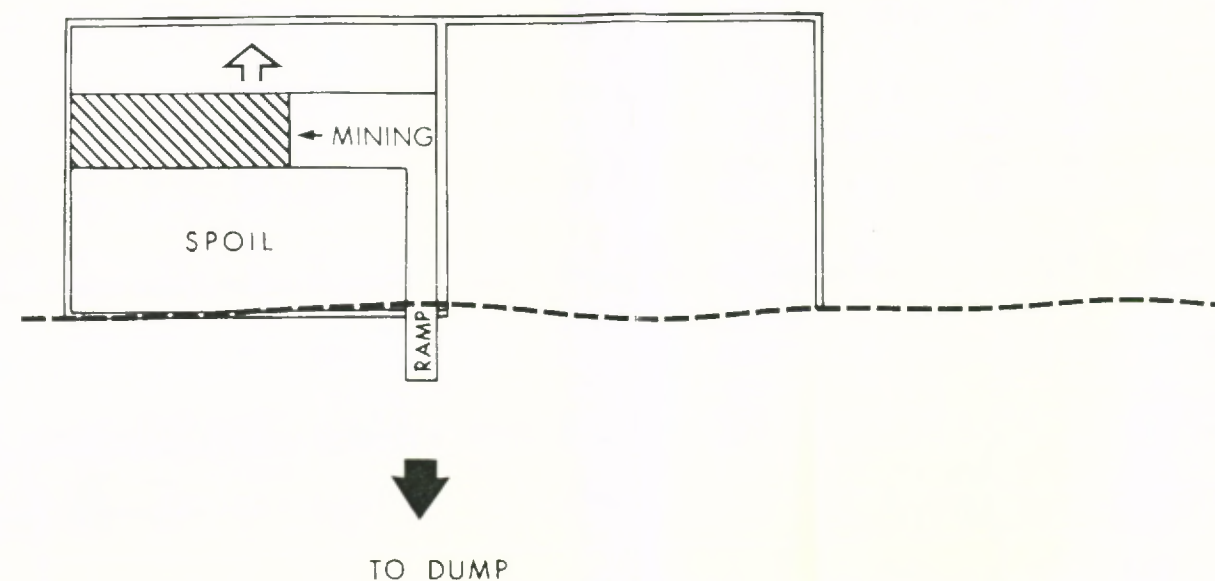
1. Form cut-off barriers to exclude groundwater from first mining block.



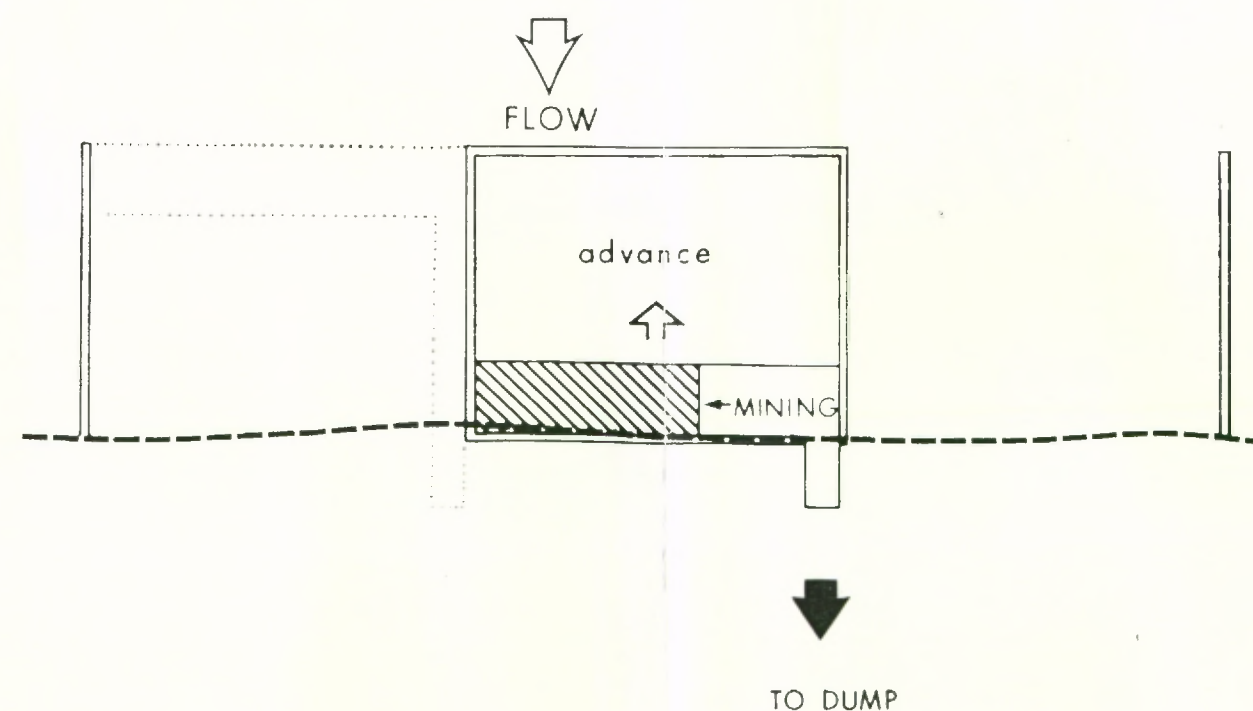
2. Excavate boxcut placing spoil outside the mining block.
 - Form ramp and mine coal.
 - Start forming barriers for next mining block.



3. Excavate cuts and mine coal progressive down dip.
 - Place spoil into previous cuts with excess due to swell and the ramp placed outside the mining block.



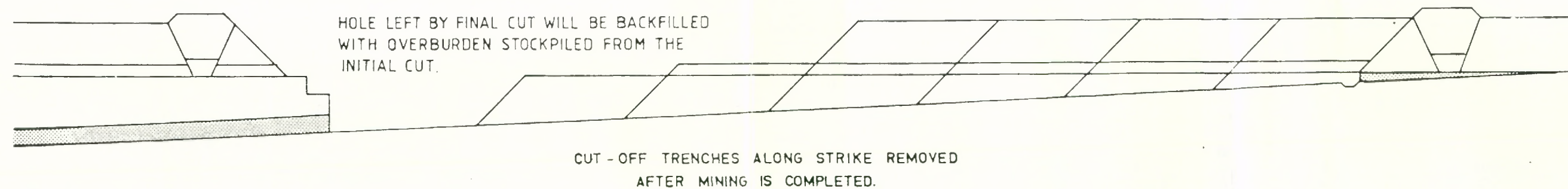
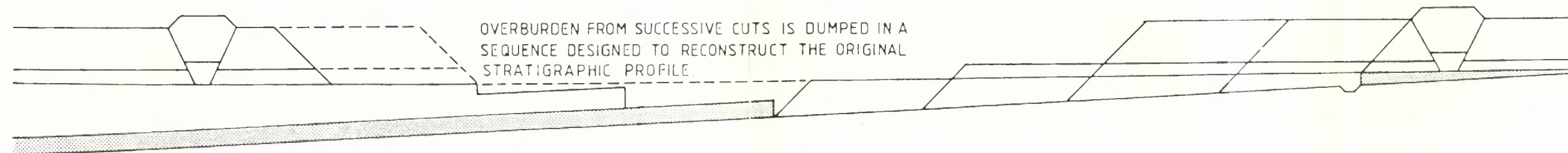
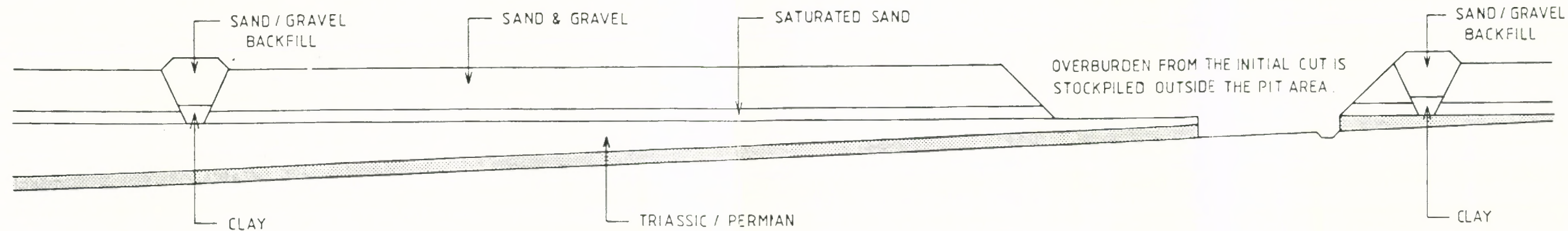
4. Excavate boxcut in second mining block, placing spoil in final cut and ramp of first mining block.
 - Remove barriers along strike in first mining block.
 - Repeat procedure for second mining block.



SCHEMATIC ONLY

ENSHAM COAL PROJECT

HOLLINGSWORTH DAMES & MOORE			
TITLE FLOODPLAIN MINING CONCEPT - PLAN			
DATE JANUARY 1987	DRG APP'D <i>CAP</i>	DRG NO	4-10



SCHEMATIC ONLY

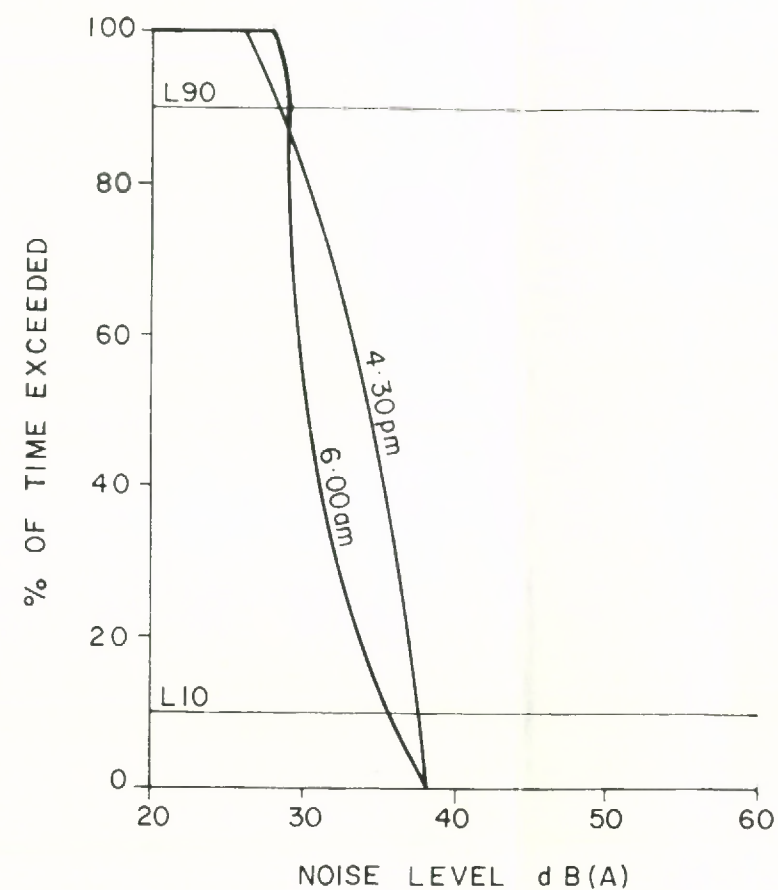
ENSHAM COAL PROJECT



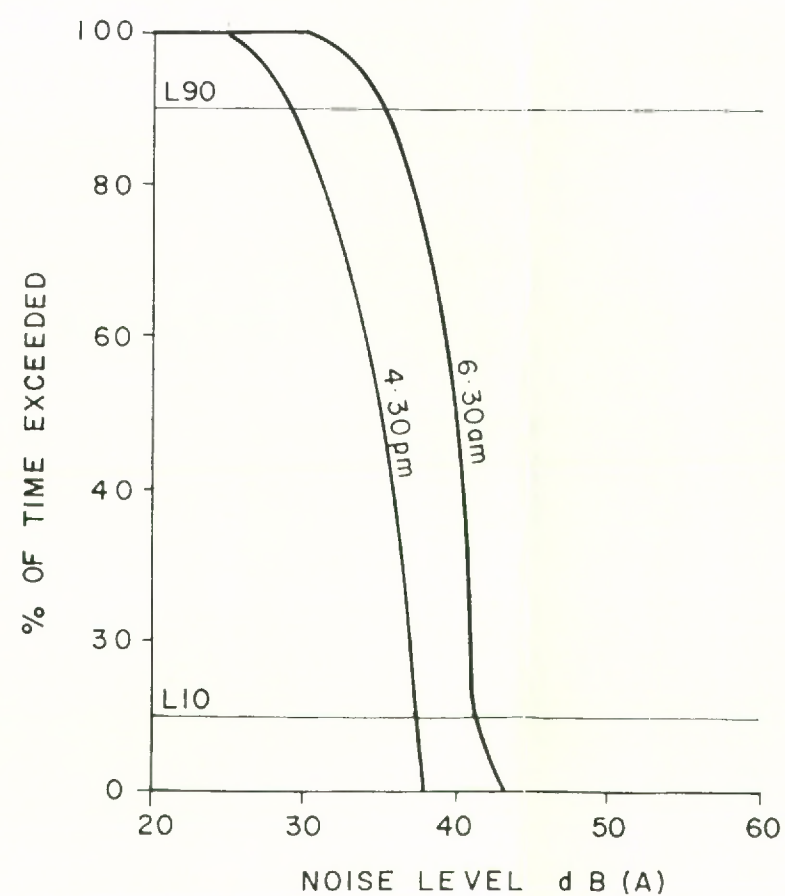
HOLLINGSWORTH DAMES & MOORE

TITLE FLOODPLAIN MINING CONCEPT
— CROSS SECTION

DATE JANUARY 1987 ORG. APPR'D *CMP* ORG. NO. 4-11



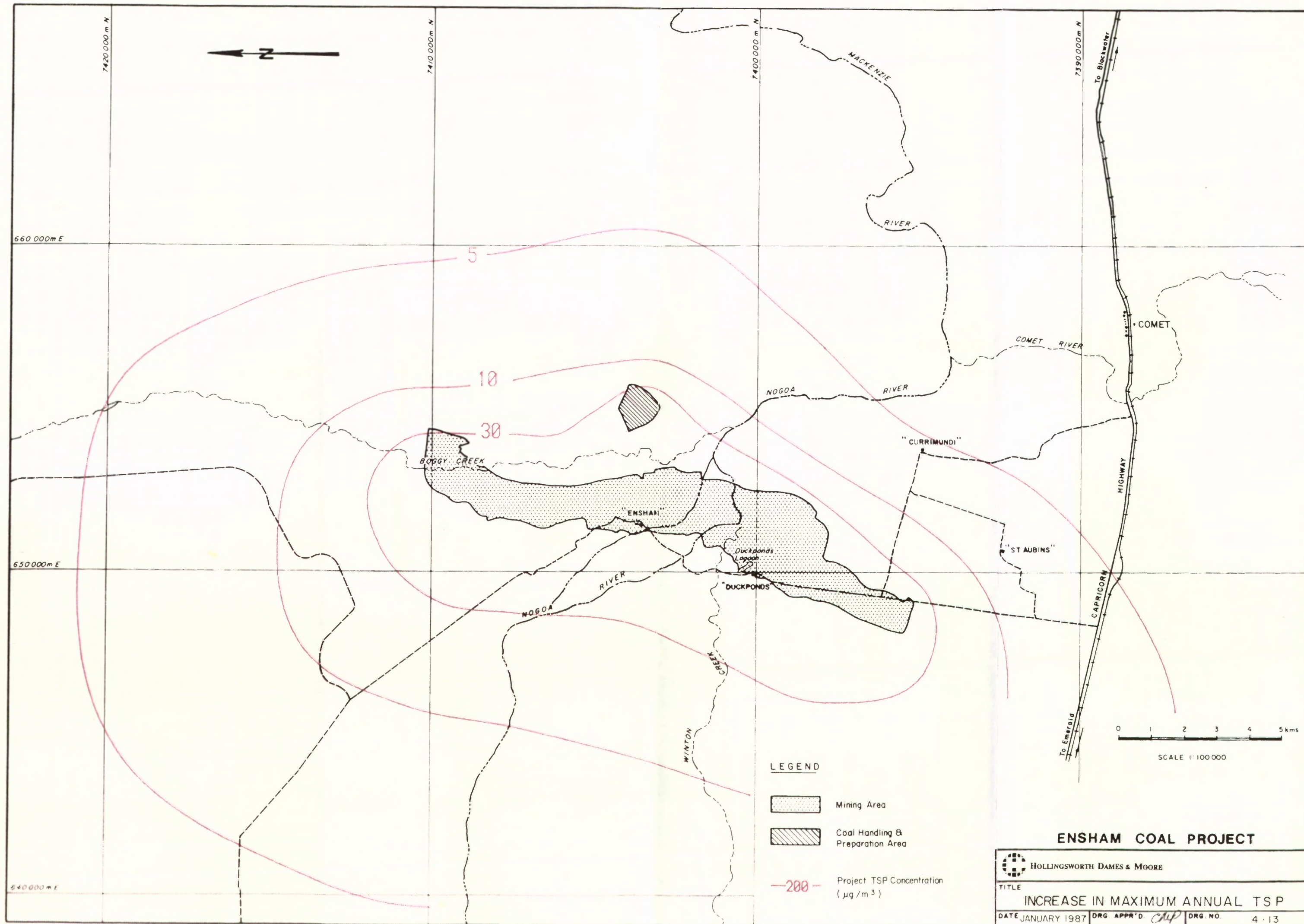
MINE SITE



ACCOMMODATION AREA

ENSHAM COAL PROJECT

 HOLLINGSWORTH DAMES & MOORE		
TITLE MEASURED AMBIENT NOISE LEVELS		
DATE JANUARY 1987	DRG. APPR'D.	DRG. NO. 4-12



LEGEND

-  Mining Area
-  Coal Handling & Preparation Area

—200— Project TSP Concentration ($\mu\text{g}/\text{m}^3$)

ENSHAM COAL PROJECT



HOLLINGSWORTH DAMES & MOORE

TITLE

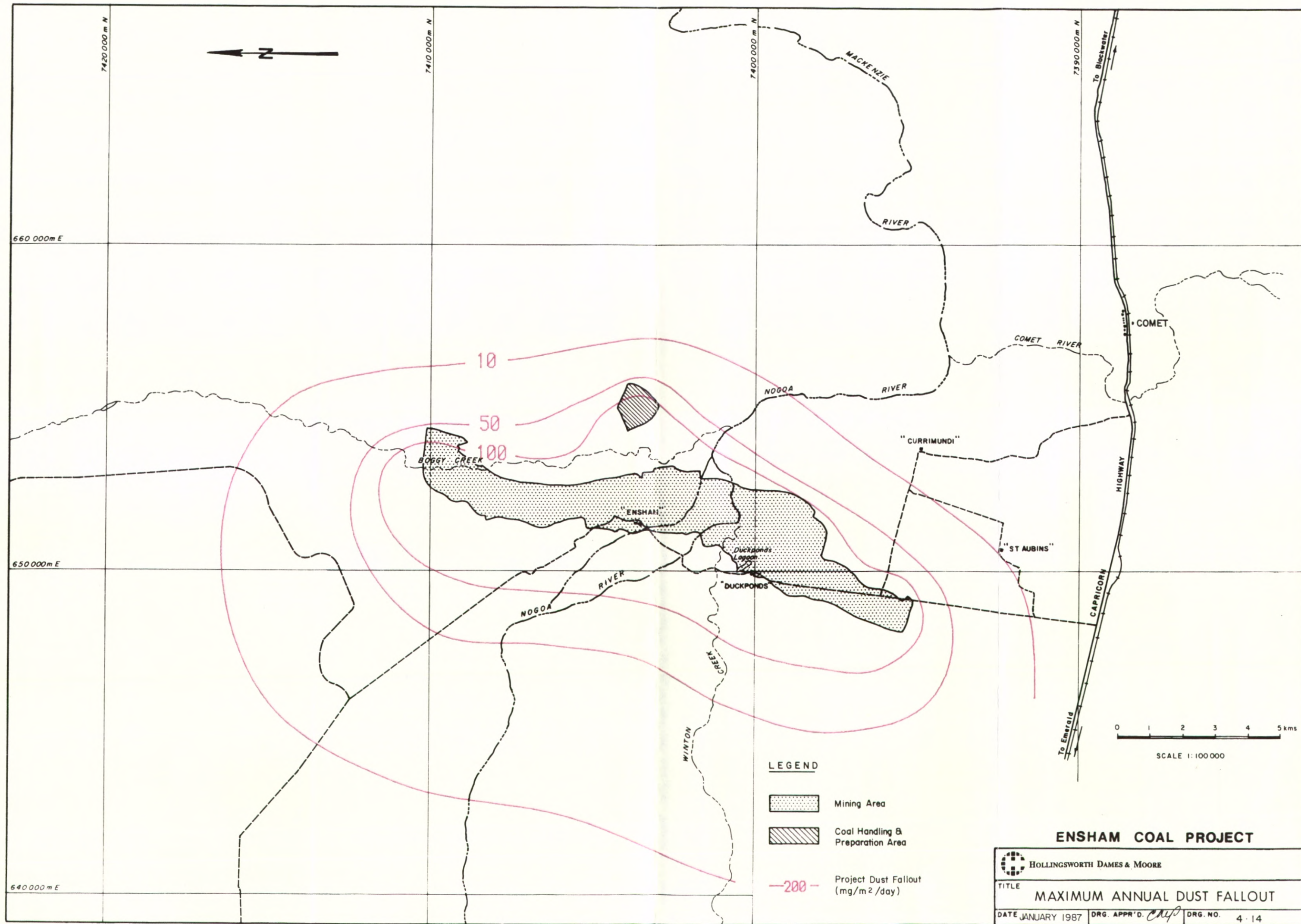
INCREASE IN MAXIMUM ANNUAL TSP

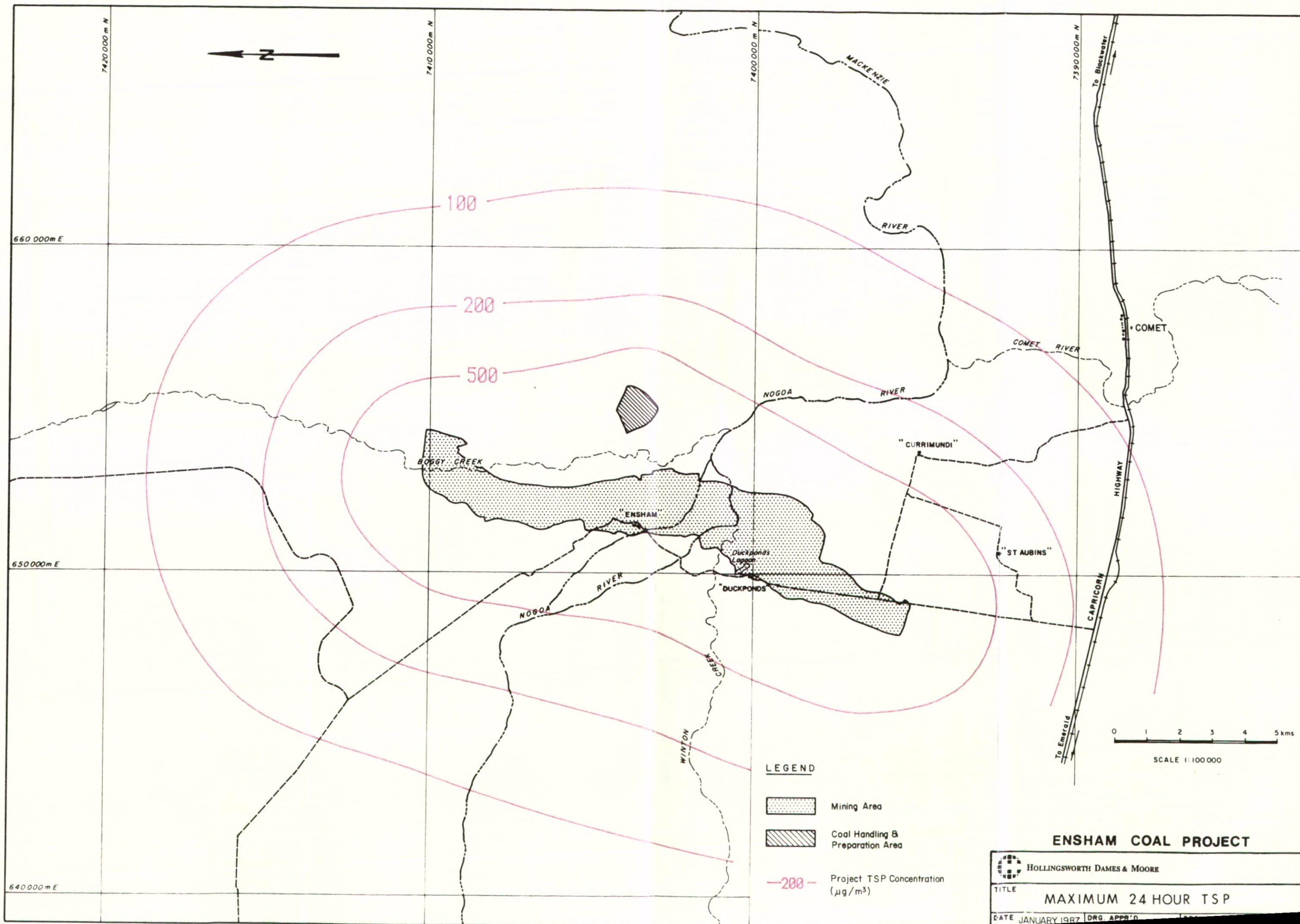
DATE JANUARY 1987

DRG APPR'D. *CHP*

DRG NO.

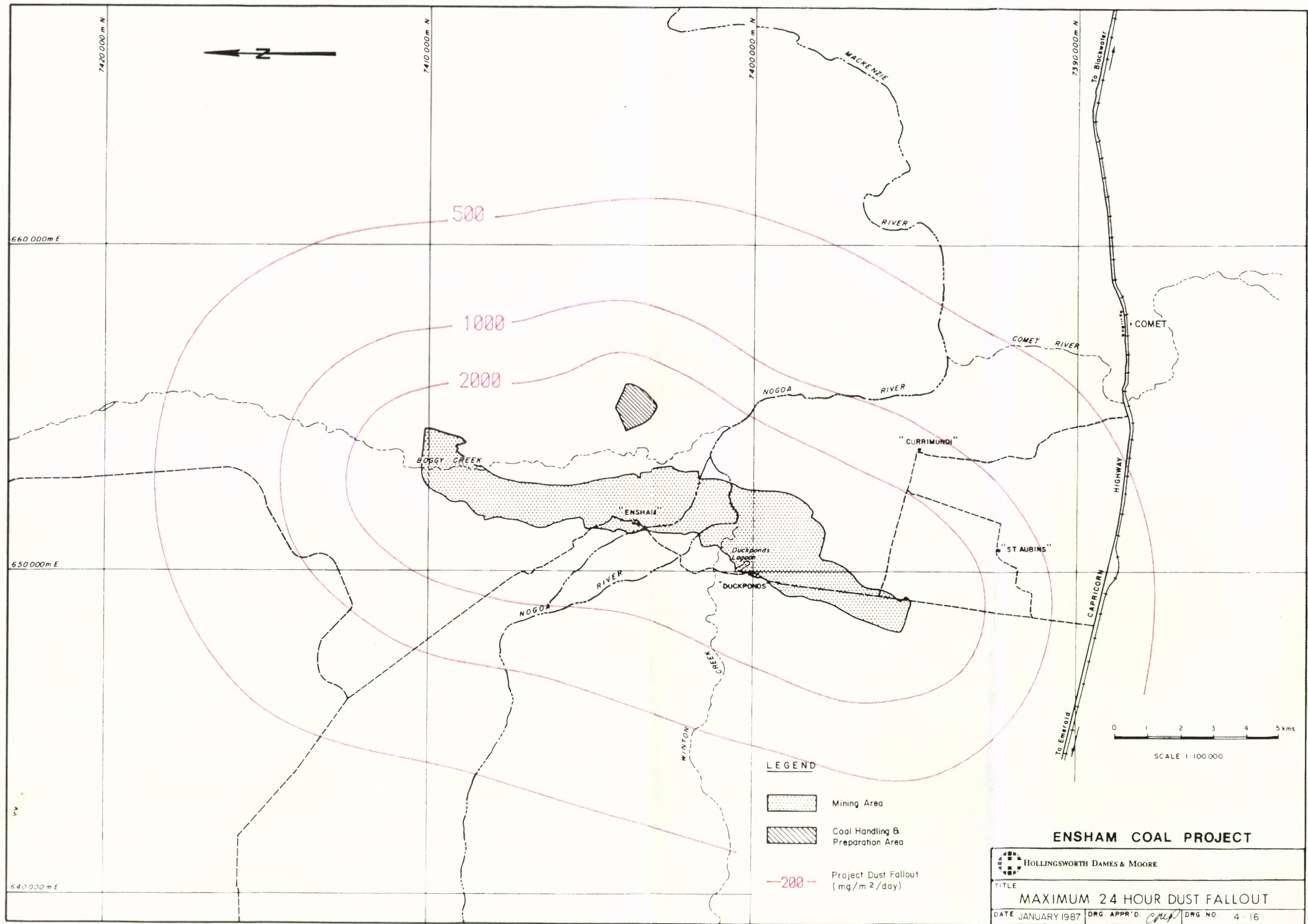
4-13

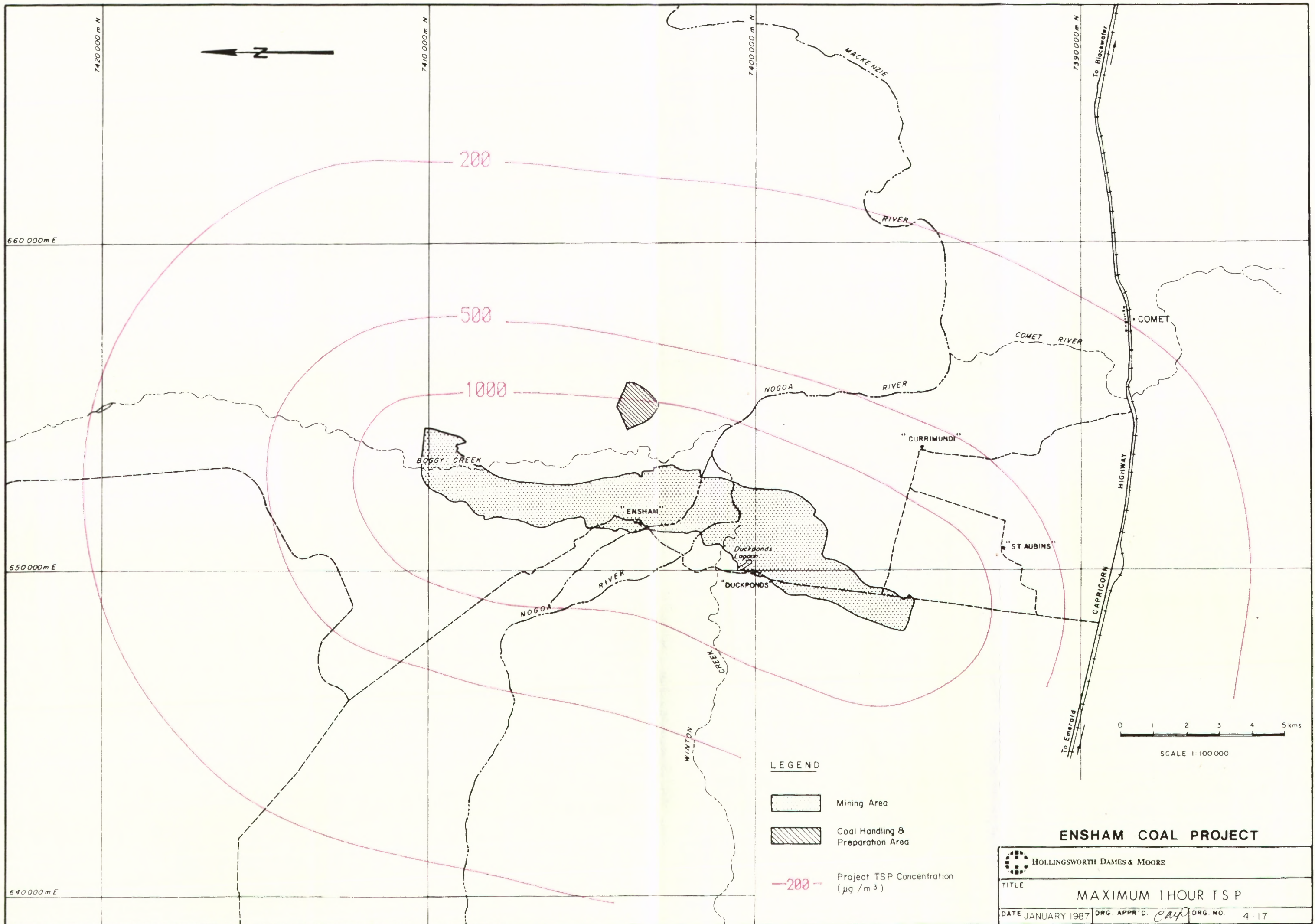


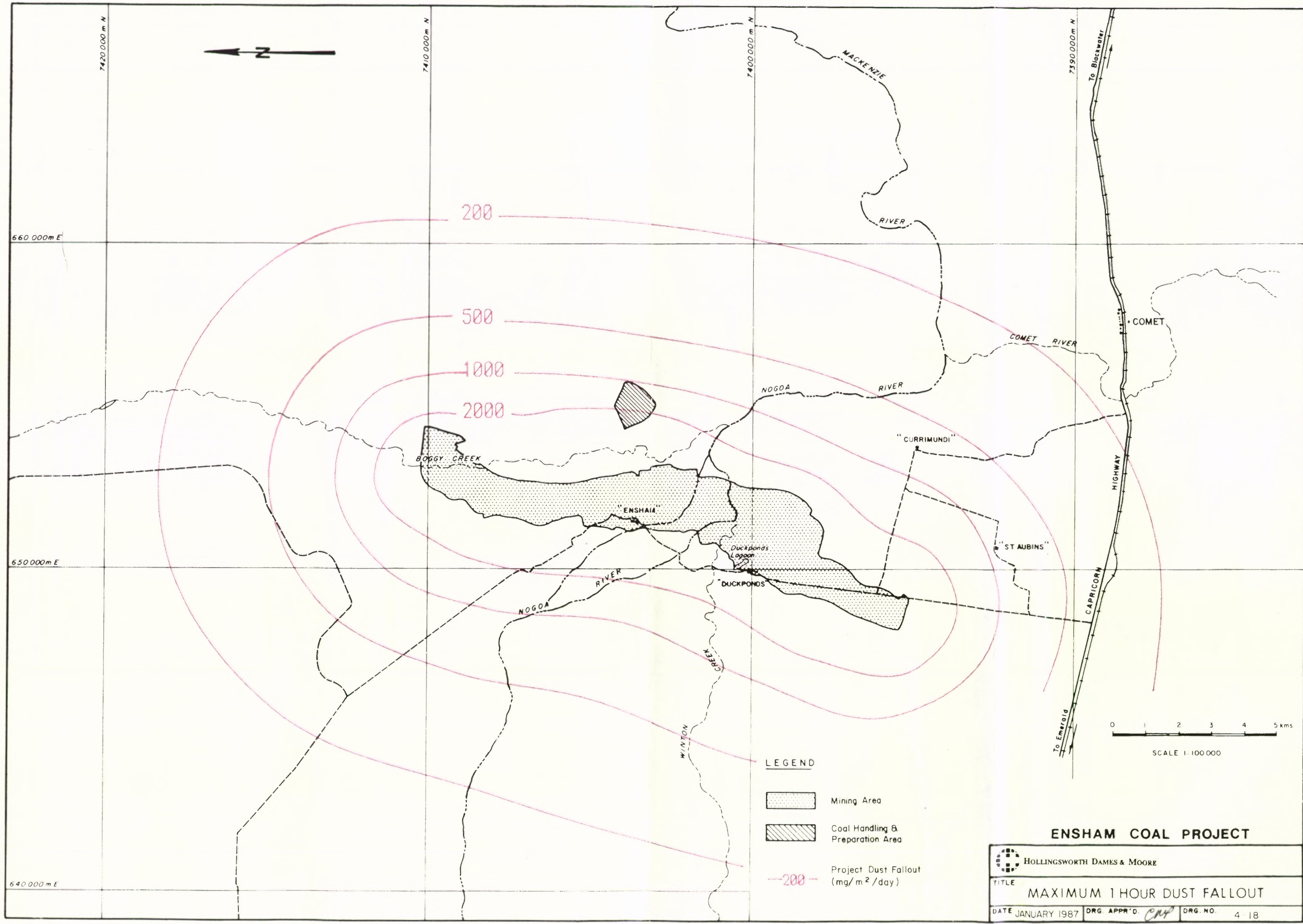


ENSHAM COAL PROJECT

HOLLINGSWORTH DAMES & MOORE	
TITLE MAXIMUM 24 HOUR TSP	
DATE JANUARY 1987	ORG. APPR'D [Signature]



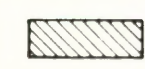




LEGEND



Mining Area



Coal Handling & Preparation Area

—200—

Project Dust Fallout
(mg/m²/day)

ENSHAM COAL PROJECT



HOLLINGSWORTH DAMES & MOORE

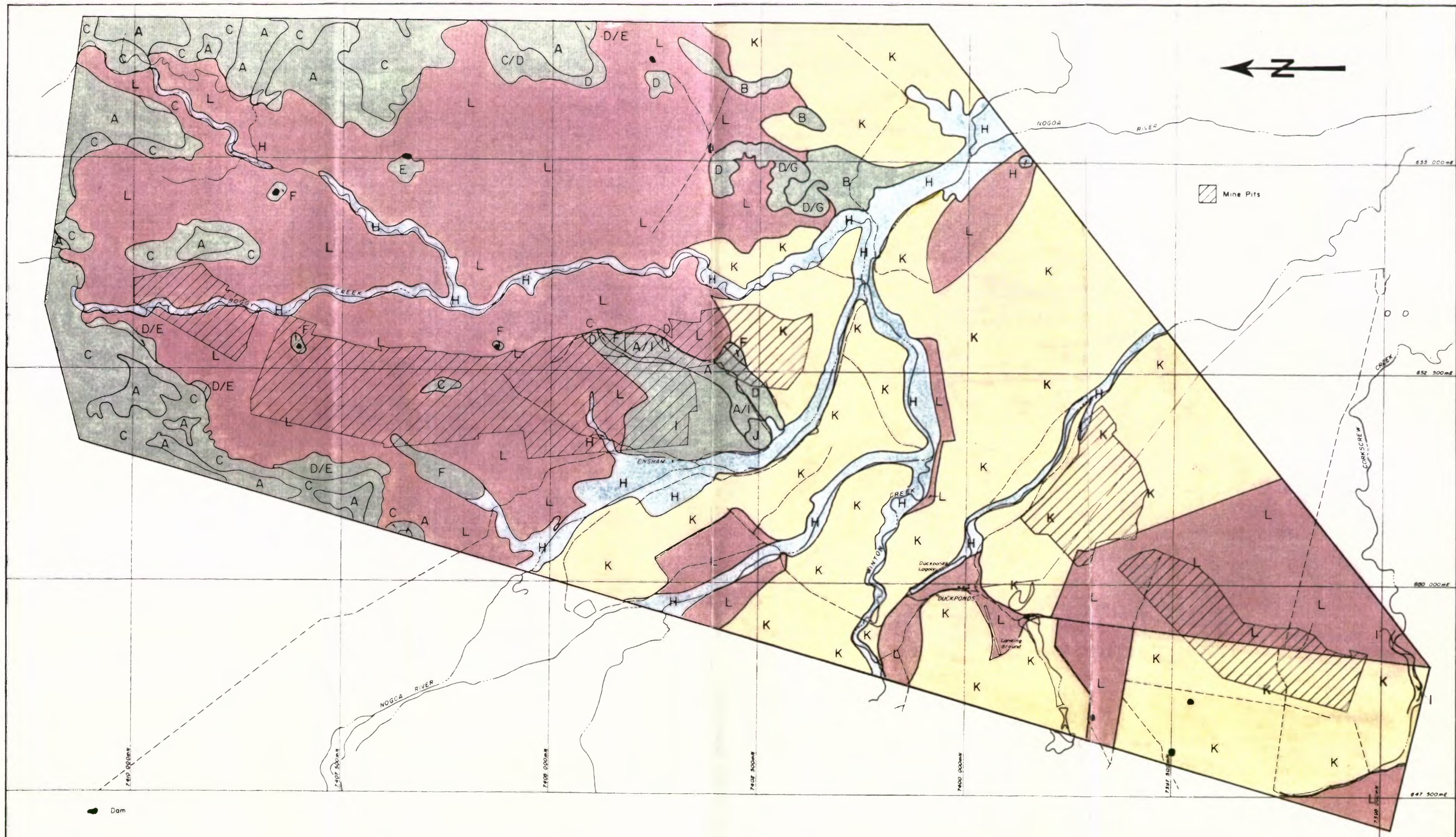
TITLE

MAXIMUM 1 HOUR DUST FALLOUT

DATE JANUARY 1987

ORG. APPR'D. *CM*

DRG. NO. 4-18



● Dam

Legend



Narrow Leaved Ironbark
Bloodwood Woodland



Silver Leaved Ironbark
Bloodwood, Ghost Gum, Grassy Woodland



Lancewood
Mountain Yapunyah Open Forest



Brigalow
Mountain Yapunyah Open Forest



Brigalow
Blackbutt Shrubby Open Forest



Brigalow
Poplar Box, Mixed Low Woodland



Burrow's Wattle
Low Open Mallee Forest



Fringing Forest &
Woodland Communities



Mixed
Woodland



Semi Evergreen
Vine Thicket



Cultivated
Open Space



Grazing and/or
Disturbed Land

0 500 1000 1500 2000 2500metres

ENSHAM COAL PROJECT

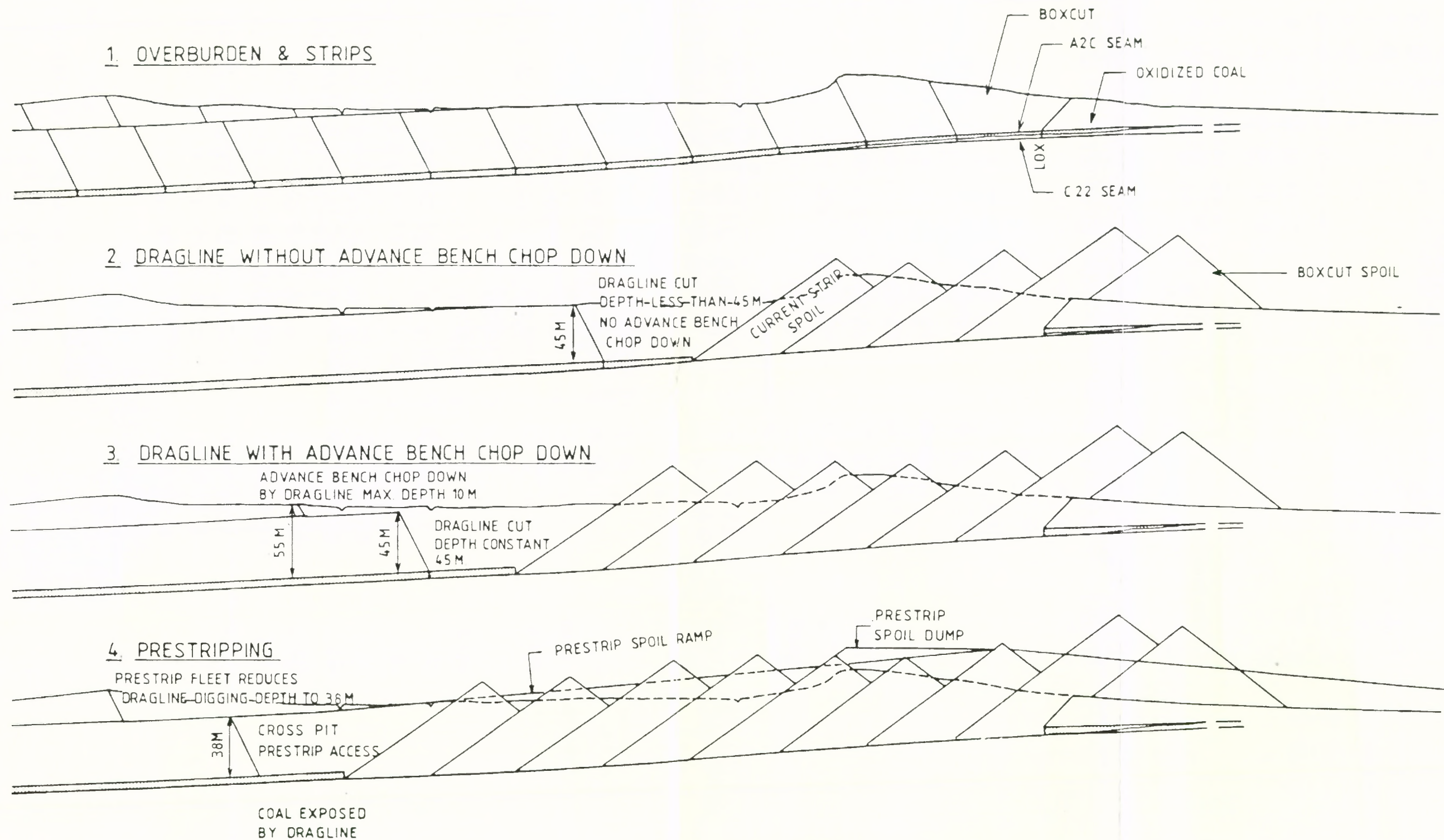


HOLLINGSWORTH DAMES & MOORE

TITLE

VEGETATION / LAND USE

DATE



SCHEMATIC ONLY

ENSHAM COAL PROJECT

 HOLLINGSWORTH DAMES & MOORE	
TITLE REHABILITATION SEQUENCE	
DATE AUGUST 1989	DRG. APPR'D. DRG. NO. 4-20

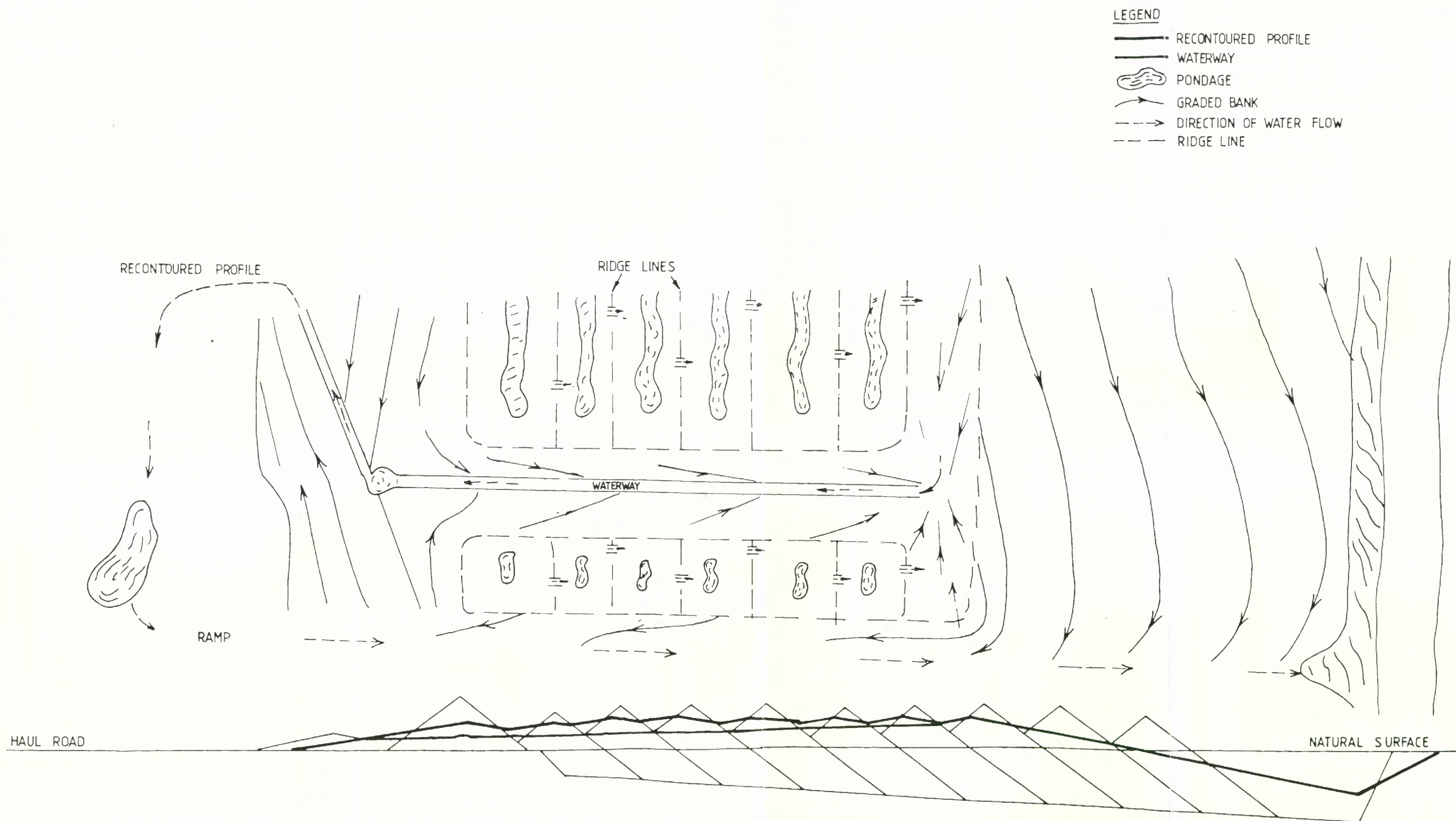


FIGURE 5 CROSS SECTION OF Pit 'D' (D-D) AND PLAN INDICATING THE FINAL LANDFORM AND DRAINAGE SCHEME

ENSHAM COAL PROJECT



HOLLINGSWORTH DAMES & MOORE

TITLE

PIT 'D' DRAINAGE PLAN

DATE

DRG. APPR'D.

DRG. NO. 4-21

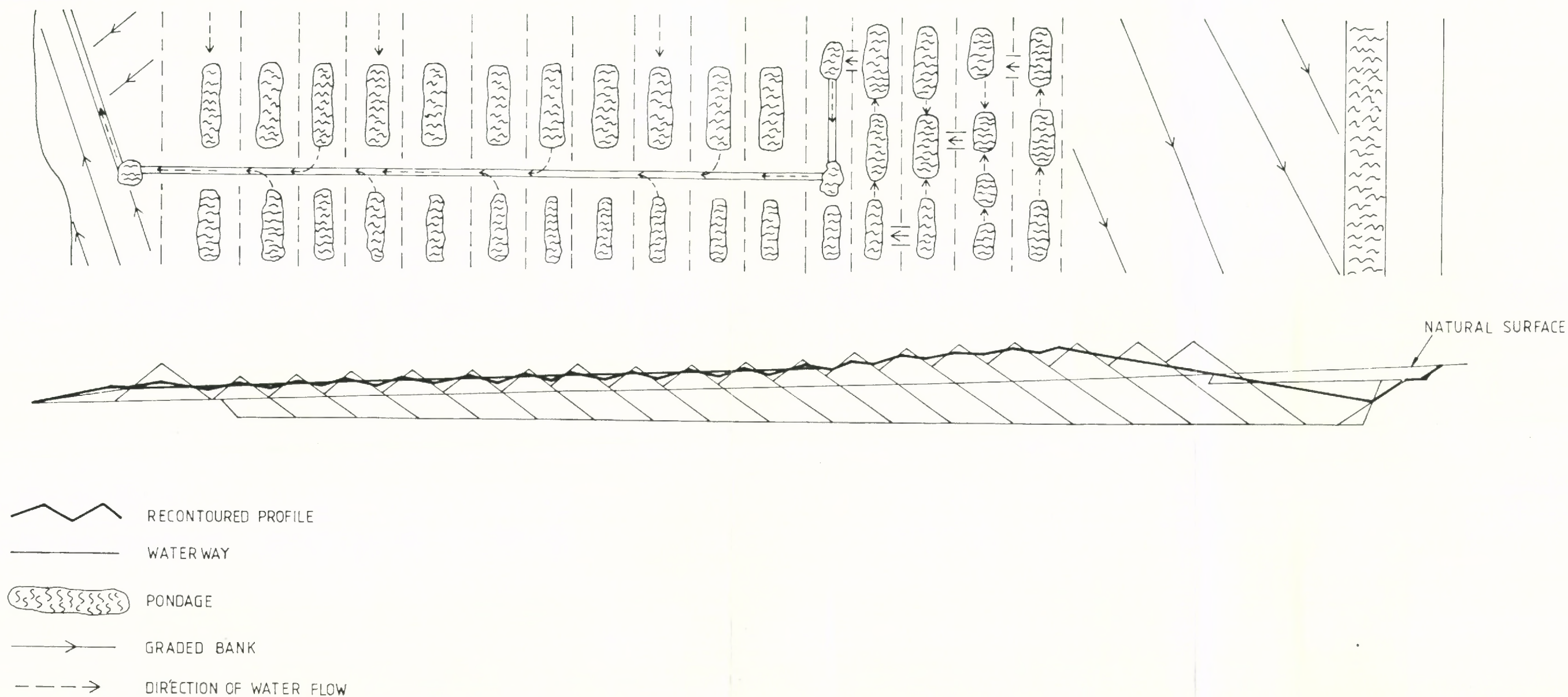


FIGURE 8 CROSS-SECTION OF PIT 'B' (B-B) AND
PLAN INDICATING THE FINAL LANDFORM
AND DRAINAGE SCHEME

ENSHAM COAL PROJECT



HOLLINGSWORTH DAMES & MOORE

TITLE

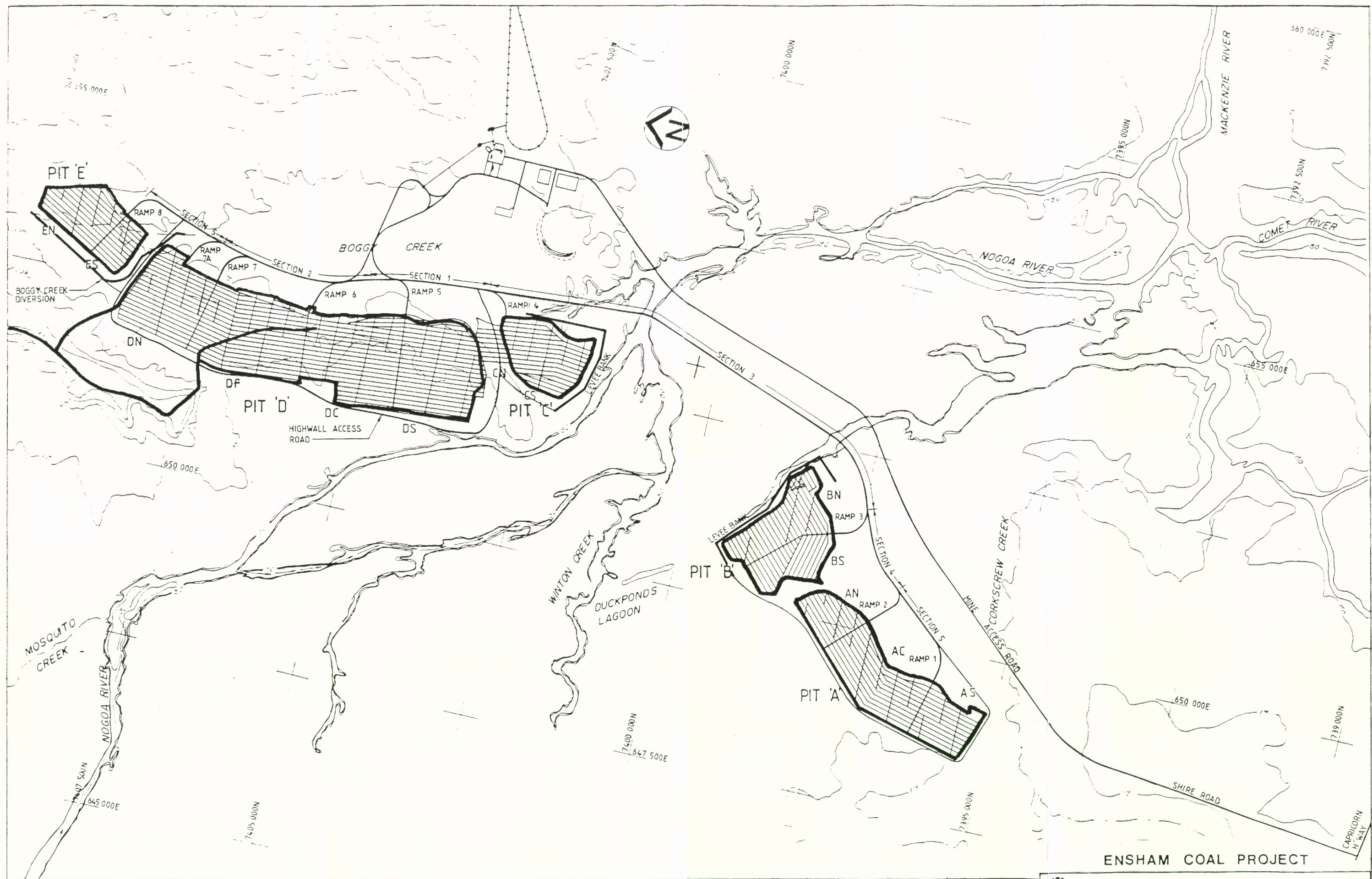
PIT 'B' DRAINAGE PLAN

DATE

DRG. APPR'D.

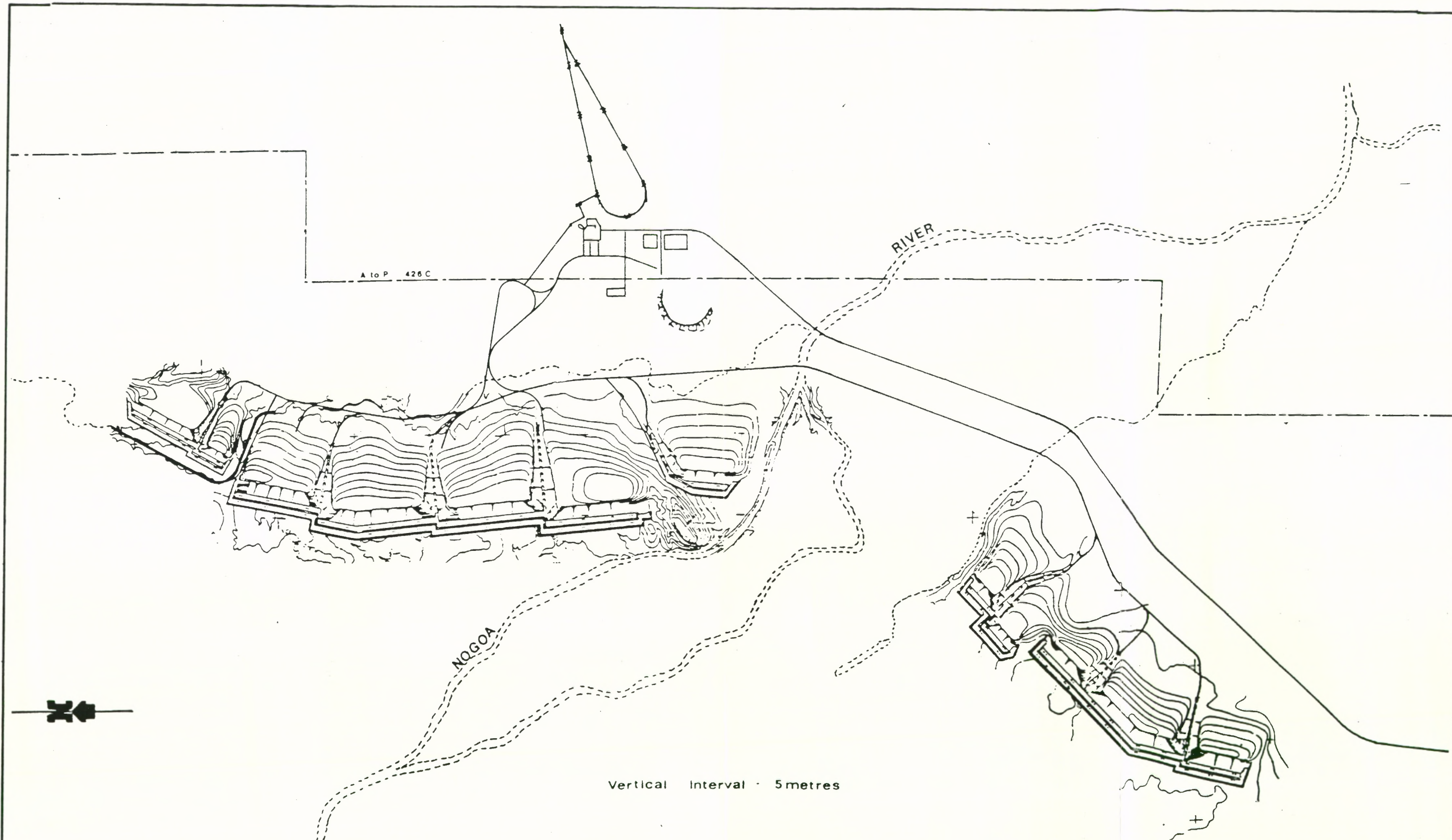
DRG. NO.

4-22



ENSHAM COAL PROJECT

	HOLLINGSWORTH DAMES & MOORE
TITLE	FINAL VOID CATCHMENTS
DATE AUGUST 1989	DRG APPR'D. DRG. NO. 4-23



ENSHAM COAL PROJECT

 HOLLINGSWORTH DAMES & MOORE		
TITLE SPOIL CONTOURS - YEAR 15		
DATE AUGUST 1989	DRG. APPR'D.	DRG. NO. 4-25

**5.0 THE MAN MADE ENVIRONMENT AND THE
EFFECTS OF THE PROJECT**

5.0 THE MAN MADE ENVIRONMENT AND THE EFFECTS OF THE PROJECT

This section looks at the effects of the project on the man made environment. Of particular benefit from the project will be the significant boost it will generate in employment and financial activity. For example the project will generate almost 1,100 new jobs throughout Australia and inject over \$120 million annually into the national economy.

The project will have some effect on the existing infrastructure facilities in Emerald because of the increase in the town's population which will result from the project. To minimise these effects, Ensham Coal Management will be contributing towards a number of significant infrastructure facilities including:

- housing
- roads and drainage
- headworks - water supply and sewerage
- community facilities
- recreation facilities.

Details of the contributions to be made are subject to negotiations between the Emerald Shire Council, the Queensland Government, and Ensham Coal Management.

5.1 Economic Effects

5.1.1 General

This Section discusses the economic impact of the Ensham project on the Fitzroy Region (Statistical Division), the State of Queensland, and Australia. It involves the measurement of the static economic impact of the construction and operational phases of the proposed mine using input-output analysis. In this type of static analysis, a single representative or "typical" year is chosen for each of the construction and operation phases. The "typical" year for each of the development phases is chosen from the mine planning schedule adopted for the purposes of this study. A detailed cost breakdown of construction and operation expenditures is obtained for each level of the economy modelled. These expenditure data are inserted as new final demands into the appropriate input-output model, after allowing for adjustments to compensate for different base year prices, accounting formats, and import allocation.

The resultant multiplier effects apply, strictly speaking, only to the year modelled, and cease to exist after that period unless the expenditure pattern is continued in subsequent periods. This feature is of less consequence in the operation phase of the analysis, since the operational expenditure pattern used in this report is expected to rise rapidly from years -1 to year 3 and then to remain much the same from Year 4 to Year 15. The impacts are therefore expected to remain approximately constant

during most of the life of the operation. Year 10 has been chosen as a "typical" year for this analysis. The construction phase multiplier effects, on the other hand, refer to a weighted average of Years -1 and 1 of the construction phase. These years represent the peak of the construction period, and the multiplier effects will vary for the other years. Furthermore, the construction impacts are not permanent as the construction activity itself is not permanent. All values in the study have been estimated in real terms.

The accuracy of these results depends on certain assumptions. Of particular concern in this study are the assumptions of constant returns to scale in the static model, and the limitations on the accuracy of any input-output table and the data used in the study, which is, by its very nature, preliminary. These assumptions are likely to result in, particularly in times of economic recession, the multiplier estimates (especially the employment and income effects) being over-estimated, and should therefore be regarded as upper limits, particularly in the short term construction phase. This level of accuracy also imposes restrictions on some of the finer details in the report; the disaggregated flow-on effects in particular should be interpreted as order-of-magnitude estimates only.

5.1.2 Construction Phase

The construction phase of the project begins in Year -1 with the bulk of it completed by Year 3. The construction period analysed in this report refers to a weighted average of Year -1 and Year 1, and represents an average expenditure of about \$190.6 million with approximately \$91.8 million assumed to occur in the Fitzroy region and approximately \$185.0 million in the State of Queensland.

This expenditure represents inputs purchased directly from other firms, which in turn purchase inputs from other (or the same) firms in another round of purchases, and so on. In addition, these firms pay wages and salaries to employees who purchase commodities for personal consumption. All of these additional effects over and above the initial capital expenditure are termed multiplier or indirect effects, and can be expressed in terms of either output, income (wages and salaries) or employment. The construction phase multiplier effects for the Year -1/1 are provided in Table 5.1.

Table 5.1
Output, Income and Employment Effects by Sector
Mine Construction, Year -1/1

Sector	Fitzroy Region	Queensland	Australia
A. OUTPUT EFFECTS (A\$ million)			
Capital Costs	91.8	185.0	190.6
Flow-on Effects	64.5	199.5	358.7
Total Effects	156.3	384.5	549.3
Main Output Effects by Sector (%)*			
Building, Construction	54.2	22.7	15.7
Non-metalic Mineral Products	7.1		
Machinery, Applicances, Equipment	21.3	17.5	
Transport, Communication		6.1	6.4
Finance, Business Services		9.9	14.2
Trade	5.4	7.2	9.7
Other Manufacturing			7.0
Metal Products			6.4
B. INCOME EFFECTS (A\$ million)			
Income Level	8.9	10.6	10.6
Flow-on Effects	9.3	15.0	19.4
Total Effects	18.2	25.6	30.0
Main Income Effects by Sector (%)*			
Building, Construction	45.0	14.6	16.0
Non-metalic Mineral Products	5.3		
Machinery, Applicances, Equipment		19.5	18.7
Main Income Effects by Sector (%)*			
Transport, Communication	8.6	10.1	8.8
Trade	8.7	11.3	13.5
Finance, Business Services		13.5	10.2
Metal Products		5.0	

Table 5.1 cont'd
Output, Income and Employment Effects by Sector
Mine Construction, Year -1/1

Sector	Fitzroy Region	Queensland	Australia
C. EMPLOYMENT EFFECTS (persons)			
Employment Level	175	275	275
Flow-on Effects	140	348	607
Total Effects	315	623	882
Main Employment Effects by Sector (%)*			
Building, Construction	52.1	19.0	13.8
Machinery, Appliances, Equipment		19.4	15.9
Transport, Communication	6.3	8.0	8.3
Trade	9.7	13.2	16.9
Finance, Business Services		12.6	11.3

* Percentage of Total Effects. Impacts of less than five percent are not recorded

Part A of Table 5.1 shows that the total multiplier effects in terms of output amount to about \$549.3 million in the Nation, of which about \$156.3 million (or 28.5%) occurs in the Fitzroy region, \$228.2 million (or 41.5%) in the rest of Queensland (excluding Fitzroy), and \$164.8 million (or 30.0%) in the remainder of Australia (excluding Queensland). The percentage distribution of these output effects over the individual sectors of the economy is also provided in the table. The main sectors affected by the flow-ons are Building and Construction, Non-metallic Mineral Products, and Wholesale and Retail Trade at the Fitzroy regional level; Building and Construction, Machinery, Appliances and Equipment, Transport and Communication, Finance and Business Services, and Trade at the Queensland State level; and, in addition to these, the other Manufacturing and Metal Products sectors at the Australian economy level.

Parts B and C of Table 5.1 provide the flow-ons in terms of income and employment respectively. In addition to the average employment on the construction site of 175 (and approximately 100 in the head office in Brisbane), there are expected to be approximately 607 additional persons employed in the nation as a whole over all sectors. Of these additional persons, about 140 (or 23%) are expected to be employed within the Fitzroy region, and an additional 208 (or 34%) in the remainder of Queensland. The local industries most likely to be affected by these

employment effects are Building and Construction, Wholesale and Retail trade, and Transport and Communication. The State and National industries most affected are Building and Construction, Machinery, Appliances and Equipment, Transport and Communication, Wholesale and Retail Trade, and Finance and Business Services.

The difference in the ranking of the various sectors in terms of output, income and employment effects is caused by the different labour productivity rates among industries and at different economic levels. It would appear to be generally true that the lower the economic level of the region, the less capital intensive the industries tend to be, and within the region, labour/output ratios tend to vary to a large extent. It is this difference between labour productivity rates amongst different industries within a region which gives rise to the employment multiplier concept.

5.1.3 Operational Phase

The operational phase of the project is expected to begin in Year -1 with full production expected to continue for at least 15 years. The operational period analysed in this report refers to Year 10, with a total estimated operating cost of about \$244.8 million. It is taken as a "typical" or representative year of full production, and the resultant economic impacts should therefore remain roughly constant for the full production period. The output, income and employment multiplier effects of the operational phase for Year 10 are provided in Table 5.2.

Table 5.2
Output, Income and Employment Effects by Sector
Mine Operation, Year 10

Sector	Fitzroy Region	Queensland	Australia
A. OUTPUT EFFECTS (A \$ million)			
Operating Costs	227.8	244.8	244.8
Flow-on Effects	156.5	241.0	425.9
Total Effects	384.3	485.8	670.7
Main Output Effects by Sector (%)*			
Transport, Communication	42.7	33.8	29.2
Other Manufacturing	9.1	10.9	13.0
Finance, Business Services		7.0	12.7
Trade	6.3	8.3	11.0
Machinery, Appliances, Equipment	6.7	7.2	
Electricity, Gas, Water	8.7	8.4	6.2

Table 5.2 cont'd
Output, Income and Employment Effects by Sector
Mine Operation, Year 10

Sector	Fitzroy Region	Queensland	Australia
B. INCOME EFFECTS (A \$ million)			
Income Level	48.3	49.8	49.8
Flow-on Effects	26.3	49.0	72.7
Total Effects	74.6	98.8	122.5
Main Income Effects by Sector (%)*			
Transport, Communication	56.7	45.3	37.5
Trade	6.7	10.6	14.4
Machinery, Appliances, Equipment	9.2	5.7	7.3
Finance, Business Services		7.8	8.5
Other Manufacturing			7.9
Electricity, Gas, Water			5.2
C. EMPLOYMENT EFFECTS (persons)			
Employment Level	396	409	409
Flow-on Effects	248	469	690
Total Effects	644	878	1099
Main Employment Effects by Sector (%)*			
Transport, Communication	51.0	40.0	34.1
Machinery, Appliances, Equipment	11.1	6.4	6.0
Trade	9.1	13.8	17.6
Other Manufacturing		5.3	7.3
Finance, Business Services		8.1	9.2

*Percentage of Total Effects. Impacts of less than five percent are not recorded.

Part A of the table shows that of the \$670.7 million in total output effects accruing to the Nation, \$384.3 million (or about 57.3%) remain in the Fitzroy region, with an additional \$101.5 million (or about 15.1%) going to the remainder of Queensland. The balance of \$185.2 million (or 27.6%) will flow to the rest of Australia. At all economic levels, the dominant sector affected by this flow-on is Transport and Communication, particularly at the Fitzroy regional level. The flow-on effects are also

directed towards the Other Manufacturing sector, Machinery, Appliances and Equipment, Electricity, Gas and Water, and Trade. In addition, the Finance and Business services sector is affected at the State and National economy levels.

Part C of Table 5.2 provides the total employment flow-on effects for the operational period. In addition to the approximate 396 persons employed in the mine and town operations (with approximately 13 in Brisbane), an additional 690 persons are expected to be employed in the Nation as a whole, of which approximately 248 (or about 36%) will remain in the Fitzroy region, with an additional 221 persons (or about 32%) going to the remainder of the State. Transport and Communication is the sector most affected by these employment flow-ons in all three levels of the economy, with Machinery, Appliances and Equipment and Wholesale and Retail Trade also featuring at the local level. The Other Manufacturing and Finance and Business Services sectors are also affected in the State and National economies. This is in common with many impact studies of large projects; the employment flow-ons are mainly felt in the "service" sectors which are more highly labour intensive.

In contrast to the construction phase impacts mentioned above, the Fitzroy region receives a larger proportion of the total multiplier effects during the operational phase than the State or Nation. On the other hand, Queensland and Australia receive the large amount in flow-on effects during the construction phase. This is characteristic of many projects of this nature, as much of the large construction equipment is purchased at the State or National levels, but once construction is completed, ongoing operational and employment expenditure tends to concentrate at the regional level, as local support industries expand to cater for the needs of the mine and workforce.

5.2 Population

5.2.1 General

The majority of the permanent workers generated by the project will reside in Emerald, and rely on Emerald for the bulk of their commercial and recreational needs. Other communities that may be affected by the project workforce to a less significant extent include the small town of Comet south-east of the mining area and the larger community of Blackwater (refer Drawing 2.2).

5.2.2 Emerald

On the basis of the 1986 Census statistics (Australian Bureau of Statistics), Emerald had a population of 5,982, which, as outlined in Table 9.A of Appendix 9, represents an average annual growth rate of 5.3% since the 1981 Census. The current population estimate is approximately 6,200. The recent growth rates are down on the growth experienced during the period from 1976 to 1981 when an annual growth of 7.9% was experienced. That growth was largely due to the injection of workers into the town associated with Gregory coal mine. As Table 9.A reveals, the

town also experienced another period of significant population growth of 5.9% per annum, between 1966-1971, which was due to the influx of workers involved in the construction of the nearby Fairbairn Dam. During the 1971-1976 intercensal period population growth was only 1.6% per annum. It is expected that population growth in Emerald, without the influence of any further significant development projects, would be a more conservative figure of around 1% per annum.

Population growth in Emerald is currently significantly higher than that of the overall Emerald Shire and well in advance of both the regional (Fitzroy Statistical Division) and state averages. The town's share of the shire's population has also increased significantly over the last 15 years from around 50% in 1971 to about 63% in 1986.

The age and sex structures of the Emerald population, based on the 1986 Census figures outlined in Table 9.B in Appendix 9, reveal that the town has a relatively young population with a higher than average proportion of males.

The youthful profile of the Emerald population is the result of the fact that 61.3% of the town's population is less than 30 years of age, compared with 55.8% for the Emerald Shire and 48.9% for Queensland, while only 5.5% of the town's population is in the 60 years and over age category compared with 9.3% and 15.3% for the shire and the state respectively. A comparison of 1976, 1981 and 1986 Census statistics reveals that while the shire and state populations are gradually maturing, the Emerald population tends to be influenced by the developments occurring around Emerald. The youthful nature of the Emerald population is due largely to the effects of the development of the nearby Gregory coal mine which attracted many young families and young single people to the town.

Both Emerald and the Emerald Shire have relatively uneven sex structures compared with the state average, with males accounting for 54.6% and 55.2% of their respective populations compared with 50.1% for Queensland as a whole. In fact, there has been significant growth in male dominance of the Emerald population since the 1976 Census when males accounted for 52% of the town's population. This growth is significant considering there was a slight decrease in the male component of the state population between 1976 and 1986. This predominance of males and the growing proportion of single people in the Emerald population as is evidenced by the marital status statistics in Table 9.C, Appendix 9, can again be attributed to the influence of the development of the Gregory mine which attracted many men, particularly single men, for its construction and operation workforces.

Table 9.C of Appendix 9 reveals that Emerald has a relatively mobile population, with only 27.7% of the town's 1986 population in the same residence as 1981 compared with 31.6% for the Emerald Shire and 43.1% for the state. Other statistics highlighted in Table 9.C reveal that the Emerald community is fairly cosmopolitan. Although 91.5% of the Emerald population is Australian born, a figure that has increased since 1976 against the trend in both the shire and the state, there is still a fairly

broad cross-section of nationalities in the town's population. In recent years there has been a significant increase in the proportion of New Zealanders in the town's population with corresponding declines in the proportion of people from the United Kingdom and the United States.

As at the 1986 Census only 21.0% of Emerald families earned less than \$18,000 per annum compared with 33.3% for the shire and 33.6% for the state, while 20.3% of families in the town earned over \$40,000 per year as opposed to 19.2% and 17.2% for the Emerald Shire and Queensland respectively.

5.2.3 Project Population

The workforces associated with the development of the Ensham Project, their dependants and the associated service population will have a marked impact on the population of Emerald. The extent of the population increases and the characteristics applying to the incoming populations will vary according to the particular stage of development and any overlap that occurs between these stages.

Construction Phase

It is expected that the initial construction phase for the works to be constructed at the mine site, will take 48 months (refer Table 5.3). The peak mine construction workforce, expected to occur during the first quarter of Year 1, has been estimated at 420. Based on the assumptions outlined in Section 5.3.2, all of the mine construction workforce is expected to be imported from outside of the area. Due to the relatively short term nature of the construction phase employment, and with reference to the past experiences of other mining and industrial projects, it is expected that 80% of the workforce could be of single status (ie. not married, or married but unaccompanied by family) while the remaining 20% could be married.

On these assumptions, it is expected that at the peak of the construction phase, 292 single and 73 married workers will need to be imported. Because of the temporary nature of the work, it is anticipated that the typical family profile of the married construction worker could be one where both parents are under 35 years of age with 0 or 1 child per family. Consequently, a family multiplier of 2.5 (ie. worker + wife + 0.5 children) has been adopted and will be applied to the total married workforce. On this basis, the peak construction workforce can be expected to result in an additional population of 548 (refer Table 5.3).

As well as the mine construction workforce there will also be workforce associated with the housing construction programme in Emerald. It is expected that the construction phase for the housing will take 96 months and require a peak workforce of 258 during Years -1 and 1.

In addition to the direct workforce associated with the construction phase of the mine, the project will also generate a service workforce consisting of indirect and induced labour. The indirect workforce will include those workers in support industries supplying goods and services to the mine, whereas the induced workforce will account for those workers in industries satisfying the needs of the direct and indirect workers. In other words, the project generates the direct and indirect workforces, while the direct and indirect workforces themselves generate the induced workforce. Based on the assumptions outlined in Section 5.3.2, a local service workforce multiplier equivalent to 10% of the total direct construction workforce has been adopted and it is assumed that 60% of this service workforce could be recruited locally in Emerald. Therefore, out of a peak construction phase service workforce of 55, only 22 will need to be imported from outside the area.

It is expected that a high percentage of this service workforce will stay on after the completion of the construction phase to support the subsequent operational workforce. Therefore, it is likely that the service workforce will be much more permanent than the direct construction workforce and as a consequence, is expected to have a higher percentage of married workers (50% married, 50% single) with a more developed family structure (family multiplier of 3.0). Based on these assumptions, the peak construction phase imported service workforce of 22 would be expected to consist of 11 single and 11 married workers resulting in a total service population of 44 (see Table 5.3).

The combined direct and service workforces associated with the construction phase will therefore generate a maximum imported population of approximately 827 in the peak construction year (see Table 5.3).

There will also need to be construction of housing infrastructure in the town of Emerald. A major part of this work will be carried out by contractors. Certain community works including repairs and improvements to existing Council facilities will also be carried out by the Emerald Shire Council. While some work will go to local contractors and provide employment for some local residents, additional personnel will be attracted from outside Emerald. This additional workforce and associated families will generate some additional demand for services for the duration of the construction phase.

Operations Phase

The initial build up in operations personnel will commence in Year -1 during the construction phase of the project, with the major influx of workers during Years 1 and 2 after which time the mine will be largely fully operational (refer Table 5.4).

Table 53

Construction Phase Population Estimates

Year	Quarter	Mine										Town										Service										Combined									
		(A) Total W/F	(B) Imported W/F Ax1.0	(C) Singles Bx0.8	(D) Marrieds Bx0.8	(E) Family Dx2.5	(F) Total Pop'n C+E	(G) Total W/F	(H) Imported W/F Gx0.7	(I) Singles Hx0.8	(J) Marrieds Hx0.2	(K) Family Jx2.5	(L) Total Pop'n I+K	(M) Total W/F (B+H)x0.1	(N) Imported W/F Mx0.4	(O) Singles Ax1.0	(P) Marrieds Nx0.5	(Q) Family Px0.3	(R) Total Pop'n O+Q	Total W/F A+G+M	Imported W/F B+H+N	Singles C+I+O	Marrieds D+J+P	Family E+K+Q	Total Pop'n F+L+R																
-1	March	111	111	89	22	55	166	103	72	58	14	35	93	18	7	4	4	12	16	232	190	151	40	102	275																
	June	147	147	118	29	73	220	206	144	115	29	73	188	29	12	6	6	18	24	382	303	239	64	164	432																
	Sept.	233	233	186	47	118	351	250	181	145	36	90	235	41	16	8	8	24	32	532	430	339	91	232	618																
	Dec.	365	365	292	73	183	548	258	181	145	36	90	235	55	22	11	11	33	44	678	568	445	120	306	827																
1	March	263	263	210	53	133	396	258	181	145	36	90	235	44	18	9	9	27	36	565	462	364	98	250	667																
	June	153	153	122	31	78	231	224	157	126	31	78	204	31	12	6	6	20	28	408	322	254	68	174	459																
	Sept.	51	51	41	10	25	76	223	156	125	31	78	204	21	8	4	4	12	16	703	215	173	45	115	296																
	Dec.	72	72	58	14	35	107	120	84	67	17	43	110	16	6	3	3	9	12	208	162	148	34	87	229																
2	March	73	73	58	15	38	101	120	84	67	17	43	110	16	6	3	3	9	12	209	163	128	35	90	223																
	June	45	45	36	9	23	68	82	57	46	11	28	74	10	4	2	2	6	8	346	106	93	22	57	150																
	Sept.	64	64	51	13	33	97	82	57	46	11	28	74	12	5	3	3	9	12	158	126	100	33	70	183																
	Dec.	97	97	78	19	48	145	44	31	25	6	15	40	13	5	3	3	9	12	312	133	106	28	72	197																
3	March	121	121	97	24	60	187	43	30	24	6	15	39	15	6	3	3	9	12	491	157	124	33	84	238																
	June	114	114	91	23	58	172	43	30	24	6	15	39	14	6	3	3	9	12	662	150	118	32	82	223																
	Sept.	119	119	95	24	60	179	43	30	24	6	15	39	15	6	3	3	9	12	839	155	146	33	84	230																
	Dec.	67	67	54	13	33	100	43	30	24	6	15	39	10	4	2	2	6	8	959	101	80	21	54	147																
4	March	—	—	—	—	—	—	92	64	51	13	33	84	6	2	1	1	3	4	98	94	52	14	36	88																
	June	—	—	—	—	—	—	115	87	65	16	40	105	8	3	2	2	6	8	123	118	67	18	46	113																
	Sept.	—	—	—	—	—	—	115	81	65	16	40	105	8	3	2	2	6	8	123	118	67	18	46	113																
	Dec.	—	—	—	—	—	—	46	32	26	6	15	41	3	2	1	1	3	4	49	48	27	7	18	45																
5	March	48	48	38	10	25	73	2	2	2	—	—	2	5	2	1	1	3	4	7	52	41	11	28	79																
	June	71	71	57	14	35	106	2	2	2	—	—	2	7	3	2	2	6	8	9	76	61	16	41	116																
	Sept.	73	73	58	15	38	111	2	2	2	—	—	2	7	3	2	2	6	8	9	78	62	17	44	121																
	Dec.	38	38	30	8	20	58	2	2	2	—	—	2	4	2	1	1	3	4	6	42	33	9	23	62																
6	March	—	—	—	—	—	—	17	12	20	2	5	15	1	—	—	—	—	—	18	12	10	2	5	15																
	June	—	—	—	—	—	—	34	24	19	5	13	32	2	1	1	1	3	4	36	25	20	6	16	36																
	Sept.	—	—	—	—	—	—	34	24	19	5	13	32	2	1	1	1	3	4	36	25	20	6	16	36																
	Dec.	—	—	—	—	—	—	51	36	29	7	18	47	4	2	1	1	3	4	55	38	30	8	21	51																
7	March	—	—	—	—	—	—	73	51	41	10	25	66	5	2	1	1	3	4	78	53	42	11	28	70																
	June	—	—	—	—	—	—	73	51	41	10	25	66	5	2	1	1	3	4	78	53	42	11	28	70																
	Sept.	—	—	—	—	—	—	73	51	41	10	25	66	5	2	1	1	3	4	78	53	42	11	28	70																
	Dec.	—	—	—	—	—	—	73	51	41	10	25	66	5	2	1	1	3	4	78	53	42	11	28	70																

A maximum operational workforce of 407 is expected to be achieved by Year 7.

It is expected that some local workers will be able to gain employment at the mine, and for the purposes of this study it is assumed that 12% of the operational workforce will be recruited from the local workforce.

Due to the more permanent nature of the mining operations, and with reference to similar operations elsewhere in the region, it is assumed that on the average 70% of the workforce could be married and 30% single. Consequently, from a maximum imported operational workforce of 353 there is expected to be 247 married and 106 single workers (refer Table 5.4).

In accordance with experiences of similar projects and the current family structure of Emerald which already includes a substantial coal mining component, it is assumed that, on the average, each married worker would have 1.5 children, giving a family multiplier of 3.5 (worker + wife + 1.5 children). Taking into account the married/single ratio and the family multiplier adopted, the peak imported workforce of 353 is expected to generate a population of the order of 988 (refer Table 5.4).

As with the construction phase, the service workforce (indirect and induced workers) associated with the operational phase must also be taken into account to ascertain the full impact of the proposed project. Based on the assumptions outlined in Section 5.3.2, a service workforce for the operational phase of the project has been estimated (refer Table 5.4). It is assumed that up to 45% of this service workforce could be recruited locally. Assuming that the service workforce has similar population characteristics as the direct workforce, the maximum imported service workforce, comprising 6 single and 24 married workers, would generate a population of approximately 97 (refer Table 5.4).

Therefore, during the peak of operations a combined project and service workforce of 461, is expected to generate an imported population of the order of 1,085 (refer Table 5.4).

5.2.4 Summary

In the short term there will be a marked increase in the overall Emerald Shire population with the influx of construction workers to the mine site. In the longer term, the major population effects of the project will be in the Emerald urban centre where the majority of the mine workforce will be housed. The resulting population growth rates in Emerald are expected to be similar to that experienced in the town during the late 1970's and early 1980's, which were the result of the introduction of the Gregory mine population to the town.

Table 5.4

Operational Phase Population Estimates

Direct						Town						Combined						
Year	(A) Total W/F	(B) Imported W/F Ax0.88	(C) Singles Bx0.3	(D) Marrieds Bx0.7	(E) Family Dx3.5	(F) Total Pop'n C+E	(G) Total W/F Bx0.15	(H) Imported W/F Gx0.55	(I) Singles Hx0.2	(J) Marrieds Hx0.8	(K) Family Jx3.8	(L) Total Pop'n I+K	Total W/F A+G	Imported W/F B+H	Singles C+I	Marrieds D+J	Family E+K	Total Pop'n F+L
-1	9	8	2	6	21	23	1	1	-	1	4	4	10	9	2	7	25	27
1	157	138	41	97	340	381	21	12	2	10	38	40	178	150	43	107	378	421
2	220	194	58	136	476	534	29	16	3	13	49	52	249	210	61	149	525	586
3	252	222	67	155	543	610	33	18	4	14	53	57	285	240	71	169	596	667
4	323	284	85	199	697	782	43	24	5	19	72	77	366	308	90	218	769	859
5	325	286	86	200	700	786	43	24	5	19	72	77	368	310	91	219	772	863
6	351	309	93	216	756	849	46	25	5	20	76	81	397	334	98	236	832	930
7	407	358	107	251	879	988	54	30	6	24	91	97	461	388	113	275	970	1085
8	400	352	106	246	861	967	53	29	6	23	87	93	453	381	112	269	948	1060
9	400	352	106	246	861	967	53	29	6	23	87	93	453	381	112	269	948	1060
10	396	348	104	244	854	958	52	29	6	23	87	93	448	377	110	267	941	1051
11	401	353	106	247	865	971	53	29	6	23	87	93	454	382	110	270	952	1064
12	401	353	106	247	865	971	53	29	6	23	87	93	454	382	110	270	952	1064
13	401	353	106	247	865	971	53	29	6	23	87	93	454	382	110	270	952	1064
14	401	353	106	247	865	971	53	29	6	23	87	93	454	382	110	270	952	1064
15	401	353	106	247	865	971	53	29	6	23	87	93	454	382	110	270	952	1064

As indicated in the previous sections, the population generated by the project is expected to exhibit a relatively youthful profile with a high proportion of males. A significant proportion of the incoming married women are likely to be in the child bearing age group, while a high percentage of their children will be either not of school age or in the preschool and primary school age groups.

The injection of the Ensham population to Emerald is expected to continue the current trend in the town of a reducing average age and a growing predominance of males over females. In addition, the need to recruit nationally for a proportion of the mine workforce should result in a further broadening of the social mix of the town's population, while the higher than average wages paid to mine workers should see a growth in the affluence of the Emerald community.

In general, the Ensham population is expected to have some impact on the structure of the Emerald population resulting in a trend toward some characteristics of a mining town, continuing the trend established by the Gregory mine population.

5.3 Workforce and Employment

5.3.1 Emerald

The labour force in Emerald in the 1986 Census (refer Table 9.E, Appendix 9) accounted for 50.9% of the population, which is significantly higher than comparative figures for the Emerald Shire (44.9%) and the state average (39.8%). This higher than average participation rate in the workforce is a likely product of the extra workers brought to the town for the development and operation of the Gregory coal mine, the additional employment created in the town as a result of the mine, and the fact that Emerald functions essentially as a regional service centre.

Although there are up to date unemployment statistics available for Emerald, the 1986 Census figures are considered to be indicative of the current situation in the town where the unemployment rate of 6.0 is markedly lower than the shire (10.4%) and state (11.1%) figures (refer Table 9.E, Appendix 9). The lower than average unemployment rate in Emerald is a further product of the additional employment created in the town by the Gregory coal mine project. While there was an increase in unemployment in Emerald between 1981 and 1986, this was in line with the shire and state wide trends.

The average age of the Emerald workforce at the 1986 Census is considerably lower than both the shire and state figures as is evidenced by the fact that 51.3% of the town's workforce was less than 4 years of age compared with 47.7% for the Emerald Shire and 41.2% for Queensland (refer Table 9.F Appendix 9). At the same time, the 55 years and over age category accounts for only 5.4% of the Emerald workforce compared with 7.0% and 9.4% for the shire and state respectively. The relatively young Emerald workforce is largely the result of the many young people attracted to the town to work on the Gregory coal project. In addition, as

a well established regional service centre, Emerald, unlike many smaller country towns and single industry mining towns, is able to retain a higher proportion of its young school leavers by providing a wider range of employment opportunities.

Males account for higher than average proportions of the Emerald and Emerald Shire workforces, with 67.6% in the town and 61.7% in the shire compared with 61.7% for the Queensland average as at the 1986 Census (refer Table 9.F, Appendix 9). This high male participation rate in the town and shire workforces is the result of the traditional predominance of males over females in the major employment areas in Emerald and the Shire, in particular mining, agriculture and transport and storage (refer Table 9.G, Appendix 9). As might be expected in a community where the mining, agriculture and transport and storage industries are major employers, Emerald has a higher than average proportion of single people in its workforce, particularly single males. At the 1986 Census (refer Table 9.E, Appendix 9) 36.5% of the Emerald workforce have never married compared with 35.9% for Emerald Shire and 32.9% for Queensland. This figure reflects the effect of the Gregory coal mine project in attracting single people to the town.

Employment by industry statistics from the 1986 Census (refer Table 9.G, Appendix 9) reveal that, in line with the Queensland average, the Wholesale & Retail Trade industry is the largest employer in Emerald, accounting for 20.0% of the workforce about the same percentage as that recorded for the State. Other major employers are the Mining industry and the Transport and Storage industry with 12.0% and 15.3% of the workforce respectively. This is to be expected in a town which is a well established service centre. Although these industries are major employers in Emerald they represent only relatively small proportions of state wide employment, 2.0% and 6.2% respectively. While manufacturing is a major employer throughout Queensland employing 11.7% of the state's workforce, the industry accounts for only 4.1% of the Emerald workforce.

The occupational structure of the Emerald labour force at the 1986 Census (refer Table 9.G, Appendix 9) reflects the importance of the mining operation with the town. The single major occupational category in Emerald is Tradespersons and labourers and related workers which accounts for 17.8% of the town's workforce, slightly higher than the state average figure of 15.7%.

5.3.2 Project Employment

Workforce Size

At the height of the construction phase in Year -1, the project is expected to support a direct workforce both at the mine site and in Emerald of 623, in addition to generating an estimated service workforce of 55 (refer Table 5.3). The development and construction phase for the mine will be carried over an 8 year period. For Year -1 to Year 3 and during Year 5 a construction work force will be maintained on site. No construction will take

place in Year 4. The third dragline will be erected and commissioned in Year 5. A work force will also be employed on the construction of the accommodation in Emerald. This work force will be maintained in Emerald for the first 8 years of the project to construct the additional housing required to accommodate the growing mine workforce.

As outlined in Table 5.4, there is likely to be a steady growth in the mine's operational workforce during the initial construction phase of the project, beginning with an initial mine workforce of 157 in Year 1 and culminating in a peak operational workforce of 407 in Year 7. The direct operational workforce is expected to generate flow-on employment for a maximum service workforce of 54 during Year 7 of the operation.

Workforce Source

It is expected that a number of different contractors will be used to construct the mine facilities, and because these contractors are likely to have established work crews, it is assumed that all construction workers at the mine will be imported into the area. However, this assumption is made for project planning purposes only, in particular for the need to adequately cater for the accommodation of mine site construction workers, and does not preclude locals from seeking employment with individual contractors.

Some local sub-contractors are likely to be involved in the construction of the mine housing in Emerald. Even assuming that all of the housing contractors are from outside the local area, it is still expected that some local workers could find employment with these contractors, particularly as labourers. Therefore, for the purposes of this study it is assumed that 30% of the town construction workforce could be recruited locally necessitating the importation of 181 of a total of 258 workers at the peak of housing construction activities. During the peak of all of the mine and town construction activities late in Year -1, it is expected that a total of 568 workers will need to be imported into the area (refer Table 5.3).

Section 5.1 outlines the flow-on employment effects of the proposed mine, and during the construction phase it is estimated that an average direct workforce of 365 could generate a service workforce of 140 within the Fitzroy Region. It is important to remember however that the figure of 140 is the estimated upper limit and varying economic conditions could significantly reduce this figure. It is expected that the majority of this additional employment would be centred in Rockhampton. Therefore, on this basis, and with respect to the experience of similar projects, a local service workforce multiplier equivalent to 10% of the total direct construction workforce has been adopted. At the peak of the construction phase this would result in a service workforce of 55.

Emerald is a well established service centre which is expected to be able to provide a high proportion of the service population likely to be generated by the construction phase of the Ensham project. Therefore, it is assumed that 60% of the construction phase service workforce could be recruited locally and on this basis only 22 of the peak construction phase service workforce of 55 will need to be imported from outside the area.

It is expected that local workers will be able to fill some of the positions associated with the operations phase of the mine, in particular school leavers, graduates from the TAFE College and rural workers seeking more secure employment in the face of a generally contracting rural economy. Therefore, for the purposes of this study it is assumed that 12% of the direct operational workforce could be recruited locally, with the bulk of the mine workforce, particularly those in more specialised positions, imported from outside the local area. Consequently, it is expected that approximately 358 workers out of a peak direct operational workforce of 407 would need to be imported.

The regional flow-on service employment generated by the average operational mine workforce, is estimated to be of the order of 248 (refer Table 5.2), however, changing economic conditions could significantly reduce this figure. Although the majority of this additional employment is likely to be centred in Rockhampton, Emerald would be expected to experience a marked increase in its support workforce so as to service the needs of the miners and their dependants. Because the operational workforce is relatively permanent and because the married workers are expected to have a larger family unit than the married construction workers, it is expected that the operational phase population will create a higher per capita demand for goods and services than the construction phase population. Consequently, a larger service workforce will be required, and for the purposes of this study, a local service workforce multiplier equivalent to 15% of the total direct operational workforce has been adopted. Usually the operational workforce would be expected to generate a somewhat larger local service workforce. However, because Emerald is already a well established service centre which is expected to be able to cater for a high proportion of the increased consumer demand within its existing service capabilities, the lower local service workforce multiplier is considered justified.

As was the case with the construction phase, it is likely that a good proportion of the flow-on service workforce will be recruited locally. However, the proportion is likely to be lower than that adopted for the construction phase, as the operation's phase service workforce is expected to include a higher proportion of skilled workers eg. teachers, nurses etc. that could be difficult to recruit locally. Therefore, assuming that 45% of the flow-on service workforce could be recruited locally, at the peak of

operations, 30 out of a total service workforce of 54 will need to be imported. Assuming the service workforce has similar population characteristics as the direct workforce, the imported service population is expected to total approximately 97 (refer Table 5.4).

It is also possible that some of the mine workforce could be drawn from that component of the local labour force that is already gainfully employed. The company will obviously only have control over the direct project workforce and these workers will be selected according to those best qualified and suited to the particular position. Consequently, on this basis, it is possible that some of the mine workforce could come from the ranks of those already employed in Emerald. However, because of the skilled/semi-skilled nature of much of the work associated with mining, the local content of the mine workforce is likely to be relatively small. Any possible movement of labour could cause some short term disruption to local employers in the region until they are able to fill the vacated positions with other workers - possibly from the ranks of the steady stream of itinerant workers who follow in the wake of newly announced development projects.

In summary, during the mine's construction phase it is expected that most of the direct workers, except for a small number of those constructing the mine housing in Emerald, will need to be imported, while 33 out of a maximum flow-on service workforce of 55 are expected to be able to be recruited locally. During the operations phase of the project it is expected that a small proportion of the direct mine workforce could be recruited locally, amounting to about 49 jobs out of a peak workforce of 407. In addition, it is expected that almost half of the service workforce generated by the peak operational workforce could be recruited locally, representing about 24 jobs. Consequently, the direct and indirect employment generated by the project would be expected to make a significant contribution to the reduction of local unemployment in Emerald. In particular, the nature of the type of employment opportunities generated at the mine and in town, in the form of apprenticeships and service orientated jobs, should be of particular benefit to young people and school leavers which generally comprise a large proportion of the unemployed.

Workforce Structure

On the basis of the company's proposed operations, and with respect to the experience of similar projects and the findings of surveys by the Australian Federation of Construction Contractors, the anticipated occupational structure of the project's construction workforce is summarised at Table 5.5.

Table 5.5
Occupational Structure of Peak Construction Workforce

Occupation	%	Number
Professional/Semi Professional	10	62
Skilled trades (foreman, plant operators, tradesman)	47	293
Semi-skilled/unskilled	43	263
Total	100	623

A breakdown of the proposed mine workforce into particular work categories based on specific Company requirements is as follows:

Table 5.6
Work Categories of Peak Operational Workforce

Work Category	%	Number
Administration, Management etc.	8	31
Mining	52	212
Coal Preparation	9	35
Maintenance	32	129
Total	100	407

The expected occupational structure of this operational workforce based on past industry trends is summarised at Table 5.7.

Table 5.7
Occupational Structure of Peak Operational Workforce

Occupational	%	Number
Professional	6	24
Technical	9	37
Skilled	61	248
Semi-skilled/Unskilled	24	98
Total	100	407

During the early development stages of the mine and the construction of housing and associated facilities in Emerald, the construction workforce required will result in a growth in the construction industry component of the Emerald and Emerald Shire labour forces. However, this growth will be only shortlived because when the initial construction phase is completed and operations commence, the majority of the workers will be classified under the Mining Industry category, resulting in a significant growth in this category's share of the Emerald labour force. Both the construction and operational phases of the project are expected to generate flow-on service employment in Emerald (refer Section 5.3.2). Most of this flow-on employment will be generated in the service sectors of Emerald, particularly the Wholesale & Retail Trade and Community Services and the Recreation categories which are already major employment sectors in the town (refer Table 9.G, Appendix 9). The mine workforce will be largely categorised under the Tradespersons, Plant and Machine Operators occupational groupings which already account for about 30% of the town's workforce.

The increase in employment generated by the project will undoubtedly increase the town's workforce participation rate. A large proportion of the mine workforce is expected to be male and although an equally high proportion of the flow-on workforce is expected to be female there is still likely to be a significant growth in the number of males in the already strongly male dominated Emerald workforce. The relatively youthful profile of the mine workforce and the likelihood that many young people will be involved in the flow-on workforce, is likely to result in a further reduction of the average age of the Emerald workforce which is already considerably lower than the state average.

In summary, the direct and service workforces generated by the Ensham project are likely to have the effect of altering the structure of the Emerald workforce to the extent that it will be similar to that of a mining town like Moranbah, with a relatively young workforce dominated by males. However, the Emerald workforce would be expected to have a more evenly balanced industry base than that of a mining town, as Emerald is a well established service and administrative centre.

Workforce Training

In order to maintain a skilled workforce, to avoid industrial relations problems, to provide promotional opportunities and to promote safety, the company proposes to establish an extensive programme of on-the-job and off-the-job training.

Investigations by the company have identified the major training need areas which will be co-ordinated and administered by a company Training Officer with assistance from line

managers/supervisors and specialist outside resources when necessary.

- **Induction Program**

All new employees will proceed through an induction program during the first twelve months of commencing employment with the company. The objectives of such an induction programme will be to assist new employees to quickly adjust to the company, the working environment and their position by:

- Familiarising them with company objectives, values, relevant procedures and safety requirements.
- Explaining their role, and expected standards of performance.
- Familiarising them with work place layout and procedures.

- **Supervisor Training**

All new supervisors will receive training to prepare them for effectively carrying out their role. The objectives of such a training programme will be as follows:

- To prepare supervisors for their present and future roles.
- To clarify the role, responsibilities and relationships of the supervisor.
- To familiarise supervisors with the company's policies, procedures, rules, documentation and their interpretation.
- To promote common and consistent understanding and approach in the application of company policies, particularly industrial relations.
- To develop interpersonal skills in the handling of people on the job, eg. communicating, counselling, motivating and on-job training.
- To develop supervisor skills in the planning, scheduling and co-ordination of their work and that of their work crews.

- **Operator Training**

Training requirements for operators fall into two categories:

- Adaptation training for operators with prior relevant work experience.

- Development of "skills" for those who do not have prior relevant work experience.

The objectives of such training are to ensure that operators can use Ensham equipment safely, efficiently and cost-effectively, in keeping with company policies and procedures. Training will be conducted on-the-job by the operator's supervisor and/or by using the equipment supplier's representatives as instructors.

- **Trade Training**

All tradesmen will receive training to ensure they can adapt their skills to the Ensham situation. The objective of such training will be to ensure that tradesmen can use Ensham equipment safely, efficiently, and cost-effectively, in keeping with company policies and procedures. Training would be conducted on-the-job by the tradesman's supervisor and/or by using the equipment supplier's representatives as instructors.

- **Apprentice Training**

All apprentices are required to undertake on-the-job and off-the-job training, as per the relevant requirements. The objectives of an apprentice training programme are to provide the apprentice with the skills that he or she requires to become an effective trades person and to provide the employer with future skilled trades people.

The content of the Ensham apprentice training programme will include:

- Induction
- Apprentice regulations
- Requirements of the Apprenticeship Agreement
- Basic trade skills and practices (both on and off job training)
- On-job safety procedures.

Apprentices will be rotated through as many work areas as is possible during their training, to ensure a good base of practical knowledge and experience. An Apprentice Master will co-ordinate the on-job training activities of apprentices in the electrical and mechanical trades, with off site block training also provided at the Emerald TAFE College.

- **Safety Training**

All Company employees will receive safety training. The objectives of the Safety Training are to develop and

maintain positive attitudes toward safety, to teach safe working practices, and to teach statutory safety requirements.

Safety training would include:

- Resuscitation training
- First Aid training
- Rescue training
- Safe work practices.

All site employees would be required to undertake refresher training in resuscitation techniques and first aid every twelve months. For some groups, eg. electricians, this period could be shortened to six months. Rescue training will be conducted for work rescue teams monthly. All first line supervisors will be encouraged to conduct monthly safety meetings with their subordinates, to ensure safe work practices.

A Safety Officer will co-ordinate and administer safety training, and provide assistance to line personnel in designing and teaching safety training sessions and programs. St John's Ambulance would also be used to assist site personnel development and conduct safety training sessions and procedures.

All employees will receive training in the industrial relations environment at Ensham, disputes handling and general communications. The objectives of the training are:

- To develop an employee's understanding of their employment entitlements as an employee of Ensham.
- To develop an understanding of the industrial relations environment at Ensham.
- To give employees an understanding of entitlements under their relevant awards.
- To ensure that employees are aware of disputes handling procedures and how to use them.
- To develop employees communication skills to encourage and enhance their participation in problem/dispute solving forums.
- To encourage employees to be involved in consultative meetings on all issues of concern.

This course will be conducted by the Employee Relations Officer, in conjunction with supervisors and union representatives.

5.4 Accommodation

5.4.1 Emerald

Although the predominant form of housing in Emerald is the self-contained dwelling unit, flats and units account for a higher than average proportion of the town's housing stock when compared with the Queensland average and other country towns throughout the state. However the most striking difference between the structure of occupied private dwellings in Emerald and the normal situation is the high percentage of caravan usage in Emerald. The 1986 statistics revealed that 14.1% of households and 9.3% of the population of Emerald were recorded as residing in caravans.

At April 1990, there were less than 20 vacant building allotments and about 15 houses on the market in Emerald. There was virtually no rental accommodation available and agents had waiting lists of people wishing to rent.

The town is divided into 2 by the Nogoa River with much of the new development occurring north of the river (pers. comm.). Most of this land on the north side of town has now been developed. The available land is currently available for between \$17,500 and \$22,000. There is still some land available on the south side of Emerald for between \$14,500 and \$17,000. There is land which is in a position to be developed, although some lag time would be required before such blocks would be available. There is a subdivision for which the infrastructure is currently being provided. It will yield about 20 residential blocks when development is completed.

Housing ranged in price from \$50,000 for a 2 bedroom chamferboard dwelling to \$220,000 for a house with 4 flats. Average price for a detached dwelling was about \$70,000.

On the basis of the 1986 census figures, over half of the households in Emerald are in rented accommodation. Normally this would be unusual for a country town but it is to be expected in Emerald where a large number of houses are provided at nominal rent to miners by their employers, in addition to the rental accommodation provided for many of the large contingent of public sectors workers in the town. Like land and housing, rental accommodation is expensive and in very short supply.

Rental accommodation ranges from about \$100 each week for a 2 bedroom flat up to about \$180 each week for a 3 bedroom home. Additional flats are to be constructed in Emerald. When completed they should be available for rental. These units should partly alleviate the current short fall.

With respect to temporary or short term accommodation, in March 1990 Emerald had seven motels with about 200 units, two hotels with about 40 units, and five caravan parks. The caravan parks in the town collectively provide approximately 330 powered sites. In addition these parks have a

total of 54 cabins and on site caravans. Most of the parks provide a relatively good standard of facilities.

Occupancy rates at all the existing motels and hotels are generally high. This in part is a reflection of the importance of Emerald as a commercial and administrative centre for the central highlands region. Emerald is an important stop over point for agricultural, mining, and other commercial and public sector representatives. There is also an increasing number of tourists passing through the town and several motels specialise in the tourist coach trade. Tourist numbers are highest during the months from April to November.

Occupancy rates at the major caravan parks is generally medium to high. A number of the parks cater for workers for the agricultural industries, particularly cotton, as well as workers associated with the Gordonstone mine. Tourist numbers increase during the winter months.

Most of the private caravan parks and the showground park have room for further expansion if required.

5.4.2 Project Accommodation Proposals

The company recognises that to attract a suitable workforce into the area, an adequate supply of good standard accommodation will need to be provided. On this basis suitable accommodation will be available at the mine and in Emerald for the construction and mine workers.

Construction Phase

During the mine's construction phase, there is expected to be a peak direct workforce at the mine of 365. An additional contract workforce will be involved in the construction of housing in Emerald. It is proposed to provide on-site accommodation for the mine construction workers, all of whom are expected to be imported from outside the area (refer Section 5.3.2). The construction camp will provide separate accommodation facilities for single and married workers.

The imported housing construction workers will be responsible for their own accommodation largely because of the short term nature of the housing construction contract, and the fact that at least 30% of the required workforce is expected to be recruited locally. There will be some temporary accommodation made available in the motels, hotels and at the caravan parks. It is expected that the majority of the imported housing construction workers would rely on caravans for their accommodation and as outlined in the preceding Section, most of these existing caravan parks are capable of some expansion.

Accommodation at the mine site will be provided in residential units and a caravan park. The accommodation units will be arranged into camps of 8 units, each connected to a central

ablution block by covered concrete patios. Each unit will consist of 5 rooms fitted with air conditioners and heaters. The caravan park will consist of 80 serviced sites.

The single persons quarters will be available to contractors as required, while the provision of caravans will be the responsibility of individual contractors or married workers. A camp manager will be appointed to be responsible for the booking of camp facilities, camp maintenance, the servicing of the single rooms and the provision of catering services at both the wet and dry canteens. The camp will be located within walking distance of the construction site (refer Drawing 3.6).

All of the construction workers are expected to rely on Emerald for the majority of their shopping, recreation, entertainment, medical and schooling needs. Although the mine camp is approximately 45km from Emerald, car ownership of the construction workers is expected to be very high and as such there should be no major problems with transportation to town. Arrangements will be made to ensure children from the mine camp will be bused to the schools in Emerald.

Operational Phase

Based on the assumptions outlined in Section 5.2.3, the maximum imported operational workforce for the mine of 358, is expected to consist of 251 married and 107 single workers, all of whom are expected to be accommodated in Emerald. It is expected however that a small number of these workers will belong to incoming family groups and as such will not require separate accommodation. For the purposes of this study, it is assumed that of the single workers (apprentices, single females etc.) 20% will fall into this category. As a consequence, while accommodation will still need to be provided for all of the married workers, only 86 single workers will require separate accommodation.

Due to the fact that Emerald generally has only a relatively small supply of available housing and residential land on the market at any one time, and because of the need to provide a uniform standard and quality of housing for mine workers, it will be necessary for the company to subdivide and develop suitable areas of land. Integration of the workforce into the town is important. Existing developed lots will be purchased and undeveloped parcels of land to the north, south and east of the town will be obtained and subdivided. One such area under consideration for part of the residential development is on the south-eastern side of town on the eastern side of the Nogoia River. This site could include parts of the Camping and Water Reserve (R.7) and the Gravel Reserve (R.179).

The proposed development areas will be subdivided into building allotments for detached dwellings. The minimum block size will

be approximately 800m and all blocks will be developed above the relevant flood level.

In the interests of overcoming the design deficiencies of earlier mining towns and generally avoiding the stereotype nature of the housing in many of these towns, the company will adopt a total design concept in the development of its housing. This will entail the use of architectural services, not only in house design, but also on house placement, street layouts and landscape requirements.

The single employee will be housed in duplex units created within the town. Each duplex unit will have 2 bedrooms and will accommodate 2 single persons. There will be two duplex units per lot of land and they will be finished in accordance with the local industry standard.

The housing distribution for the 251 married workers and management is expected to be as summarised in Table 5.8.

Table 5.8

Housing for Married Workers and Management

Type	No.
4 bedroom high set	17
4 bedroom low set	11
3 bedroom high set	154
3 bedroom low set	104
management	7
Total	293

This distribution can however be progressively adapted to suit actual demand. Some surplus housing accommodation will be available for single workers. The company will provide this accommodation on similar terms and conditions as are currently provided for similar mine housing throughout the central Queensland mine fields.

The location and development standards for all project housing will be determined in accordance with the requirements of the Emerald Shire Town Planning Scheme.

Summary

The construction and operation phase accommodation arrangements proposed by the company are expected to

adequately cater for the housing needs of the company's mine workforce and construction phase contract workers. To ensure that accommodation is available when needed, accommodation contracts will be let on the basis that housing is provided in sufficient time to meet the perceived demand.

A comparison of Tables 5.3 and 5.4 will reveal that the housing construction workforce timetable has been formulated to take account of the periodic increases in the mine workforce and resultant demand for housing. Throughout the development of the project the company will monitor the housing situation to ensure that supply keeps pace with demand.

The service workforce generated by the proposed development will be responsible for its own accommodation. Because only a relatively small number of service workers are expected to be imported into Emerald, it is considered that the existing land and housing market in the town could cater for the accommodation requirements of the service population. However, in the interests of avoiding any unnecessary pressure on the Emerald real estate market from non-project personnel, the Land Administration Commission has land available for future subdivision.

The proposed residential subdivisions may be undertaken by the Company or by the Lands Administration Commission. These blocks would be disposed of at market prices. The proposal of distributing the new residential development throughout the town as much as possible will also have the added advantage of providing a better mix of mine and non-mine populations, thus facilitating a higher degree of social interaction within the whole community.

5.5 Community Facilities

5.5.1 Commerce and Industry

Although the Emerald region was explored extensively by Leichhardt in the mid 1800's, it was not until the construction of the western railway line that the town of Emerald was established in 1879. The railway opened up the country facilitating the development of agricultural and pastoral activities in the region which in turn saw Emerald develop as a major rural service centre. In particular, major developments which have spurred the growth of the town since the railway include the Queensland British Food Corporation's illfated foray into large scale grain and pig farming in the area in the late 1940's, the construction of the Fairbairn Dam and associated Emerald irrigation network in the late 1960's, and the development of Emerald as the dormitory housing area for the Gregory coal mine north-west of the town in 1979.

In addition to farming and mining, another contributing factor to the growth of Emerald has been its geographical position in the Central Highlands and the resultant development of the town as a regional centre.

The town is the regional headquarters for State Government Departments of Land Management, Water Resources, Primary Industries and the Capricornian Electricity Board has a full range of primary, secondary and tertiary education facilities including an Agricultural College and a TAFE College incorporating a branch of the Capricornian Institute. The town also has a newspaper serving the Central Highlands together with national and commercial radio and television stations; and is a major air, road and rail transport centre.

As a principal service and administrative centre for surrounding rural areas and a mine population, Emerald has a well developed service industry structure. The town has a good range of commercial facilities including three supermarkets, a variety of professional and semi-professional based services including accountants, solicitors, consulting engineers and most of the major banks and building societies, and a well developed light industrial sector. Emerald also has a Chamber of Commerce and a branch of the Central Highlands Tourist Association both of which are actively promoting the town.

The increase in population generated by the proposed development and the relatively high disposable incomes of the mine workers, should lead to a marked increase in the demand for goods and services in Emerald. The incoming population, as outlined in Section 5.2.3, is expected to be relatively young and this should reflect in their demand patterns. In particular, there is likely to be an increased demand for supermarket and specialty store shopping facilities, professional services and advice, and restaurant and take-away food facilities. Although the proposed mine will have its own maintenance facilities and workshops, it is likely that the mine will periodically require the services of a variety of local light industries, such as steel fabrication, equipment hire services, and plumbing, earthmoving and concrete contractors.

The initial increase in population generated by the proposed development will provide a stronger customer base for the shopping facilities currently undergoing expansion. These facilities are likely to be able to cater for the initial stages of the project's development. However, once the mine is fully operational, the increased demands of the miners and their families will provide opportunities for the establishment of new facilities. In addition, Emerald's existing light industrial sector is likely to be expanded by industries responding to the increased demands of the project. Overall, these changes are expected to benefit the whole community by providing a wider range of shopping facilities, better competition, and an expanded and more viable light industrial sector.

5.5.2 Education

As indicated previously, Emerald is a major educational centre with primary, secondary and tertiary education facilities. The town currently has two state pre-schools, a kindergarten, two state primary schools, a catholic primary school, a state high school, a TAFE College and an Agricultural College.

There is one full-time state pre-school and one part-time state pre-school in Emerald. The full time pre-school is a double unit facility attached to the Emerald North State School and in March 1990 had an enrolment of 71. This is a reduction in the enrolment number which peaked in about 1986 with an enrolment of 98. Because the Emerald North pre-school was unable to cater for the demand for pre-school places, a temporary pre-school was established in Emerald in April 1986. The pre-school operates on a half day basis out of the Emerald RSL club and at the present time has an enrolment of 49 children. A further 7 children are enrolled in the Emerald Special Education Development Centre. The Emerald Kindergarten currently has an enrolment of about 115 and like the pre-schools, is currently operating near capacity, with only limited scope to deal with any increase in demand.

The Emerald and Emerald North Primary Schools had enrolments of 292 and 392 respectively as at March 1990. Over the last few years while enrolments have gradually declined at the older Emerald Primary School and grown at the newer Emerald North facility, overall state primary school enrolment levels in the town have increased only marginally. Enrolment levels at St. Patricks Catholic Primary School have also remained fairly static over the last few years, with the school having a March 1989 enrolment level of 216. A Special Education Unit was established at the Emerald North Primary School in 1984 and in March 1990 it had an enrolment level of 8. There is a small one teacher school at Comet just south of the proposed mine site and in March 1990 it had an enrolment of 8 which indicates the trend of declining enrolments at the school since it peaked in 1982 with a population of 43.

The Emerald State High School had a March 1990 enrolment of 589, which continues the gradual decline on enrolment levels after peaking in 1983 at 722. The decline in recent years is partly due to the commissioning of new and expanded high schools at Capella and Clermont. It is considered that the Emerald High School would have some existing capacity to cater for any increased demand and the scope for future expansion if required.

The Emerald Agricultural College was established in 1972 and has a current enrolment of about 125, all of whom are live in students. Enrolments are generally at capacity level with the only growth being due to the provision of a further dormitory which increased enrolment capacity from 100 to its present level. During 1990 a further dormitory will be constructed allowing the intake of 16 students in 1991. This will be expanded in 1991 allowing an extra 16 students by 1992. It is hoped all additional facilities will be filled by females. As part of this programme of works other support facilities will also be constructed.

The Emerald TAFE College accepted its first enrolments in 1986. Full time enrolment is approximately 90, with about 20 apprentices, 120 to 180 part time business, 100 trade and 50 adult and community education students. The College also caters for evening pre-vocational, catering and recreation studies. Other courses include Business Studies, Engineering

TABLE 5.9

BREAKDOWN OF IMPORTED SCHOOL AGE CHILDREN
FOR CONSTRUCTION PHASE

Year ¹	DIRECT					SERVICE					COMBINED				
	(A) Total Pop'n	(B) Total Children	(C) Pre- School Bx0.2	(D) Primary Bx0.45	(E) Secondary Bx0.1	(F) Total Pop'n	(G) Total Children	(H) Pre- School Gx0.15	(I) Primary Gx0.45	(J) Secondary Gx0.15	Total Pop'n A+F	Total Children B+G	Pre- School C+H	Primary D+I	Secondary E+J
-1	783	55	11	25	6	44	11	2	5	2	827	66	13	30	8
+1	631	45	9	20	5	36	9	1	4	1	667	54	10	24	6
+2	211	17	3	8	2	12	3	-	1	-	223	20	3	9	2
+3	226	15	3	7	2	12	3	-	1	-	238	18	3	3	2
+4	105	8	2	4	1	8	2	-	1	-	113	10	2	5	1
+5	113	8	2	4	1	8	2	-	1	-	121	10	2	5	1
+6	47	4	1	2	-	4	1	-	-	-	51	5	1	2	-
+7	66	5	1	2	1	4	1	-	-	-	70	6	1	2	1

1 Maximum population in that particular year.

TABLE 5.10

BREAKDOWN OF IMPORTED SCHOOL AGE CHILDREN
FOR OPERATION PHASE

Year	DIRECT					SERVICE					COMBINED				
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	Total	Total	Pre-	Primary	Secondary
	Total Pop'n	Total Children	Pre- School Bx0.2	Primary Bx0.45	Secondary Bx0.2	Total Pop'n	Total Children	Pre- School Gx0.2	Primary Gx0.45	Secondary Gx0.2	A+F	B+G	C+H	D+I	E+J
-1	23	9	2	4	2	4	2	-	1	-	27	11	2	5	2
+1	381	146	29	66	29	40	18	4	8	4	421	164	33	74	33
+2	534	204	41	92	41	52	23	5	10	5	536	227	46	102	46
+3	610	233	47	105	47	57	25	5	11	5	667	258	52	116	52
+4	782	299	60	135	60	77	34	7	15	7	859	333	67	150	67
+5	786	300	60	135	60	72	34	7	15	7	863	334	67	150	67
+6	849	324	65	146	65	81	36	7	16	7	930	360	72	162	72
+7	988	377	75	170	75	97	43	9	19	9	1085	420	84	189	84
+8	967	369	74	166	74	93	41	8	18	8	1060	410	82	184	82
+9	967	369	74	166	74	93	41	8	18	8	1060	410	82	184	82
+10	958	366	73	165	73	93	41	8	18	8	1051	407	81	183	81
+11	971	371	74	167	74	93	41	8	18	8	1064	412	82	185	82
+12	971	371	74	167	74	93	41	8	18	8	1064	412	82	185	82
+13	971	371	74	167	74	93	41	8	18	8	1064	412	82	185	82
+14	971	371	74	167	74	93	41	8	18	8	1064	412	82	185	82
+15	971	371	74	167	74	93	41	8	18	8	1064	412	82	185	82

and Construction, Hair Dressing and Hospitality, with Rural Studies and Mining courses planned for the future.

The imported direct and service married workers are expected to introduce a significant number of dependant children into the population. Estimates of children numbers generated by the construction and operation phase imported workforces, along with classifications of school age children into pre-school, primary school and secondary school categories, are provided in Tables 5.9 and 5.10 respectively.

The project's construction phase will generate only a relatively small number of school aged children over fairly short periods of time. The maximum number of children likely to be resident at the mine site is expected to be during the first year of construction (Year -3), where there will be an estimated 11 pre-school, 25 primary school and 6 secondary school aged children. Although there is a primary school at Comet, it is considered to be too small to adequately cater for any significant increase in enrolments and it is unlikely that expansion would be warranted for the short term requirements of the project's construction population. Therefore, it is expected that the primary school pupils along with any high school students will be bused into the schools in Emerald, while the younger children would be taken into the Emerald pre-school or kindergarten either individually or in groups by their families.

Once the mine is fully operational, the increased population generated by the imported direct and indirect workforce is expected to generate a maximum of 420 children, 357 of which could be of school age. Of these school-age children, 84 are expected to be in the pre-school age group, 189 in primary, and 84 in secondary. Increased enrolment levels of this magnitude would require a major upgrading of some existing facilities and in other instances, the provision of new facilities. The 84 pre-school children would require at least a new double unit pre-school facility. The additional 189 primary school children are expected to be able to be catered for by expansion of the existing Emerald North Primary School. Expansion of the existing Emerald High School is expected to adequately cater for the additional 84 secondary school age children.

5.5.3 Health

Emerald is the main centre for health facilities in the sub-region and at the present time offers a good standard of medical care. The town has a public hospital offering general medical, surgical, paediatric, maternity and emergency services. The hospital has a total of 56 beds, 1 professional medical staff and 26 nursing staff. There is also a Community Health Services Centre attached to the hospital which provides advice and assistance on a variety of health and family issues including school health, home help, health education and equipment and family and health problems.

In addition to the hospital medical staff, Emerald also has three medical practitioners, a dentist and a dental clinic. There is a full time Maternal and Child Welfare clinic in the town which is the sub-regional

headquarters for the Springsure - Rolleston - Clermont area. The clinic has three permanent staff housed in a relatively modern and up-to-date facility. The Emerald Ambulance centre is the operational headquarters for the Blackwater - Middlemount - Capella region and a centre for the Rockhampton aerial ambulance. The Emerald centre operates on a twenty-four hour basis, has eight staff, four large ambulances and a large emergency ambulance/rescue vehicle.

Based on Queensland Health Department guidelines and the town's current population, the Emerald Hospital should have an average daily census of about 28 (ie. 28 occupied beds per day) but during 1986/87 the actual recorded census was only 20.7. Consequently, the hospital would appear to be operating well within its capacity, and it is expected that it will be able to cope with any increased demands from the incoming population.

The increased population of children is likely to place demands on the services of the Maternal and Child Health Clinic. However the existing full-time service is expected to be able to adequately deal with the increased demand. Although other health services in the city (eg. doctors, chemists, ambulance etc.) appear to be adequate, it is expected that these will be expanded or new services provided by the individuals or organisations concerned, if the need arises.

5.5.4 Social and Welfare

As outlined previously, Emerald is a long established rural service centre, and recognised administrative centre of the Central Highlands region. As such, the town has a fairly well developed community structure with established extended family networks and a variety of community and welfare organisations. In more recent times the town has taken on the added role as a mine housing area which has injected a different social element into the community.

As a long established service centre, a variety of social and welfare organisations have developed in Emerald. In addition to community and service groups like Apex, Lions, Leos, Rotary, the RSL, Masonic Lodge and the QCWA., there are a number of church groups, St. Vincent de Paul, Emerald Ladies Welfare Committee, Red Shield Service Unit and special purpose organisations like the Central Highlands Aged Person's Home Committee, Alcoholics Anonymous and the Emerald Nursing Mother's Association.

There is an Emerald and District Social Development Council which is a community organisation that employs a Community Development Officer and provides information and advice on a wide range of social and welfare matters. In addition, the Council refers clients to local, state and federal government departments and agencies or to other community organisations; acts as a liaison office for the Department of Social Security; provides office space for the mobile Legal Aid Office; and operates as an agency for the Commonwealth Employment Service. At the present time members of the Emerald community are endeavouring

to establish a Community Care Centre in the town which among other things could serve as a centre for a Meals on Wheels service. A Family Day Care Scheme is in operation in Emerald, providing small group child care, in private homes, with "mothers" who are carefully chosen and registered with the local organisation. The scheme which is subsidised by the Federal Government, provides flexible hours of care for children of any age where parents are working, need time to go shopping and to keep appointments, are recuperating from an illness or when there are family emergency situations.

It would appear that the Emerald community is essentially made up of five major groupings; state government employees including workers in the various regional branches of government departments and teachers, railway workers, miners, the town service population and a rural grouping of mainly farm workers or farm owners who work on the land but live in the town.

Emerald therefore has a fairly diverse community structure, but while there appears to be strong cohesion within groups, there are indications that there is a lack of cohesion between these groups. In addition, local sources have indicated that the Emerald community is not strongly "people" orientated, in other words, while there is a strong push for the provision of entertainment and recreation facilities, there is only limited support for the provision of services to assist families and individuals. This is to be expected in a well established community whose members are used to looking to their families for support and assistance and not the wider community. This could make the assimilation process by the Ensham workforce and their families into the town a little more difficult. However, due to the influx of the Gregory mine population into the town the situation is gradually changing, and people are becoming more aware of the importance of community as well as family support.

A high proportion of the mothers in the incoming Ensham population are expected to have children in the pre-school age groups and because the incoming population will lack any significant extended family networks, there is expected to be a high demand for child care facilities and the services of social welfare agencies. While Emerald has a relatively good range of basic child care and welfare organisations as outlined previously in this Section, the increased demands of the Ensham population are expected to necessitate such groups as the Day Care Scheme, the Nursing Mothers Association and the Maternal and Child Welfare Clinic to expand their activities and facilities. Any such expansion is likely to be facilitated by an increase in membership and involvement in these organisations brought about by the growing population of the town.

An interesting feature of Emerald is the town's ability to retain a relatively high proportion of its youth, particularly school leavers. This is a somewhat unusual situation for a country town as the general trend is for many of the young people to drift away to the larger cities and towns, particularly on the coast. The situation in Emerald is largely the result of the town's broader commercial and industrial base being able to provide a wide range of job opportunities for young people. In addition, the TAFE

College in the town will provide further incentive for school leavers wanting to further their education, to stay on in Emerald. The direct and indirect employment opportunities generated by the Ensham project will provide further employment opportunities for both the existing and incoming young people. This should enable the town to continue to retain many of the school leavers and teenagers which should assist in preserving existing family networks in the town and fostering the development of such networks within the newer mining population.

Shift work which is an essential part of the operations of the mines has the potential to create a number of family problems. While there is no simple solution to these, the provision of a good system of child care will assist in giving parents the opportunity to adjust their life styles to cope with the demands of shift work.

In situations where a mine workforce is introduced into an existing non-mining community there are often problems associated with the wage differentials between miners and the existing residents (eg. stronger buying power of miners, increase in prices etc). However, problems of this type are not expected to be as significant in Emerald because, not only does the town already have a significant mine population but also a relatively large contingent of public sector workers, which together means that the town is already a relatively affluent community.

It is believed that self help groups organised from within the Emerald community are in the best position to deal with the social and welfare issues facing the town. Not only does this place the role of the decision maker into the hands of those who will be most affected by the decisions, but in this way the community is more likely to accept the consequences of its own decisions.

In the organisation of community groups, the Emerald community has the added advantage of already having the services of a Social Development Council which can assist in the establishment, administration and development of these community groups, advise the community on the use of existing services and facilities, and act as a liaison between the community and the local authority and the major developers. With the increasing population in Emerald the demand for the services of the Community Development Officer is likely to increase along with the demand for some form of social counselling and increased visits from other welfare and community officers.

The introduction of the Ensham population into Emerald is not expected to create any significant social problems. There will, no doubt, be a period of adjustment and assimilation for both the incoming population and the existing residents. However, the presence of an existing mine population in the town is expected to speed up the assimilation process. In addition, the increase in the mining component of the town's community structure is likely to increase the pressure for the provision of more "people" orientated services.

5.5.5 Culture and Recreation

Emerald currently boasts a wide variety of sporting organisations, with senior and junior teams in such sports as rugby league, rugby union, Australian rules, soccer, cricket, netball, basketball, hockey and tennis. Other popular sports include touch football, golf, lawn bowls, squash, gymnastics, martial arts, pony club and horse racing. The town also has a number of special interest recreation groups, including boy scouts, girl guides, sailing and power boat and ski clubs associated with the Fairbairn Dam, a darts association, keep fit classes and a local branch of the Queensland Recreation Council which assists in the development of recreation in the town.

On the basis of accepted facility provision standards, Emerald would appear to be relatively well provided with recreation facilities. The existing playing fields in Emerald are well established. The Emerald Shire Council has appointed the Emerald Sports Development Committee (ESDC) to be responsible for the orderly upgrading of the town's sporting facilities. This committee is very active and has developed a five year plan for the provision of the necessary improvements. The additional funding provided by the Ensham Project will allow the ESDC program to be accelerated. The ESDC has a policy of partially funding development projects with the balance of the funds coming from the various user groups and sporting clubs.

Major sporting facilities in the town, including the squash courts, bowling green, olympic swimming pool and an 18 hole golf course, appear to cater more than adequately for current needs.

The incoming Ensham population, because it will be relatively young, is expected to be fairly active, and as a result there is likely to be a marked increase in demand for both active and passive recreation pursuits. It is considered that there is a more than adequate number and range of sporting organisations in Emerald to cater for the Ensham population, with any expansion of existing clubs or requirements for other sports being provided in response to demand. Although existing facilities are currently heavily used, plans for the expansion and redevelopment of existing sports grounds and the development of new sporting fields are expected to be able to cater for the expected extra patronage from the Ensham population.

At this early stage of the project, discussions have commenced between the mining company and the Emerald Shire Council concerning the company's involvement in the plans to expand, redevelop and develop sporting facilities in the town. Because the Ensham population is largely an unknown quantity in terms of their recreation requirements, it is considered that it would be more appropriate and cost effective not to provide additional sporting facilities until the specific recreation requirements of the Ensham population are known. Because of the wide range of facilities already existing, any slight delays in the provision of

additional facilities as a result of this approach are not expected to have any significant effects.

Cultural pursuits are relatively well catered for in Emerald, with a wide variety of groups concerned with activities such as ceramics, lapidary, pottery, little theatre, country music, photography, gardening, town band, ballet, arts and crafts, and historical issues. As with the sporting organisations, it is considered that there is a wide enough range of cultural groups to satisfy the needs of the Ensham population. If this is not the case, any new activities are expected to be catered for in response to demand. As was discussed for the provision of social welfare facilities and organisations in Emerald (refer Section 5.5.4), it is believed that self help groups organised from within the Emerald Community are in the best position to provide for their cultural needs in response to community demand.

5.6 Engineering Infrastructure

The provision of headworks for the Ensham Coal Project involves the external supply of water and sewerage facilities to the subdivisions. These will be constructed by the Emerald Shire Council. The conceptual designs for the Ensham facilities are discussed below in the context of Council's overall development strategies.

5.6.1 Water Supply

Demand for domestic water supply will increase with the additional population generated by the Ensham Coal Project. The Emerald Shire Council has prepared a program for augmenting the existing system to meet the needs of a population of 11,000 (13,500 EP). This includes the Ensham Project.

Funding provided by the Ensham Coal Project will be used to augment the existing system to meet the additional demand created by the project's development.

5.6.2 Sewerage

The existing sewage treatment plant and reticulation system will require augmentation as a result of the Ensham Project.

Depending on the final location of the workforce accommodation, it will be necessary to upgrade a number of pump stations and associated rising mains. Upgrading of sections of the treatment plant will be carried out with the eventual augmentation of the plant capacity being required.

5.7 Road Transport

5.7.1 Existing Road Conditions

Access to the proposed mine site is obtained from the Capricorn Highway. The highway is the major Central Queensland road route

connecting Longreach in the west with Rockhampton on the coast where it connects with the Bruce Highway, the main north/south coastal route between Brisbane and Cairns.

Comet is 217km by road from Rockhampton along the Capricorn Highway which represents a travel time of around 2.5-3 hours. Emerald is a further 40km to the west. Table 5.7 provides an inventory of existing conditions along the Capricorn Highway between Emerald and Rockhampton. In general, the route is predominantly two lanes of 7m bitumen seal, relatively flood free and in good to fair condition.

Table 5.11
Capricorn Highway Road Inventory - Rockhampton to Comet

Road Sector	Segment Distance (km)	Pavement Width (m)	Pavement Condition
Rockhampton - Kabra	12	7.0	good
Kabra - Stanwell	10	6.0 - 7.0	fair
Stanwell - Bushley	6	7.0	good
Bushley - Westwood	18	6.0	poor-fair
Westwood - Grantleigh	10	7.0	good
Grantleigh - Gorango	18	6.0	poor-fair
Gorango Range - Range Duaringa	31	5.6 - 7.0	fair-good
Duaringa - Dingo	36	5.6 - 7.0	fair-good
Dingo - Blackwater	48	Generally 7.0	fair-good
Blackwater - Comet	35	Generally 7.0	good
Comet - Emerald	41	Generally 7.0	fair-good

5.7.2 Construction Equipment Transport

Development of the mine will necessitate the transport of construction equipment and materials to the site. It is expected that some of these loads will be transported to the site by rail while others will travel by truck. Some of the truck loads, particularly those from southern states, are likely to travel along the inland route, via the Newell Highway to Goondiwindi, the Leichhardt Development Road to Miles, the Leichhardt Highway through Taroom to Banana, and then either via the Dawson Highway through Springsure to Emerald and then along the Capricorn Highway or via Rannes and Baralaba and onto the Capricorn Highway just west of Duaringa. Although the latter of the final two route options is the shortest, it is not suitable for excessively heavy or over-size vehicles as it is largely unsealed and includes many timber bridges which are in poor condition. Consequently most of the heavy vehicle movements from

southern states can be expected to approach the mine site along the Capricorn Highway from the west.

Construction Phase

Materials that will be transported to the site during the construction phase will be mining equipment, structural steelwork and construction materials.

The mining equipment will be mainly imported from USA, Japan or Europe and will be transported by road to the site from the point of entry to Queensland which will most probably be Brisbane. During the 4 year initial construction period, approximately 20,000 tonnes of such equipment will be delivered. If all of this material was to be delivered by truck, it would result in approximately 190 trips per year or a trip each 1.5 working days. However some of these loads will be oversized and/or heavy.

Structural steelwork will also be transported to the site mainly from Brisbane but where possible from Mackay or Rockhampton. A total weight of approximately 5,000 tonnes will be required. This would generate about 200 truck movements of which only a small proportion should be oversize and/or heavy loads.

Other construction materials (eg. concrete materials) will be obtained locally and will be transported by local road transport. Concrete materials will be obtained on site.

In addition to the number of trips indicated above, the construction workforce is likely to generate approximately 125 light vehicle movements per day.

Operations Phase

Materials that will be transported to the mine during the operations phase are explosives, fuel, spare parts and consumables.

It is proposed to store explosives on site in an appropriately located magazine of ten tonnes capacity. This is sufficient for approximately 28 days operation. The primary blasting agent is ANFO which will be delivered as ammonium nitrate in bulk by truck. The annual requirement for explosives at the mine will be approximately 10,900 tonnes which will result in the delivery of approximately 10 truckloads of ammonium nitrate per week.

Fuel for the operation of mining equipment will be trucked from the fuel depot in Emerald. On current planning the annual requirement will be 11,000 tonnes. This could produce an average 2 truck loads per day.

Spare parts and consumables will generally be supplied from Mackay or Rockhampton and would be needed at the rate of 3,000

tonnes per annum. These will be delivered by both rail (the goods train services) and road. An existing light commercial courier service operating in the region could cater for the road transport demands. Assuming an equal amount of goods to be delivered by road and rail, this would represent 1 - 2 trucking movements per week from Mackay or Rockhampton.

5.7.3 Effects on Mine Access Route

Capricorn Highway

Workers travelling between Emerald and the mine will travel via the Capricorn Highway. The number of vehicles per day that would be generated on this route by the mine would be a maximum of approximately 450 vehicles/day commencing in year 7. This would represent an increase of approximately 68% over the existing 700 vehicles per day currently using this section of the highway. As can be seen from Table 5.11 this section of the road is built to a good standard and the proposed increase in traffic caused by the mine is unlikely to warrant any significant upgrading.

The turnoff point from the Capricorn Highway to the mine site will be approximately 9km west of Comet as shown on Drawing 2.2. This will be a channelised T junction with appropriate acceleration, deceleration and passing lanes and will be built in accordance with the Main Roads Department's requirements. Given the existing and proposed volumes of traffic, construction of the intersection to this standard is not expected to create any significant traffic hazards.

During the construction phase, construction loads will be delivered to the site by road and rail (refer Section 5.7.2). While it is recognised that an 11.9km section of the Capricorn Highway to the east of the mine between Comet and Blackwater has a narrow paved surface, this is not considered to be of any significant detriment because of the following:

- many of the heavy construction loads are likely to be delivered by rail to Comet
- most of the trucks bringing loads from southern states will approach the site from the west via Emerald
- the operational workforce will be accommodated in Emerald and will also approach the mine from the west.

Mine Access Road

As discussed in Section 3.14, an 18.75km access road will be constructed from the Capricorn Highway to the industrial area. This will be a bitumen sealed road with two 3.0m wide traffic lanes and two 1.0m wide paved shoulders. It will be built to the Main Roads Department's standards and will adequately cater for the expected volume of traffic.

A section of the mine access road crosses the Nogoia River floodplain and particular attention will be paid to drainage aspects. The proposed bridging of the Nogoia River by the access road will provide immunity from a flood with a 1 in 2 year return period. Backwater computer analysis of this structure shows for flows of $3,000\text{m}^3/\text{s}$ and $5,000\text{m}^3/\text{s}$ that there is negligible increase in flood levels caused upstream by the bridge and that all upstream effects disappear within 1km of the boundary of the mine site.

5.7.4 Effects on Local Roads

A number of local roads cross the proposed mine area. These include the road from the Capricorn Highway which currently provides access to the "St. Aubins", "Currimundi", "Duckponds" and "Ensham" homesteads, and a road on the northern side of the river running north-west from "Ensham". This road continues south-east of "Ensham" as a gazetted but unmade road which eventually crosses the Mackenzie River and continues on to Comet. These roads primarily provide access to local properties and with the exception of the road from "Duckponds" to the Capricorn Highway are generally constructed to a low rural standard.

Both of these roads will be affected by the project. The southern road (ie. Duckponds to the Capricorn Highway) will be replaced by the mine access road and this will provide improved access to both "St. Aubins" and "Currimundi". Access will not need to be maintained to "Duckponds" or "Ensham" as both of these homesteads will be purchased and vacated to enable mining to proceed. A small section of the constructed part of the road on the northern side of the river will also be cut by the proposed mine. However this only provides access for "Ensham" and as this homestead will be removed as part of the mine plan, such access will no longer be required. As this road further to the south-east is not constructed, its cutting by the mine will have no practical effect. It is proposed to apply for a permanent closure of this section of the road.

5.7.5 Effects in Emerald

Ensham workforce will be accommodated in various sections of Emerald. Access to the mine will generally be via local and arterial streets, and then the Gregory and Capricorn Highways.

The Ensham Coal Project funding for roads will be used to upgrade the arterial roads affected, to provide additional carparking and bikeway facilities, and to improve roads in the central business district. Details of the upgrading programme cannot be provided until the locations of the proposed residential areas are known. Nevertheless the upgrading to be undertaken will be such that potential traffic problems which could arise as a result of the increased project traffic will be overcome.

5.7.6 Effects on Regional Roads

Increased traffic flows on the regional road network will result from the mine development and the increased population in Emerald. These will be due to:

- inter-regional trips from Emerald to the major coastal centre of Rockhampton (approximately 3 hours drive) for recreational, shopping, business, cultural and social purposes
- increased commercial and service vehicle traffic to supply the needs of the increased population
- mine provisioning trips from outside the Bowen Basin area which would be of the order of 1-2 truck trips per week during the operation phase.

It is estimated that the above trips could result in an additional 100 vehicles per day on the Capricorn Highway. This would result in an increase of approximately 10% over existing traffic volumes from Emerald to Blackwater and a similar percentage over existing traffic volumes between Blackwater and Rockhampton.

Local recreational, cultural and sporting trips will also be generated by the increased town population to areas beyond Emerald such as the gemfields, Fairbairn Dam, Moranbah, Dysart, Clermont and Blackwater, all towns with which Emerald has sporting and social ties.

The regional road network has the capacity to handle these increased flows.

5.8 Rail

The Ensham mine is located about 16km north of the main Rockhampton to Emerald rail line. It is also approximately 20km west of the Burngrove to Gregory rail line which links with the central line.

The line from Gregory to the Clinton Coal Terminal is an S class line which means it is of a special standard of construction to handle all mineral trains, (wagons up to 90 tonnes) and as such is capable of handling any other form of rail traffic the railways currently operate.

At present, however the sections from Burngrove to Rocklands and from Rocklands to Callemondah are "A" class, restricting wagons to 71 tonnes and electric locomotions to 110 tonnes. Much of the line is a single track, with passing loops at regular intervals. However further sections of the line have been duplicated and controlled by directional signals which can allow for two lines of traffic in one direction should it be required.

The Queensland Railways has a programme for the electrification of the Central Queensland rail lines. This has resulted in the recent electrification of the Burngrove to Gladstone line and Gregory to Burngrove lines.

The proposed rail route has been specifically built to carry coal production from the region and it would appear that there would be sufficient capacity for the line to accommodate the additional two unit trains required by the Ensham Coal Project. These would average one trip per day each between Ensham and Gladstone. The requirements for accommodating this additional traffic will be subject to detailed discussions with Queensland Railways.

Table 5.12
Existing Rail Traffic on the Gregory - Callemondah Line

Average Number of train movements per week (in both directions) Gregory - Callemondah Line			
Train Type	Gregory to Burngrove	Burngrove to Rocklands	Rocklands to Callemondah
Passenger	-	-	5
Goods	2	10	24
Mineral	6	26	26
Total	8	36	55

5.9 Air Transport

5.9.1 Existing Services

Emerald airport is the airport most likely to be affected by the project's development although some additional traffic is likely to be generated also at Rockhampton and Blackwater. Table 5.13 provides relevant details for each of these three airports.

Table 5.13
Airport Conditions

Airfield	Capacity	Runways (m length)	Night Lights	Operational Hours
Rockhampton	Boeing 727	1981 sealed 1645 sealed	yes	no restriction
Emerald	ATR	1463 sealed 926 sealed	pilot activated	no restriction
Blackwater	ATR	1524 sealed	emergency only	no restriction

Rockhampton is on the main Brisbane - Cairns route used by the two major airlines. The service to and from Brisbane and Rockhampton is at least twice daily. There are also additional services to and from Rockhampton by a number of smaller airline companies.

Both Emerald and Blackwater have a regular Sunstate service from Brisbane and Rockhampton using the Short 360 aircraft and the 22 passenger Short 330. Queensland Pacific also flies between Brisbane, Blackwater and Emerald using a 28 seater Mohawk or a smaller Chieftan aircraft. Piccolo flies between Rockhampton and Emerald using a 5 seater Partennavia aircraft. Rockhampton and Emerald using a 5 seater Partennavia aircraft. At there are 20 flights each week between Brisbane, Blackwater and Emerald and flights each week between Rockhampton, Blackwater and Emerald.

5.9.2 Project Effects

An adequate level of service exists for travel to either Blackwater or Emerald. The likely population increase in Emerald due to the project (refer Section 5.2) will result in an increase in air travel demand particularly between Brisbane and Emerald. A significant level of travel directly related to the mine's operation can also be expected. It is difficult to quantify the above likely increases in air travel, but by comparison with experience in Blackwater, an increase of the order of 2,000 to 2,500 passengers per year can be expected. Given the adequate level of

facilities already existing at Emerald airport, the above passenger increase is expected to be catered for by increasing the frequency of existing services as necessary. Consequently there are no proposals as part of this project to upgrade any existing facilities or to construct any new ones.

5.10 Land Tenure

The extent of the proposed mining lease application area is shown on Drawing 5.4. Lands within this area are a combination of freehold and leasehold. The current landowners for each of the properties to be included in the Mining Lease are also shown on Drawing 5.4. Land ownership in the proposed mining lease is shown at Table 5.14.

Table 5.14
Land Ownership Summary

Owner	Area (ha)
Shirley Margaret Nixon	1025.828
Douglas Colburn Mayne, Raymond John Colburn Mayne and Jennifer Ann Mayne	120
Ensham Coal Managment	363.5
Colin A.Dettrick and C.A. Dettrick	357.6
Roger Frank Lee and Carolyn Lee	5251.606
Reginald Clarence Nixon and Shirley Margaret Nixon	6379.7

Prior to the development of the mine, the Ensham Joint Venture will enter into discussions with the relevant landholders in the area to negotiate suitable land tenure arrangements.

There are no Reserves within the proposed lease area except for a stock route on the southern side of the river and a road reserve running through the "Duckponds" and "Ensham" properties.

The location of the stock route is not proposed to be mined within the initial 15 year period examined in the mine feasibility study. Consequently during this

period the stock route will remain open and accessible as required. If necessary, appropriate control measures such as fencing will be provided. If mining extends beyond the initial 15 year period, the stock route alignment will be mined. In this case alternative stock access with appropriate fencing will be provided through the recontoured and rehabilitated mined-out areas.

In developing the accommodation areas in Emerald, the company proposes to purchase sufficient areas of land in a number of different locations to provide accommodation for all of the mine's workforce as discussed in Section 5.4. The company will then construct the houses by contract to ensure that they are available prior to the workforce arriving in Emerald. Once workers are established, the company will investigate the implementation of an appropriate house ownership scheme.

5.11 Land Use

5.11.1 General

Beef cattle and grain production are the two main primary industries in Emerald Shire and Peak Downs Shire (Table 5.15). Whilst cattle breeding and fattening is the major enterprise, many properties grow crops as well as run cattle. Grain sorghum is particularly important in the mixed farming system since stubble and failed crops are used to fatten cattle. Sorghum is the most commercially important grain crop, followed by wheat.

Table 5.15
Primary Production 1986 - 1987
Major Crops and Livestock

Product	Emerald Shire		Peak Downs Shire	
	Area (ha)	Production	Area (ha)	Production
All Crops (tonnes)	73,400	-	118,000	
Wheat (tonnes)	19,326	24,918	33,178	55,476
Sorghum (tonnes)	28,800	26,431	49,747	49,746
Cotton (tonnes)	5,700	7,767	Minor crop only	
Sunflower (tonnes)	8,078	2,943	22,158	12,837
Meat Cattle (head)		122,591	79,126	
Sheep (head)		-		5,287

5.11.2 Side Effects

There are two residential homesteads, "Ensham" and "Duckponds", within the proposed lease area. Both of these will be purchased and vacated to enable mining to proceed. The homesteads which are nearest to but outside of the lease area are "Currimundi" and "St Aubins" which are located to the south east (refer Drawing 5.4). Both of these are outside of the proposed lease area and will not be disturbed by the project. The nearest residential community is Comet approximately 10km to the south-east.

Current rural uses within the study area are crop production and grazing and have been summarised below. The extent of land used for cropping by the landholders in the study area is shown in Drawing 4.19.

Cropping

South of the Nogoia River there is extensive cultivation of grain sorghum particularly on the alluvial plains with heavy clay and cracking soils. Successful crops have also been grown on the more sandy grandational soils. North of the Nogoia River there is limited cultivation.

Grazing

Grazing is the predominant land use north of the Nogoa River. The area has been extensively cleared of brigalow scrub for improved cattle grazing, with buffel grass (*Cenchrus ciliatus*) being the most common pasture grass.

Regrowth of cleared pastures appears to be a problem. Paddocks periodically are burnt and/or bulldozed. Very little native pasture area remains in the area.

Within the area shown on Drawing 4.19 there are currently about 3,200ha being used for grain sorghum production and 4,000ha of improved grazing land. About a third of this agricultural land will be directly affected by clearing for mining, plant operation and accommodation. The area under cultivation of sorghum represents about 5% of the total area for the shires of Emerald and Peak Downs however due to the unavailability of production figures for areas of this size the productivity value of the crop cannot be evaluated.

The loss of primary production will only be temporary as the disturbed area will be rehabilitated back to agricultural land suitable for crop cultivation and grazing once mining is completed (refer Section 4.8).

5.12 Aesthetics

The southern half of the proposed lease area south of the Nogoa River is of low relief being composed of lowlands and floodplain. The area has been cleared for agriculture with the only remaining native vegetation being woodland communities fringing the Nogoa River and its tributaries.

North of the Nogoa River however the landscape is more varied. Around "Ensham" homestead the terrain is hilly and there is a steep rocky outcrop to the east. Here the native vegetation offers a diversity of vegetation types and is the only location within the study area of mixed shrub woodland and a semi evergreen vine forest remnant. The Nogoa River with its billabongs fringed with large coolabah trees and the surrounding undulating vegetated terrain make this area scenically attractive. However it is frequented only by local residents and a few visitors. The northern section of the study area is composed of lowlands bordered by steep escarpments to the west and low moderate slopes to the east. Two rocky outcrops occur in the centre of the lowlands and a series of outcrops occur to the east of the "Ensham" outcrop. All of the lowland area has been cleared for agriculture, however the outcrops and plateaus are vegetated. While this topographic relief gives the area some aesthetic character, the features of the area are common in the district and are not in any way distinctive.

The proposed mining operation will substantially alter the aesthetic character of the local district. In determining the nature and severity of this impact, four basic factors must be taken into account. Firstly, there is the nature and extent of the

proposed operation. Secondly, there is the proposed aesthetic treatment of the facilities associated with the mine and town. Thirdly, there is the type of country in which the development is situated and its relationship with adjacent physical features. Lastly, there is the type of rehabilitation programme proposed.

The major visible impact will arise from the creation of overburden dumps. These will be visible due to their height and colour which will contrast with the existing landscape. Other features which will contribute to the alteration of the present landscape include the coal stockpiles and mine plant and facilities.

The visual impact created by the open-cut mining programme is unavoidable in the short term. Progressive rehabilitation and judicious planting of vegetation screens will lessen this impact. However the mine site will not be visible from any major public roads and hence even in the short term, the aesthetic effect of the project will not be significant.

In the long term, once mining has ceased and the area has been rehabilitated and all plants dismantled and removed, no significant adverse aesthetic impact should be apparent. The proposed rehabilitation measures (refer Section 4.8) principally recontouring and revegetating, should ensure that the mine site will be left in a state which is aesthetically compatible with the surrounding countryside.

5.13 Archeology

To assess the likelihood of archeological artifacts occurring within the proposed mining area, an archeological survey of the site was undertaken in September 1985 by an archeologist approved by the Queensland Department of Community Services. This survey revealed that much of the proposed mining area has low archeological sensitivity and that the types of site most likely to be found in the area are open sites and isolated finds. The areas of greatest archeological sensitivity are:

- the interface of terrain units QaO and Qal adjacent to the Nogoa River and Winton Creek
- the interface of terrain units Qa2 and Cz3 adjacent to Boggy Creek
- the banks of the ephemeral creeks in unit Cz4.

The following table summarises the predicted sensitivity and nature of the archeological material likely to be found in each of the terrain units in the proposed mining area.

Table 5.16
Predicted Archeological Sensitivity of Terrain Units

Unit	Description	Sensitivity	Site Type
Qa0	Channels of major streams	Very low	Possible scarred trees, open sites and middens.
Qa1	Flood plains primary alluvium	Low on plains, moderate adjacent to Qa0	Open sites
Qa2	Secondary alluvium in creeks	Very low but moderate adjacent to Cz3.	Open sites
Cz2	Very gently undulating plains	Very low	Isolated finds
Cz3	Gently undulating plains	Low, but moderate adjacent to Qa2	Isolated finds open sites
Cz4	Strongly undulating plains	Low away from creeks, moderate adjacent to creeks	Open sites isolated finds
Ta3	Plateaus and slopes	Very low	Isolated finds

During the survey (15 man days) only 12 archeological sites were recorded. However it is likely that large numbers of open sites occur in the study area and that the proposed open cut mine may have an impact on many of these. While certain area within the study area are known or predicted to be of moderate archeological sensitivity, especially the margin of the major stream channels, most of the proposed mining area is of low sensitivity. Furthermore the mining procedures to be employed in the extraction of the coal are likely to have minimal impact on the areas of greatest sensitivity. This is particularly the case with the more significant sites located in the western half of the proposed mine area and sites along the banks of stream channels and adjacent to Duckponds Lagoon.

On the basis of the above, the archaeologist's report raised no objection to the mine being developed. The only significant site identified was the site found adjacent to Duckponds Lagoon. The Duckponds site extends for approximately 800m along the northern margin of the lagoon and up to 200m away from the lagoon bank on to the flood plain. It contains an open scatter of artefacts with the greatest concentration of artefacts being located within 25m of the lagoon. The site has been disturbed by past farming activity and the private collection of artefacts. As floods are common in the area, it is likely that there are deeper deposits of artefacts which remain intact.

The Duckponds Lagoon site is regarded as having the greatest research potential of any site in the region. It is considered that as a result of past disturbances, most of the open sites in the proposed mining area are of comparatively limited scientific value. However, the lower stratified layers of the site has the potential to provide valuable information.

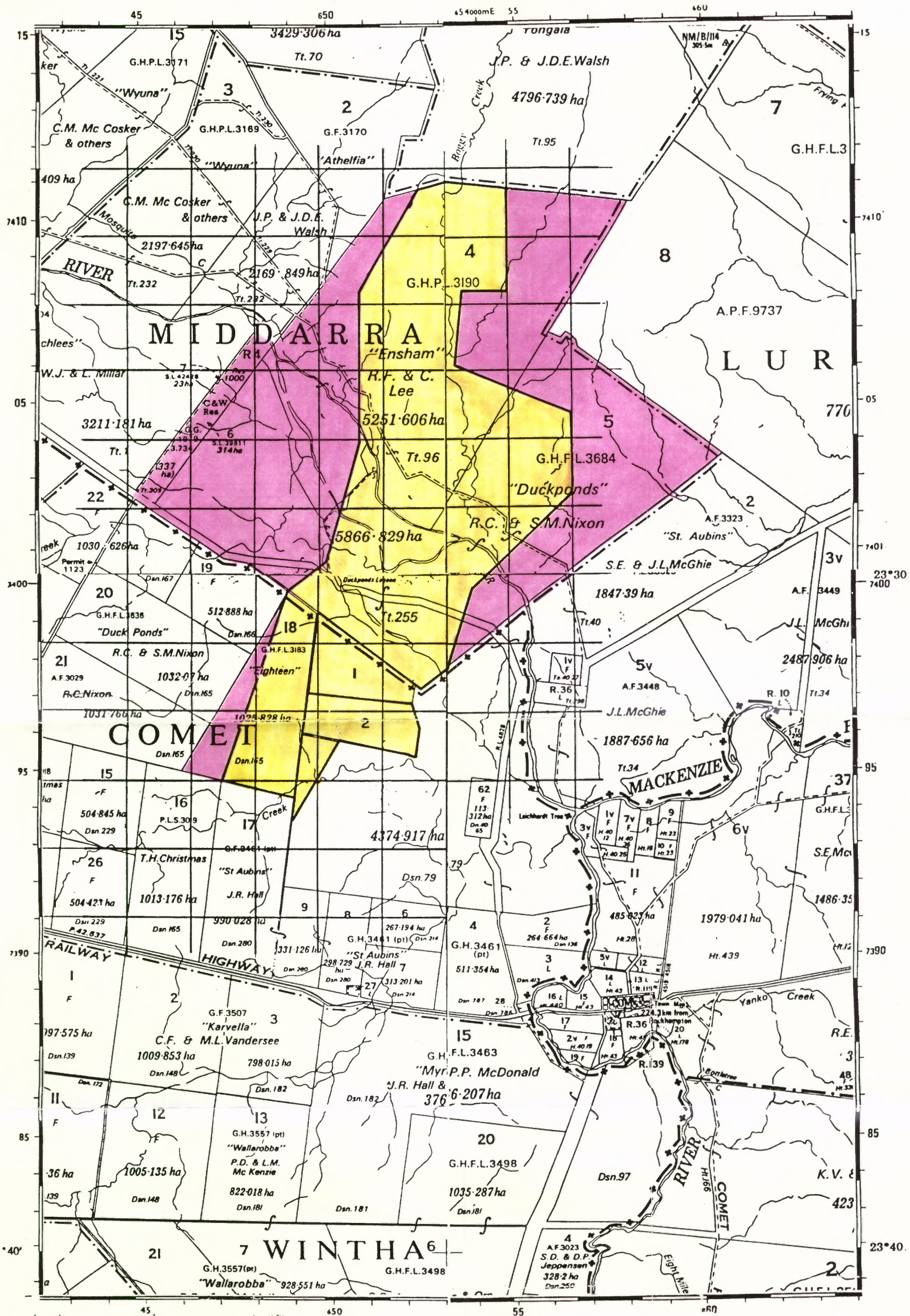
The site is located on the western extremity of the proposed pit area near the location where open cut mining is not likely to be economic and underground methods may need to be employed. Consequently this area may not be disturbed in the mining operation. Should subsequent mining plans indicate that Duckponds Lagoon is within the area of surface mining, a collection of artefacts will be made at the site and an open area salvage excavation will be undertaken prior to any disturbance. Subject to that proviso, the Heritage Branch of the Department of Environment and Heritage agrees with the report's recommendation that no objection can be made on archaeological grounds to the development of the coal mine.

The descendants of the aboriginal groups who traditionally occupied the area now live in Emerald and Rockhampton. They retain some interest in this area. Current interest falls loosely into four categories. These categories, in descending order of importance are:

- Sacred and secret sites
- Burial sites
- Sites of historical importance
- Prehistoric archaeological sites.

No sacred and secret sites, burial sites or sites of historical importance are located within the proposed mining area. The Duckponds Lagoon site is a prehistoric archaeological site only, being an open surface scatter of artefacts. The site is therefore of limited interest to the aboriginal people.

Prior to this survey, discussions were held with the Central Queensland Aboriginal Corporation for Cultural Activities to describe the location and nature of the planned mine and the methods to be employed in the archaeological survey. The field survey was then conducted with one of the corporation's representatives and a final meeting was held with the Aborigines after the field work to discuss the results of the survey and the recommendations to be made in the final report. A draft copy of the archaeological report was sent to the Corporation for comment before compiling the final report.



- Mining Lease Applications
- Land Outside Of Lease Purchased By Ensham Coal Management Pty. Ltd.

ENSHAM COAL PROJECT

 HOLLINGSWORTH DAMES & MOORE		
TITLE LAND OWNERSHIP, AQUISITION & MINING LEASE		
DATE AUGUST 1989	DRG. APPR'D.	DRG. NO. 5-4

6.0 ENVIRONMENTAL CONSEQUENCES

6.0 ENVIRONMENTAL CONSEQUENCES

6.1 General

This section of the report considers the significant environmental consequences that are anticipated as a result of the implementation of the project. Essentially the salient features of the previous two sections have been summarised and arranged in terms of the following considerations:

- Recommended environmental safeguards
- Main beneficial effects
- Main detrimental effects

6.2 Environmental Safeguards

To reduce the level of potential effects to those which have been identified in the previous sections, a number of environmental safeguards are planned to be implemented. Some of the more significant actions which are proposed to be taken to protect the environment are summarised below.

6.2.1 Clearing/Earthworks

- Mine area will be cleared progressively in advance of each particular mining phase.
- Careful compaction control and surface stabilisation will be used for embankment surfaces.
- Silt traps will be constructed at the base of spoil piles and disturbed areas.
- Pre-mine planning will be undertaken to ensure that the identified erosion prone soils are not exposed on the surface after mining.
- Erosion control measures discussed in Section 4.1.7 will be implemented where relevant.

6.2.2 Water Quality

- Stockpiles and plant area will be provided with stormwater collection systems leading to sedimentation ponds which will discharge to the raw water pond for reuse.
- Drainage from spoil piles will pass through a sedimentation pond before being discharged.

- Regular maintenance will occur of sedimentation ponds and drainage channels.
- All pit water will be discharged to evaporation ponds.
- Tailings will be disposed of in a tailings dam to ensure that no discharge to natural streams occurs.
- Sewage effluent from the mine site will be disposed of by discharge to the mine tailings ponds.
- The Boggy Creek diversion channel will be designed to ensure that the bed remains stable and scour of the new or existing channels does not occur.
- A water quality monitoring programme will be introduced to identify the effect on the project on the local water quality.

6.2.3 Overburden Rehabilitation

- Detailed research will be undertaken to identify appropriate revegetation parameters.
- Overburden will be recontoured to produce an undulating terrain with stable slopes.
- Topsoil will be respread as soon as possible after stripping on previously recontoured areas.
- Overburden recontouring and rehabilitation will proceed progressively following mining operations.

6.2.4 Air Quality

- Haul roads will be gravelled and watered regularly.
- Conveyors will be fitted with spray systems at transfer points and at other dust generation points where necessary.
- Long term non-active sections of the product coal stockpiles will be compacted to minimise the potential for spontaneous heating and dust generation.
- Cleared vegetation will be burnt only when the wind is blowing away from inhabited areas.
- A dust monitoring programme will be introduced to measure background levels as well as levels during the construction and operational phases.

6.2.5 Noise

- Local residents will be advised of proposed blasting programmes.
- Ear protectors or other control measures will be provided for workers in noisy areas.
- Plant noise at key sites will be monitored on a regular three monthly basis.

6.2.6 Infrastructure

- The Company will negotiate with the relevant authorities to ensure that the necessary infrastructure in Emerald is available at the time required to accommodate the project's workforce.
- A suitable standard of worker housing will be provided to ensure that a satisfactory urban environment is created.
- Building allotments will be purchased or developed to cater for the projected service workforce.
- The development of social and recreational facilities in Emerald will be encouraged.

6.3 Implementation of Environmental Safeguards

The Company will make a number of administrative arrangements to ensure that the proposed environmental safeguards and rehabilitation programme can be successfully implemented. These arrangements include the following aspects:

- All proposed environmental safeguards which are required initially and which will necessitate capital expenditure have been included in the estimate of the mine's capital cost. These items will be installed during the construction phase and are considered as a necessary part of the mine facilities. Such items include the plant area drainage system, stormwater dams, drains, installation of dust control equipment on crushers and conveyors etc.
- All of the environmental safeguards and programmes which will be implemented during the course of the mining will be considered as a normal operating expense.
- An environmental scientist will be employed on the project with the following responsibilities:
 - ensuring that the capital items such as those listed above have been adequately installed during the construction phase.

- ensuring drainage systems are maintained during the life of the mine.
- regularly monitoring surface water and groundwater quality in accordance with the adopted monitoring programme.
- co-ordinating the overburden recontouring and revegetation procedures.
- ensuring that adequate erosion control procedures are undertaken on all disturbed surfaces and embankments.
- supervision of research programmes to determine suitable revegetation species and fertiliser application rates.
- scheduling of earthmoving plant to ensure that rehabilitation of overburden stockpiles can be as progressive as possible.
- It is proposed to engage consultants or research organisations to undertake detailed rehabilitation studies. These studies will include:
 - detailed assessment of topsoil suitability.
 - selection of suitable vegetation species.
 - strategies for the spreading of drainage and topsoil layers.
 - strategies for the maintenance of revegetated areas.

6.4 Summary of Main Beneficial Impacts

The beneficial impacts identified at the higher levels such as the regional, state and national levels, will outweigh the adverse effects, especially in the longer term. The majority of the adverse effects are either largely temporary or capable of mitigation.

At the national level, major benefits will accrue through such aspects as foreign exchange earnings generated by the export of coal and the taxation revenue generated by the project (both direct and indirect). The State Government will benefit through the payment of royalties and freight charges. In addition, the project will serve to reinforce the existing level of decentralisation of industry and population.

As previously mentioned, the proposed project will strengthen and widen the existing industrial/mining base and productive capacity of the region. Significant increases in business activities will also be beneficial.

In terms of employment and production, the proposed project will generate additional demands for inputs (including labour) and other indirect goods and services from within the state, and in particular from the region. The increased demand for goods and services from within the region will be particularly marked. Significant beneficial impacts in the reduction of unemployment levels, particularly youth unemployment, and the greater diversification in local job opportunities attributed directly to the project and indirectly from induced activities, will be

realised. Once the mine is fully operational, the direct and service workforce associated with the project will add up to an additional 1085 people to the town's population, further enhancing its long term prosperity.

6.5 Summary of Main Detrimental Impacts

A number of what can be seen as detrimental impacts can be associated with the project at the local level. Generally, these potential impacts are of a relatively short term nature and many can be mitigated either through the implementation of environmental safeguards or by incorporating appropriate design features in the mine plan. In many instances these anticipated impacts will be unavoidable.

The proposed open-cut mining operations will result in significant and unavoidable topographical changes in the short term with subsequent "flow-on" effects to the existing biology and aesthetics of these areas. Such changes will, however, be localised to the mine area and will be mitigated over time by such undertakings as a rehabilitation programme. Although the habitats of a number of fauna species are expected to be affected by the proposed development, because of the distribution of these species outside the development area, no individual species can be considered to be threatened. The rehabilitation programme will produce a large area of grassland with plantings of trees. Eventually this area may return to a vegetation and habitat type similar to that presently occurring in the area.

The mining operation will result in the permanent loss of agricultural land over the mine area. The efficient soil rehabilitation programme as proposed will return all areas currently used for cultivation back to an acceptable natural state.

Noise and dust from mining activities are not considered to be a significant impact either to nearby homesteads or to the residents of Comet. However the adjacent homesteads may be subjected to elevated short term dust levels on rare occasions. Blasting noise will be audible but infrequent, and given notification of proposed blasting programmes, nearby residents are unlikely to be significantly disturbed.

Some short term deleterious effects may be observed in Emerald as the town expands to accommodate the project's workforce. However as the town continues to grow, the agencies responsible for the various services throughout the town will need to carefully monitor the situation to ensure that no significant shortfalls arise.

for **HOLLINGSWORTH DAMES & MOORE**



C M PIGOTT
Director

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APPENDIX 1
TERRAIN ANALYSIS

TABLE 1.A

DESCRIPTION OF TERRAIN MAPPING UNITS

GEOLOGY: (Qa):- Quaternary Alluvium; gravel, sand, silt and clay.

Mapping Unit No.	Landform Description	Soils	Erosion Status*		Land Capability Class**		Comments
			Existing	Potential	Irrigated Lands	Dry Land	
Qa0. ⁷ / ₈	Channel and banks of major streams, including intermediate and lower stream terraces; subject to regular and sometimes erosive flood flows.	Clay, sand, silty sand, sandy silt, gravelly in places on the stream floors & lowest terraces; cracking clay soils & uniform non-cracking fine-textured alluvial soils comprise the banks and intermediate terrace levels (S/Types 5.3 & 5.6).	M-H ⁽¹⁾	M-H	5 (t ₅ ,f ₅)	8 (t ₈ ,f ₅)	(1) Mod. high incidence of bank instability due to undercutting and scouring during flood flows.
Qa1.6	Stream terraces, narrow floodplains and drainage flats mainly associated with the more minor and tributary drainage systems; slopes mostly (<1%) overall.	Mostly deep uniform or weakly gradational alluvial soils comprising dark brown silty light to med. clay with med. blocky structure becoming fine sandy or silty med. clay with coarse columnar to massive structure below about 600mm; some gravelly lenses included in places; (S/Type 5.2).	M-H ⁽¹⁾	M-H ⁽²⁾	4-5 (e ₃ ,f ₄₋₅)	4-5 (e ₃ ,f ₄)	(1) Mod. sheet and gully erosion adjacent to drainage. (2) Dry soil aggregates slake rapidly if inundated local areas severely erosion prone.
Qa1.7	Intermediate and lower stream terraces, floodplains, low levees, back plains and swale plains associated with the major drainage systems; slopes (<1%) overall.	Mostly deep, uniform or fine-textured, dark brown or brownish black med. to heavy clays (incipient cracking clays) with acidic to slightly alkaline subsoils (S/Type 5.3); minor occurrences of S/Types 4.4 or 6.3 may be associated.	M ⁽¹⁾	M-H ⁽²⁾	3-4 (f ₃₋₄ ,e ₃)	4 (f ₃₋₄ ,e ₃)	(1) Periodically prone to erosive flood overflow; some sheet and gully erosion on slopes to drainage. (2) Dry soil aggregates are prone to slaking when exposed and inundated; they may also be slightly dispersive.

TABLE 1.A (Cont'd)

DESCRIPTION OF TERRAIN MAPPING UNITS

GEOLOGY: (Qa):- Quaternary Alluvium; gravel, sand, silt and clay.

Mapping Unit No.	Landform Description	Soils	Erosion Status*		Land Capability Class**		Comments
			Existing	Potential	Irrigated Lands	Dry Land	
Qa1.8	Drainage flats and broad depressional drainage-ways; poorly drained areas; floodprone; over-all slopes (<1%).	Deep dark coloured crack-ing clay soils (S/Type 6.3).	L-M	M ⁽¹⁾	4 (w ₃ ,f ₄ ,so ₃)	4 (w ₃ ,f ₄ ,s ₃)	Depressional areas subject to regular inundation. (1) Dry soil aggregates are prone to mod. rapid slaking if exposed and inundated; they may also be slightly to mod. dispersive.
Qa2.6	Stream terraces and valley flats associated with the more minor and tributary drainage systems; infrequently floodprone; slopes (<2%).	Sandy to loamy surface duplex soils with quartz and siliceous gravel included in the surficial soil layer overlying dark brown or reddish brown extremely hard alkaline clay subsoils (S/Type 4.2).	M-H ⁽¹⁾	M-H ⁽²⁾	3-4 (f ₃ ,e ₃ ,so ₃)	4 (f ₃ ,e ₃ ,s ₃)	(1) Active sheet and gully erosion on slopes to drainage and along stream banks. (2) Soil aggregates are prone to rapid slaking when inundated and may be mod. to highly dispersive.
Qa2.7	Broad low levees of the present and prior stream systems, slight rises within the alluvial plain unit (Qa2.8); occasional areas with mod. large gilgai depressions included; slopes (<2%).	Mostly thin loamy surface duplex soils with dark brown, brownish black or dark reddish brown med. to heavy extremely hard alkaline clay subsoils, below about 250-300mm (S/Type 4.4) minor occurrences of uniform fine textured dark clay soils (S/Type 5.3) may be encountered locally.	M ⁽¹⁾	M-H ⁽²⁾	3-4 (pb ₃₋₄ ,d ₃₋₄ ,so ₃)	4 (s ₄ ,p ₄ ,s ₃)	(1) Areas of mod. severe sheet erosion on slopes to drainage. (2) Dry aggregates are prone to rapid slaking when inundated and may be slightly to mod. dispersive. In some instances the topsoil horizon is very thin and the soils tend towards the uniform fine textured soil (S/Type 5.3).

TABLE 1.A (Cont'd)

DESCRIPTION OF TERRAIN MAPPING UNITS

GEOLOGY: (Qa):- Quaternary Alluvium; gravel, sand, silt and clay.

Mapping Unit No.	Landform Description	Soils	Erosion Status*		Land Capability Class**		Comments
			Existing	Potential	Irrigated Lands	Dry Land	
Qa2.8	Near flat to very gently undulating alluvial plains; gilgai development minor or absent.	Mostly deep brownish black or dark grey cracking clay soils with med. to heavy highly alkaline clay subsoils (S/Type 6.3) lesser occurrences of uniform fine-textured soils (S/Type 5.3 - incipient cracking clay soils) are commonly associated.	L-M ⁽¹⁾	M ⁽²⁾	2 (f ₂ ,sa ₃ ,so ₃)	3 (m ₂ ,w ₂ ,s ₃)	(1) Local occurrences of mod. severe shallow gully and sheet erosion on approach slopes to drainage. (2) Surficial soils in cultivated areas are prone to sheet erosion in areas of concentrated surface water overflow; the subsoils if exposed and inundated are prone to rapid slaking and may be somewhat dispersive.
Qa2.8g	Flat to broadly depressional less well drained areas within Qa2.8 with locally intensive gilgai development.	Deep dark grey-brown cracking clay soils with alkaline subsoils becoming mottled and acidic in the deeper subsoils (S/Type 6.4).	L-M	M ⁽¹⁾	3 (so ₃ ,w ₃ ,g ₂)	3-4 (s ₃ ,w ₃ ,g ₃)	Locally prone to surface water ponding in gilgai areas; some surface planing (cutting/filling) required for cultivation. (1) The subsoils if exposed and inundated are prone to slaking and may be slightly to mod. dispersive.
Qa5.8	Dissected alluvial terrace remnants and dissected slopes to drainage.	Mostly deep cracking clay soils as for Qa2.8 (S/Type 6.3).	M ⁽¹⁾	M-H ⁽²⁾	5 (t ₅ ,g ₄)	6 (t ₄ ,g ₄ ,e ₆)	(1) Prone to surface sheet erosion of the self-mulching top-soil; mod. gully where run-off water becomes concentrated, particularly where cleared of vegetation.

TABLE 1.A (Cont'd)

DESCRIPTION OF TERRAIN MAPPING UNITS

GEOLOGY: (Qa):- Quaternary Alluvium; gravel, sand, silt and clay.

Mapping Unit No.	Landform Description	Soils	Erosion Status*		Land Capability Class**		Comments
			Existing	Potential	Irrigated Lands	Dry Land	
Qa5.8 (cont'd)							(2) The subsoils if exposed and inundated are prone to slaking and may be slightly to mod. dispersive.

TABLE 1.A (Cont'd)

DESCRIPTION OF TERRAIN MAPPING UNITS

GEOLOGY: (Qc):- Slopewash Deposits and Minor Stream Alluvium: gravel, sand, silt and clay.

Mapping Unit No.	Landform Description	Soils	Erosion Status*		Land Capability Class**		Comments
			Existing	Potential	Irrigated Lands	Dry Land	
Qc1.7	Near flat or very gently sloping lower parts of outwash slopes transitional to the alluvial plains of the more major stream systems; slopes (<1%).	Deep thin sandy to loamy surface duplex soils with brown, dark brown or reddish brown med. to heavy alkaline clay subsoils (S/Type 4.4).	M	M-H ⁽¹⁾	4 (f ₃₋₄ , pb ₃₋₄ , s ₃₋₄)	4 (d ₄ , s ₃₋₄ , f ₃)	(1) The subsoil materials in the air dry state, are be prone to rapid slaking if inundated; they may also exhibit slight to mod. dispersion characteristics.
Qc2.6	Gently sloping mildly dissected footslopes, outwash slopes and plains and stream flats associated with minor streams and tributary drainage; slopes mostly in the range (1-2%).	Mostly mod. deep uniform dark brown fine sandy or silty light to medium clays with some gravelly lenses included (S/Type 5.2).	H ⁽¹⁾	H ⁽¹⁾	3-4 (f ₃ , e ₃)	4 (f ₃ , e ₃ , g ₃)	(1) Occasionally flood-prone in lowest parts, but prone to periodic surface water overflow; locally intensive gully erosion along drainage lines mostly on lower and some middle and upper parts of slopes to drainage; the natural soil aggregates may be slightly dispersive and are prone to rapid slaking if inundated.
Qc5.6	Dissected footslopes and wash slopes comprising undulating gently sloping broadly rounded interfluvies with short mod. steep slopes towards incised dissection gullies; slopes mostly 5-12% overall locally steeper in dissection gullies.	Mod. to deep sandy/loamy surface duplex soils with yellowish brown silty med clay subsoils (S/Type 4.3); HW mudstone often exposed in floors of dissection gullies below about 750-1500mm.	H ⁽¹⁾	H ⁽¹⁾	5 (t ₅ , e ₅)	6 (t ₄ , n ₄ , e ₄)	(1) Silty subsoil materials are prone to rapid slaking when exposed and inundated; some areas highly erosion prone.

TABLE 1.A (Cont'd)

DESCRIPTION OF TERRAIN MAPPING UNITS

GEOLOGY: (Cz):- Cainozoic Soil Cover; clay, sand, gravel, ferruginous gravel and reworked laterite

Mapping Unit No.	Landform Description	Soils	Erosion Status*		Land Capability Class**		Comments
			Existing	Potential	Irrigated Lands	Dry Land	
Cz1.8	Broad depressional drainage-ways, very low overall slopes <1%.	Deep dark grey brown cracking clay soils with highly alkaline clay subsoils (S/Type 6.3).	L-M	M ⁽¹⁾	⁴ (w ₃ ,f ₄ ,s ₃)	⁴ (w ₃ ,f ₄ ,s ₃)	Depressional areas, poorly drained and prone to regular inundation. (1) The subsoil layers, if exposed, and inundated are prone to rapid slaking; they may also be slightly to mod. dispersive.
Cz2.6	Mildly dissected outwash slopes and plains and older alluvial plains and terraces; slopes (1-2%).	Mostly steep loamy surface duplex soils, commonly with sparse to mod. dense ferruginous and siliceous gravel strewn on the surface, with dark reddish brown or dark brown extremely hard alkaline sandy clay or med. clay subsoils (S/Type 4.2); some occurrences of similar but gradational red brown soils with somewhat lighter texture of surficial soils (S/Type 3.2) may be included within the unit as mapped.	L-M ⁽¹⁾	M ⁽²⁾	³⁻⁴ (t ₃ ,s ₃ ,e ₃)	⁴ (p ₃ ,s ₃ ,e ₃)	(1) Some gullyng adjacent to and in the heads of drainage gullies. (2) The deeper subsoils if exposed and saturated may slake rapidly; they may also be prone to slight dispersion.

TABLE 1.A (Cont'd)

DESCRIPTION OF TERRAIN MAPPING UNITS

GEOLOGY: (Cz):- Cainozoic Soil Cover; clay, sand, gravel, ferruginous gravel and reworked laterite

Mapping Unit No.	Landform Description	Soils	Erosion Status*		Land Capability Class**		Comments
			Existing	Potential	Irrigated Lands	Dry Land	
Cz2. ⁷ / ₈	Gentle outwash slopes and mildly dissected plains and lowlands; slopes (1-2%).	Complex association of mod. deep dark grey-brown cracking clay soils with alkaline clay subsoils together with thin loamy surface duplex soils with dark brown or dark reddish brown extremely hard alkaline heavy clay subsoils (S/Types 6.2/4.4) overlying sandy older alluvium.	M-H ⁽¹⁾	M-H ⁽²⁾	3 (t ₂₋₃ ,sa ₃ ,so ₃)	3 (s ₃ ,f ₂ ,e ₂)	(1) Mod. to severe sheet and gully erosion on slopes to drainage. (2) The subsoil and older alluvial materials are prone to rapid slaking if exposed and inundated; they may also be slightly to mod. dispersive.
Cz2. ⁷ / _{8g}	As for Cz2. ⁷ / ₈ but with locally intensive gilgai development.	Mixed occurrences of loamy surface duplex soils as for Cz. ⁷ / ₈ together with mod. deep grey-brown alkaline cracking clays which become mottled and acidic in the deeper subsoil in the gilgai depressions (S/Types 6.4/4.4).	L-M ⁽¹⁾	M ⁽²⁾	4 (g ₃ ,w ₃ ,sa ₃ ,so ₃)	4 (g ₃ ,s ₃ ,w ₃)	(1) Mod. sheet erosion on the slopes adjacent to the larger gilgai depressions. (2) The deeper subsoils, mainly in the duplex soil areas, are prone to rapid slaking when saturated and may be slightly to mod. dispersive and erosion prone.
Cz2.7	Outwash slopes & plain, undulating and mildly dissected, with gentle overall slopes (1-2%) but with some flatter & locally more steeply sloping areas included.	Mod. to deep thin loamy surface duplex soils with dark brown or dark reddish brown hard alkaline clay subsoils with gravelly lenses included in the deeper subsoil (S/Type 4.4).	M ⁽¹⁾	M-H ⁽²⁾	3-4 (t ₃₋₄ ,r ₃ ,pb ₃ ,so ₃ ,sa ₃)	4 (d ₃ ,r ₃ ,a ₃ ,k ₃)	(1) The surface soils are hard setting generally with a locally dense surface cover of ferruginous gravel. (2) The subsoil materials are prone to slaking if undated and may be somewhat dispersive.

TABLE 1.A (Cont'd)

DESCRIPTION OF TERRAIN MAPPING UNITS

GEOLOGY: (Cz):- Cainozoic Soil Cover; clay, sand, gravel, ferruginous gravel and reworked laterite

Mapping Unit No.	Landform Description	Soils	Erosion Status*		Land Capability Class**		Comments
			Existing	Potential	Irrigated Lands	Dry Land	
Cz3. ⁷ / ₈	More strongly undulating areas within Cz2. ⁷ / ₈ , including broad low rock strewn rises often occurring in association with areas of mod. intensive gilgai development; slopes mostly (<5%) locally steeper.	Mixed occurrences of mod. shallow gravelly reddish brown duplex soils with considerable ferruginous and siliceous stone cover up to 300mm, together with mod. shallow dark brown, cracking clays on some rock strewn rises and in gilgai depressions (S/Types 4.1/6.1).	L-M	L-M ⁽¹⁾	5 (r ₅ ,g ₄ ,t ₄)	6 (r ₅ ,g ₄)	(1) The subsoil materials may be slightly dispersive and may also be subject to slaking if exposed and inundated. Gilgai depression are likely to pond water for considerable periods after heavy rain.
Cz5. ¹ / ₃	Gentle to moderate foot-slopes (5-12%).	Mod. shallow coarse gravelly, sandy loam to sandy clay soils; with subangular to surrounded gravel mostly 20-25mm size, but with siliceous surface stone 100-200mm size on the high parts of the slope (S/Type 1).	L ⁽¹⁾	M ⁽¹⁾	5 (t ₅ ,r ₄₋₅)	7 (r ₅)	(1) Dense surface stone cover and vegetation help contain erosion of the natural surface. (2) The weakly cohesive subsoils slake rapidly if exposed and inundated, but high proportion of gravel included tends to reduce erosion potential.

TABLE 1.A (Cont'd)

DESCRIPTION OF TERRAIN MAPPING UNITS

GEOLOGY: (Ta):- Tertiary Sediments and Laterite; laterite or lateritised sediments, claystone, siltstone, sandstone, pebbly sandstone.

Mapping Unit No.	Landform Description	Soils	Erosion Status*		Land Capability Class**		Comments
			Existing	Potential	Irrigated Lands	Dry Land	
Ta1.4	Drainage flats and depressions, overall slopes <1%.	Mod. to deep sandy gradational soils, generally with a thick sandy surface horizon grading to yellowish brown clayey sand - sandy clay subsoils over HW sandstone (S/Type 3.1).	L ⁽¹⁾	L-M ⁽²⁾	4 (f ₄ ,pt ₃)	4 (f ₄)	(1) High infiltration, low overall surface slope. (2) Deeper subsoils may be somewhat dispersive.
Ta1.7	Drainage flats and depressions, overall slopes (<1%).	Mod. to deep thin loamy surface (stony) duplex soils with dark coloured med. - heavy alkaline clay subsoils (S/Type 4.4).	L-M ⁽¹⁾	M ⁽²⁾	4 (f ₄ ,pb ₃ ,So ₃)	4 (f ₄ ,p ₃ ,S ₃)	(1) Some gullyng on slopes to drainage. (2) Exposed dry subsoil layers may slake if inundated and may also be mod. dispersive.
Ta2.7	Near flat to very gently sloping plains and lowlands; slopes mostly around (1%) or less.	Deep thin loamy surface duplex soils with brownish black med. to heavy alkaline clay subsoils (S/Type 4.4).	L	M	3-4 (pb ₃ ,pc ₃ ,So ₃)	4 (p ₃ ,d ₃ ,S ₃)	Sparse surface stone; hard set surface condition.
Ta2.8g	Near flat to depressional plains with mod. deep gilgai depressions included; slopes mostly (1%) or less.	Deep dark grey-brown alkaline cracking clay soils over mottled acidic deep clay subsoils in the gilgai depressions; (S/Type 6.4).	L-M ⁽¹⁾	M-H ⁽²⁾	3-4 (g ₃ ,So ₃ ,w ₃)	3-4 (w ₃ ,S ₃ ,g ₃)	(1) Self mulching topsoil is prone to sheet erosion where surface slopes become appreciable. (2) Exposed (dry) subsoil layers are prone to slaking if exposed and inundated; the deeper subsoil materials may be mod. dispersive.

TABLE 1.A (Cont'd)

DESCRIPTION OF TERRAIN MAPPING UNITS

GEOLOGY: (Ta):- Tertiary Sediments and Laterite; laterite or lateritised sediments, claystone, siltstone, sandstone, pebbly sandstone.

Mapping Unit No.	Landform Description	Soils	Erosion Status*		Land Capability Class**		Comments
			Existing	Potential	Irrigated Lands	Dry Land	
Ta3. ³ / ₅	Undulating plains and lowlands and gentle to mod. colluvial slopes mostly around (2%), locally up to (5%).	Mod. shallow sand overlying dense gravels, sandy gravels, or gravelly sand to sandy loam soils (S/Type 2.1) occurring in association with mod. deep gradational sandy or loamy red earths overlying ferruginous and siliceous gravels (S/Type 3.2).	L-M ⁽¹⁾	M ⁽²⁾	3-4 (pg ₃₋₄ , t ₃ , pt ₃ , pd ₃)	3-4 (m ₃₋₄ , n ₃)	(1) Generally sandy surface soils with high infiltration and low surface run-off; some rilling on slopes to drainage. (2) The deeper sandy/loamy red earth soils are prone to slake if inundated; they may also be slightly dispersive.
Ta3.5	Near level or gently sloping crestral areas of mesas and plateau remnants; slopes mostly (<2%) locally to (5%) on the margins.	Mod. to deep sandy to loamy red or yellowish red earth soils; some uniform or weakly gradational soils occur in places (S/Type 3.2).	L-M ⁽¹⁾	L-M ⁽²⁾	4 (pt ₃ , n ₃)	4 (m ₄ , n ₃)	(1) Mostly low except on the margins of the unit. (2) The deeper cohesive soils are prone to slake if exposed and inundated and may be slightly dispersive.
Ta4 ¹ / ₃	Low rocky rises, eroded plateau crestral areas with eroded and locally benched marginal slopes; slopes about (5%) overall locally up to (12%) or more on the eroded plateau margins.	Gradational sandy red soils with copious ferruginous, siliceous and quartz gravel on low rises; mod. shallow rocky, sandy to sandy loam soils on the eroded plateau margins (S/Type 2.2).	M-H ⁽¹⁾	M ⁽¹⁾	5 (t ₅ , r ₄ , d ₄)	6 (t ₄ , m ₆ , d ₄)	(1) Soils are mostly shallow and rocky but some weakly aggregated dry soils slake rapidly if inundated; they may be prone to surface sheet erosion.
Ta5.5	Gently to mod. sloping broadly rounded crestral areas and spur slopes on dissected plateau rem-	Mod. to deep sandy to loamy red or yellowish red earth soils with sandy loam to sandy clay loam	L	L-M ⁽¹⁾	4 (t ₄ , d ₃ , n ₃)	4-6 (m ₄₋₆ , t ₄ , n ₃ , d ₃)	(1) The subsoil layers are prone to rapid slaking if exposed and inundated and may be slightly

TABLE 1.A (Cont'd)

DESCRIPTION OF TERRAIN MAPPING UNITS

GEOLOGY: (Ta):- Tertiary Sediments and Laterite; laterite or lateritised sediments, claystone, siltstone, sandstone, pebbly sandstone.

Mapping Unit No.	Landform Description	Soils	Erosion Status*		Land Capability Class**		Comments
			Existing	Potential	Irrigated Lands	Dry Land	
Ta5.5 (cont'd)	nants; slopes (5-12%).	grading to light-clay or sandy clay subsoils; (S/Type 3.2); some mod. shallow uniform coarse-textured soil (S/Type 2.2).					dispersive.
Ta6 ¹ / ₆	Mod. steep planar (dip) slopes and dissected middle and lower parts of the steep escarpment slopes; slopes mostly in the range (12-25%).	Shallow rocky soils with a sand or loamy sand matrix, together with mod. shallow gravelly red or yellowish brown duplex soils over laterite or lateritised sedimentary rocks (S/Types 1/4.1).	M ⁽¹⁾	M ⁽¹⁾	5 (t ₅ ,r ₄)	7 (t ₆ ,r ₄ ,e ₄)	(1) Local mod. severe gullyng is evident where some deeper yellow brown duplex soils occur; elsewhere soils appear mainly stab;e/
Ta8 ⁰ / ₁	Escarpment slopes, steep to very steep, (to >66%), locally sub-vertical, sections included.	Exposures of laterite or lateritised sedimentary rocks together with pockets of shallow rocky soils with a sandy or loamy sand matrix (S/Type 1).	M ⁽¹⁾	M-H ⁽¹⁾	5 (t ₅ ,r ₅)	8 (t ₇₋₈ ,r ₅)	(1) Steep slopes tend to be projected by fairly dense vegetation and bouldery scree material; localised slope failures are evident within the unit; clearing is likely to increase erosion potential.

TABLE 1.A (Cont'd)

DESCRIPTION OF TERRAIN MAPPING UNITS

GEOLOGY: (P-T):- Permo-Triassic, Burngrove Formation and Rewan Formation - Undifferentiated; comprising carbonaceous mudstone, interbedded mudstone and fine lithic sandstone, siliceous siltstone, calcareous lithic and feldspathic sandstone.

Mapping Unit No.	Landform Description	Soils	Erosion Status*		Land Capability Class**		Comments
			Existing	Potential	Irrigated Lands	Dry Land	
P-T2.6	Outwash plains and drainage flats, mod. intensively dissected and eroded; overall slopes (1-2%).	Mostly mod. shallow uniform brown or reddish brown clay soils over HW rock (S/Type 5.1); dense surface mantle of ferruginous and siliceous gravel.	M-H ⁽¹⁾	M-H ⁽¹⁾	5 (t ₃ , r ₃ , e ₅ , f ₃ , Sa ₃ , So ₃)	6 (r ₃ , f ₃ , g ₃ , S ₆ , e ₆)	(1) Dry soils slake if exposed and inundated and may be slightly dispersive; severe sheet and gully erosion adjacent to drainage; lower parts may be prone to flash flooding.
P-T3.6	Broad low rises and gently sloping dissection slope interfluvies; slopes mostly (<2%) locally to (5%) on approaches to dissection gullies.	Mostly shallow, gravelly surface, uniform brown or reddish brown clay soils (S/Type 5.1) over HW rock within 300-600mm of the surface; some rock outcrop in places.	L-M ⁽¹⁾	M-H	4 (t ₃ , r ₃ , d ₄ , Sa ₃ , So ₃)	6 (d ₄ , r ₃ , S ₃)	(1) Mod. dense surface cover of siliceous and ferruginous gravel helps protect natural surface against sheet erosion to some extent.
P-T3. ⁷ / ₈	Gently to mod. strongly undulating plain and lowlands with occasional low rocky rises; slopes mostly around (2%) locally to (5%).	Mixed occurrences of mod. shallow loamy surface duplex soils with dark brown, reddish brown or yellowish brown alkaline med. to heavy clay subsoils over HW rock, in association with mod. shallow dark brown cracking clay soils over HW rock (S/Types 4.1/6.1).	M-H	M-H ⁽¹⁾	3-4 (t ₃ , r ₃ , d ₃ , Sa ₃ , S ₆ ₃₋₄)	4 (r ₃ , g ₃ , d ₃ , S ₃)	(1) Exposed subsoil materials are prone to slaking and slight dispersion may occur when inundated by flood/rains; some poorly drained gilgai-like depressions occur associated with the cracking clay soil areas; locally severe erosion along dissection gullies.
P-T4. ¹ / ₆	Broad low rocky rises; slopes mostly between (2-5%), up to (10%) on the steeper marginal slopes.	Shallow rocky soils, rock outcrop, and shallow gravelly duplex soils over HW rock (S/Types 1/4.1).	M	M ⁽¹⁾	5 (t ₅ , r ₅)	6 (r ₅ , d ₄₋₆)	Some surface sheet erosion on steeper sloping areas; (1) Slaking of the subsoil layers and slight dispersion may occur when exposed soils become saturated.

TABLE 1.A (Cont'd)

DESCRIPTION OF TERRAIN MAPPING UNITS

GEOLOGY: (P-T):- Permo-Triassic, Burngrove Formation and Rewan Formation - Undifferentiated; comprising carbonaceous mudstone, interbedded mudstone and fine lithic sandstone, siliceous siltstone, calcareous lithic and feldspathic sandstone.

Mapping Unit No.	Landform Description	Soils	Erosion Status*		Land Capability Class**		Comments
			Existing	Potential	Irrigated Lands	Dry Land	
P-T5.6	Mostly gentle to mod. steep dissection slopes transitional to and occurring below P-T3.6; slopes mostly around (5%) locally to (10%).	Skeletal to shallow gravelly surface, brown clay soils over HW rock (S/Type 5.1); some areas of rock outcrop.	M-H ⁽¹⁾	M	5 (t ₄₋₅ , r ₄ , d ₄)	6 (d ₄₋₆ , r ₄)	(1) Mod. severe sheet and gully erosion on slopes to drainage.
P-T6 ¹ /6	Mod. steep hillslopes, dipslopes and dissected footslopes below the steep escarpments; slopes mostly in the range (12-25%).	Shallow rocky soils together with mod. shallow gravelly reddish brown or yellow brown duplex soils over HW rock. (S/Types 1/4.1)	M ⁽¹⁾	M ⁽¹⁾	5 (t ₅)	7 (t ₆ , r ₅)	(1) Locally severe gully erosion evident associated with deeper yellow duplex soil occurrences; elsewhere soils are mostly shallow and gravelly.
P-T7 ¹ /3	Low rocky hills and rises, dissected hillslopes, and locally benched mod. steep escarpment slopes (25-33%).	Shallow rocky sandy soils, together with some deeper uniform or weakly gradational gravelly sand to sandy loam, over HW rock (S/Type 1).	L-M ⁽¹⁾	M	5 (t ₅)	7 (t ₇)	(1) Locally mod. severe sheet erosion, in deeper soil areas; elsewhere, the rocky mantle inhibits surface runoff and helps reduce sheet erosion.
P-T8 ⁰ /1	Steep escarpment slopes, locally benched with very steep to sub-vertical sections included (33-66%+).	Rock outcrop and shallow rocky mostly sandy or sandy loam soils (S/Type 1).	M ⁽¹⁾	M	5 (t ₅ , r ₅)	8 (t ₇₋₈ , r ₅)	(1) Some surface protection afforded by bouldery scree & typically dense acacia vegetation.

Note: * Refer to Text Section 4.1.5, for explanation of class ratings.

** Refer to Appendix 4 for explanation of Land Capability Classes and Limiting Factors.

APPENDIX 2
SOIL DESCRIPTION

TABLE 2.A

SOIL DESCRIPTIONS

<u>Soil Group/Type No.</u>	<u>Description</u>
2.1	Moderately shallow frequently gravelly uniform or weakly gradational sand, loamy sand or sandy loam overlying dense ferruginous, siliceous and quartz gravels. These soils occur mainly in Terrain Unit Ta 3.3/5 in association with somewhat deeper gravelly gradational red earths.
2.2	Moderately shallow to deep gravelly weakly gradational loamy sand to sandy loams over laterite or weathered lateritised sedimentary rock. These soils occur mainly on low rocky rises and on the eroded margins of the dissected plateau (Ta 4.1/3) and on the steep dissected locally benched slopes in Terrain Unit T/P 7¹/3.
3.1	Moderate to deep sandy gradational soils with medium to fine-grained sandy surface soils grading through yellowish brown clayey sand to yellowish brown and grey mottled sandy clay subsoils transitional to weathered sandstone. Soil reaction is slightly acid to neutral throughout but may locally be moderately acidic in the deeper subsoil.

SOIL DESCRIPTIONS (Cont'd)

Soil Group/Type No.

Description

3.2

Moderate to deep gradational sandy loam or sandy clay loam surface soils grading to red or yellowish red fine sandy clay loam or light to medium clay subsoils. Soil reaction is slightly acid to neutral throughout but may be moderately acidic (pH - 5.5) in the deeper subsoils. They may be underlain by laterite or indurated mottled zone materials or may include some siliceous and ferruginous gravelly lenses in the deeper subsoil layer where developed on materials of alluvial origin.

4.1

Mostly shallow, locally moderately deep, gravelly loamy surface duplex soils with brown or reddish brown slightly acidic to alkaline clay subsoils over weathered rock. These soils occur on the middle and lower escarpment and dissected hill slopes and rocky rises (P-T 6.1/4, 4 1/6, 3.7/8 and Cz 3.7/8).

4.2

Mostly deep sandy to loamy surface duplex soils with brown or reddish brown light to medium clay subsoils. Soil reaction may range from slightly acidic at the surface to moderately alkaline in the subsoil. These soils occur mainly on the stream flats and terraces associated with the minor stream systems (Qa 2.6) and outwash slopes and plains (Cz 2.6).

SOIL DESCRIPTIONS (Cont'd)

Soil Group/Type No.

Description

4.3

Moderate to deep sandy to loamy surface duplex soils with yellowish brown slightly acidic silty medium clay subsoils. These soils occur on lower slopes and outwash slopes of re-entrant gullies mainly developed on slope wash or colluvial deposits (Qc 5.6), but in places they also appear to occur as deep sedentary soils overlying weathered sedimentary rocks.

4.4

Deep mostly thin loamy surface duplex soils with dark brown or dark reddish brown alkaline medium to heavy clay subsoils developed mainly on alluvium.

These soils occur on some extensive outwash slopes and plains and drainage flats (Cz 2.7, Ta 2.7, Ta 1.7) and as levees or slight rises (prior levees) in the alluvial plain (Qa 2.7).

5.1

Moderately shallow dark brown or dark reddish brown uniform medium clay soils over highly weathered rock; a moderate to dense surface cover of ferruginous and siliceous stone is common. Subsoil reaction is dependent on the nature of the parent rock type and may vary from acidic to moderately strongly alkaline. These soils occur mainly on the gentle pediment slopes and plains, Terrain Units (P-T 2.6, 3.6, 5.6).

SOIL DESCRIPTIONS (Cont'd)

Soil Group/Type No.

Description

5.2

Moderate to deep uniform dark brown silty light to medium clay soils with some gravelly lenses included. These soils occur on the narrow floodplains and alluvial flats (Qa 1.6) associated with the minor stream systems and are associated with lesser occurrences of Soil Type 4.2 described previously.

5.3

Deep uniform brownish black, dark brown or dark reddish brown medium to heavy clay soils (incipient cracking clays). Soil reaction may range from neutral at the surface to moderately to highly alkaline with depth. These soils occur on intermediate and lower stream terraces (Qa 1.7) and in a complex association with the cracking clay soils within the alluvial plain, Terrain Unit Qa 2.8.

6.1

Moderately shallow mostly dark brown medium to heavy cracking clays overlying weathered rock. The soils are mainly developed on or derived from Permo-Triassic shales, mudstones and lithic sandstone. Soil reaction is slightly acid to neutral at the surface becoming moderately strongly alkaline with depth. Sub-rounded siliceous stone is generally present in the surficial soil layers.

SOIL DESCRIPTIONS (Cont'd)

Soil Group/Type No.

Description

The soils generally occur in association with shallow gravelly loamy surface brown or reddish brown duplex soils, mainly within Terrain Units P-T 3.7/8 and Cz 3.7/8.

6.2

Moderately deep dark brown medium to heavy-textured cracking clay soil overlying clayey and sandy alluvium. Soil reaction ranges from neutral to slightly alkaline at the surface to moderately strongly alkaline with depth. These soils form a mosaic of cracking clay soils intermingled with dark brown thin loamy surface duplex soils (Soil Type 4.4). They occur mainly associated with Terrain Unit Cz 2.7/8. Local areas with intensive gilgai development also occur (Cz 2.7/8g).

6.3

Deep to very deep dark grey to brownish black medium to heavy-textured cracking clays generally with slightly acidic to neutral soil reaction at the surface, becoming moderately strongly alkaline below about 500mm. Moderate amounts of earthy carbonate are generally present.

These soils are of extensive occurrence within the study area and occur associated with Terrain Units (Qa 1.8, 2.8, 5.8).

6.4

Deep to very deep medium to heavy-textured cracking clay soils with strongly developed gilgai micro-relief, with vertical intervals between mounds and depressions of 400 – 600mm approximately.

Surface soils are predominantly dark grey-brown or dark grey and colours generally become lighter with depth. In the gilgai depressions the subsoil clays are generally mottled with depth but on the adjacent mounds the soil colour may remain uniform throughout. Soil reaction is generally alkaline near the surface becoming slightly to strongly acidic below about 750mm approximately.

These soils occur fairly extensively within the study area and are mainly associated with Terrain Units (Ta 2.8 and Cz 2.7/8g).

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APPENDIX 3
SOIL ANALYSES RESULTS

TABLE 3.A

ENSHAM COAL PROJECT - SOIL ANALYSES

LOCATION NO:-	E5	E5	E5	E11	E11	E18a	E18a	E18a	E18b	E18b	E18b
SAMPLE DEPTH (mm)	0-150	200-450	900-1200	0-150	600-800	0-200	300-500	950-1150	0-200	300-500	1100-1300
SOIL TEXTURE	Silty Clay Loam	Clay	Clay	Sandy Loam	Gravelly Clay	Clay	Clay	Clay	Clay	Clay	Clay
TERRAIN/SOIL MAPPING UNIT NO:-	Qac.7/h.h										
SOIL TYPE (SOIL GROUP)	Solodic										
P.F.F. (Northcote)	Dd1.13										
U.S.C. CLASS	CL-ML	CH	CH	SC-CL	CL	CH	CH	CH	CH	CH	CH
DISPERSSION RATING (Emerson Tech. Memo 15)	3m	h/7m	h/7m ^x	3m	3m	h/7m	2m	1m	h/7m	h/7m ^x	h/7m ^x
ACIDITY											
PH	5.9	7.7	7.8	6.4	6.6	7.3	7.1	7.1	7.8	8.1*	8.2*
Aluminum (Al)	ppm										
MAJOR ELEMENTS											
Nitrogen (N)	ppm	1	1	1	1	1	3	3	1	1	2
Phosphorus (P)	ppm	61	3	24	17	11	8	4	9	7	6
Potassium (K)	ppm	475	270	290	335	105	145	75	300	110	100
SECONDARY ELEMENTS											
Sulphur (S)	ppm	2	71	67	4	2	5	40	15	17	139
Calcium (Ca)	ppm	1925	15500	3075	1550	1875	3075	1625	28000	30000	4100
Magnesium (Mg)	ppm	560	1375	1100	160	230	1100	980	775	1700	1700
TRACE ELEMENTS											
Copper (Cu)	ppm	3.9	4.8	4.0	5.0	2.2	5.4	2.2	3.0	2.0	2.1
Zinc (Zn)	ppm	3.0	1.7	2.1	6.9	2.0	1.5	0.7	2.2	0.7	0.6
Manganese (Mn)	ppm	530**	340	300	475**	50	30	25	420	100	130
Iron (Fe)	ppm	320	115	110	120	65	120	90	45	30	65
Boron (B)	ppm	0.8	2.9	2.7	1.0	1.3	1.1	2.4	1.6	1.9	7.6
Molybdenum (Mo)	ppm	0.2	0.17	0.06	0.18	0.10	0.11	0.17	0.34	0.14	0.06
Organic Matter	%	5.2	2.5	1.2	4.1	0.9	1.0	0.8	3.4	1.7	0.5
SALINITY											
Electrical Cond. (EC)	mS/cm	0.083	0.680*	0.674*	0.057	0.040	0.142	0.131	0.133	0.273	1.08**
Total Sol. Salts (TSS)	ppm	267	2176**	2157**	182	128	454	419	426	874*	3456**
Sodium (Na)	ppm	200	885**	910**	30	50	120	725	45	750*	3050**
Chloride (Cl)	ppm	50	978**	1075**	14	11	26	85	14	31	1390**
CATIONS											
Cation Exchange (CEC)	ME%	15.9	89.6	25.4	9.7	11.5	26.3	27.2	21.7	146.6	42.1
Capacity	ME%										
Exchangeable Sodium (1)	ME%	5.3	7.2*	12.7*	1.3	1.8	1.9	11.3*	1.8	8.8*	13.9*
Exchangeable Sodium (2)	ME%	7.4	4.1	13.6*	8.5	2.3	2.4	1.3	0.1	1.9	27.6**
Exchangeable Potassium	ME%	0.7	2.5	2.5	2.3	0.8	0.5	0.8	0.5	0.2	0.5
Exchangeable Calcium	ME%	59.0	83.0	52.8	77.1	79.8	77.5	33.9	95.0	89.5	42.7
Exchangeable Magnesium	ME%	28.2	12.1	31.1	13.1	16.1	18.2	32.4	4.3	8.3	29.1
Exchangeable Aluminum	ME%										
Ca/Mg (ME%)	Ratio	2.1	6.9	1.7*	5.9	5.0	4.3	1.7*	1.0*	10.7	1.5*

Notes:

- x Non-dispersive but natural air dry aggregates prone to rapid slaking in water.
 * Med. to High levels - may restrict plant growth potential.
 ** High to Very High levels - possible toxicity.
 + Values indicate potential soil structure problems.
 (1) Tucker's Method (Tucker 1971)
 (2) Quantum Standard Method.

For location of sample sites refer Drawing 4.2.

TABLE 3.A (Cont'd)

ENSHAM COAL PROJECT - SOIL ANALYSES

LOCATION NO:-	E23	E23	E24	E24	E24	E38	E38	E38	E46	E46
SAMPLE DEPTH (mm)	0-250	300-600	0-200	400-650	1200-1400	0-200	500-750	1200-1450	0-200	200-400
SOIL TEXTURE	Silty Loam	Clay	Clay	Clay	Clay	Silty Clay	Clay	Clay	Clay	Clay
TERRAIN/SOIL MAPPING UNIT NO:-	Qa2.7/ 4.4		Qa2.8/ 6.3			Qa1.7/ 5.3			P-T3.7/8/ 6.1	
SOIL TYPE (SOIL GROUP)	Solodic		Grey Soil of Heavy Texture			Alluvial Soil			Black Earth	
F.P.F. (Northcote)	(Dr2.13)		(Ug5.25)			(Uf6.32)			(Ug5.32)	
U.S.C. CLASS	CL-ML	CH	CH	CH	CH	CL-CH	CH	CH	CH	CH
DISPERSION RATING (Emerson Tech. Memo 15)	2m	4/7m ^x	4/7m ^x	2m	1m	4/7m	4/7m	4/7m ^x	4/7m	4/7m
<u>ACIDITY</u>										
pH		7.3	7.8	7.4	7.1	5.8	6.9	7.5	7.8	7.7
Aluminium (Al)	ppm									8.1*
<u>MAJOR ELEMENTS</u>										
Nitrogen (N)	ppm	1	2	3	2	4	4	1	2	3
Phosphorus (P)	ppm	9	7	7	12	5	42	46	14	16
Potassium (K)	ppm	95	75	235	155	245	465	280	275	350
<u>SECONDARY ELEMENTS</u>										
Sulphur (S)	ppm	6	4	8	6	3	8	26	33	28
Calcium (Ca)	ppm	1700	3400*	3675*	2600	2650	4000*	4250*	16000*	22500
Magnesium (Mg)	ppm	870*	1050*	1060*	1200*	1350*	1000*	900*	1120*	1750
<u>TRACE ELEMENTS</u>										
Copper (Cu)	ppm	3.5	3.1	4.1	3.0	2.4	5.4	4.1	4.4	3.0
Zinc (Zn)	ppm	8.6	8.0	1.0	0.7	3.7	11.7	4.2	0.5	0.9
Manganese (Mn)	ppm	70	65	100	95	50	70	50	85**	20
Iron (Fe)	ppm	135	120	170	110	125	310	160	110	70
Boron (B)	ppm	1.1	2.3	1.3	2.3	1.8	1.3	1.8	2.9	2.2
Molybdenum (Mo)	ppm	0.22	0.14	0.14	0.19	0.09	0.18	0.16	0.22	0.48
Organic Matter	%	3.0	1.5	2.2	1.7	2.4	5.0	1.5	1.4	4.2
<u>SALINITY</u>										
Electrical Cond. (EC)	mS/cm	0.472*	0.665*	0.250	1.056**	1.034**	0.117	0.177	0.304	0.231
Total Sol. Salts (TSS)	ppm	1510*	2128*	800*	3379**	3309**	374	566	973*	739
Sodium (Na)	ppm	670*	950*	530	2150**	2400**	75	245	560	440
Chloride (Cl)	ppm	623*	1225	300	2110**	2425**	44	27	224	105
<u>CALCULATIONS</u>										
Cation Exchange (CEC)	ME%	16.2	26.3	28.6	26.8	29.8	29.1	29.5	90.7	128.4
Capacity										164.0
Exchangeable Sodium (1)	ME%							4.7	8.1*	3.0
Exchangeable Sodium (2)	ME%	15.5**	13.8*	7.7*	28.7**	29.5**	1.1	3.5	2.6	1.5
Exchangeable Potassium	ME%	1.3	0.6	2.0	1.2	1.8	4.0	2.4	0.8	0.7
Exchangeable Calcium	ME%	45.2	56.7	61.3	39.9	37.4	67.3	69.8	86.6	86.7
Exchangeable Magnesium	ME%	38.0	28.8	29.1	30.3	31.3	27.7	24.3	10.0	11.1
Exchangeable Aluminium	ME%									
Ca/Mg (ME%)	Ratio	1.2+	2.0	2.1	1.3+	1.2+	2.4	2.9	8.7	7.8

Notes:

- x Non-dispersive but natural air dry aggregates prone to rapid slaking in water.
 * Med. to High levels - may restrict plant growth potential.
 ** High to Very High levels - possible toxicity.
 † Values indicate potential soil structure problems.
 (1) Tucker's Method (Tucker 1971)
 (2) Quantum Standard Method.

For location of sample sites refer Drawing 4.2.

TABLE 3.A (Cont'd)
ENSHAM COAL PROJECT - SOIL ANALYSES

LOCATION NO:-	E55	E55	E55	E58	E58	E58	E62	E62	E74	E74	E74
SAMPLE DEPTH (mm)	0-200	300-500	500-700	0-250	350-600	1150-1450	0-200	300-500	0-100	300-500	800-1000
SOIL TEXTURE	Silty Loam	Silty Clay	Clay	Clay	Clay	Clay	Gravelly Sandy Loam	Gr.Sandy Clay Loam	Silty Clay	Clay Clay	Clay
TERRAIN/SOIL MAPPING UNIT NO:-	Qa2.6/ _{4.2}			Cz27/8/ _{6.2}			Ta4.1/3/ _{2.2}		Qc2.6/ _{5.2}		
SOIL TYPE (SOIL GROUP)	Solodic			Brown Soils of Heavy Texture			Lithosol		Alluvial Soil		
P.P.F. (Northcote)	(Dr2.13)			(Ug5.34)			(Gn2.12)		(Uf6.21)		
U.S.C. CLASS	CL-ML	CL-CH	CL-CH	CH	CH	CH	CH	GL-SC	GL	CL-CH	CL-CH
DISPERSION RATING (Emerson Tech. Memo 15)	3m	2m	1m	4/7m	4/7m	4/7m	3m	3m	4/7m	4/7m	4/7m*
ACIDITY											
pH	5.4	7.1	8.1*	7.6	7.9	8.1*	6.3	6.2	6.8	6.6	7.6
Aluminium (Al)	ppm										
MAJOR ELEMENTS											
Nitrogen (N)	ppm	11	11	36	3	4	3	11	10	18	7
Phosphorus (P)	ppm	26	5	7	16	5	6	13	7	8	5
Potassium (K)	ppm	145	130	130	235	120	135	200	155	305	210
SECONDARY ELEMENTS											
Sulphur (S)	ppm	12	18	63	15	105	98	3	6	11	5
Calcium (Ca)	ppm	1875	1700	2800	3900*	2250	22000*	2250	2450	3375*	3300*
Magnesium (Mg)	ppm	240	830*	940*	870*	950*	1260*	80	200	340	540
TRACE ELEMENTS											
Copper (Cu)	ppm	3.4	3.9	5.4	6.1	4.9	2.6	3.2	2.6	6.6	6.4
Zinc (Zn)	ppm	2.0	0.7	0.7	5.9	1.1	1.4	0.7	1.4	1.9	0.8
Manganese (Mn)	ppm	20	40	100*	100*	70	100*	20	25	80**	105**
Iron (Fe)	ppm	250	130	100	170	110	35	90	180	140	120
Boron (B)	ppm	2.1	2.0	4.1	6.6	4.0	4.6	0.9	2.3	2.3	1.4
Molybdenum (Mo)	ppm	0.21	0.19	0.19	0.32	0.14	0.14	0.12	0.17	0.22	0.12
Organic Matter	%	5.3	1.8	0.8	3.0	0.7	0.3	6.3	7.3	4.9	1.4
SALINITY											
Electrical Cond. (EC)	mS/cm	0.103	0.252	0.552	0.361	1.33**	1.103**	0.104	0.095	0.137	0.121
Total Sol. Salts (TSS)	ppm	329	806*	1766*	1155*	4256**	3530**	333	304	438	387
Sodium (Na)	ppm	80	700*	1850*	550	2400**	2650**	30	35	40	45
Chloride (Cl)	ppm	37	301	672*	405	2350**	2250**	50	40	66	55
CALCULATIONS											
Cation Exchange (CEC)	ME%	11.5	17.3	27.1	27.7	22.5	126.2	12.0	13.9	19.9	21.0
Capacity											
Exchangeable Sodium (1)	ME%			15.4**	11.2*	24.3**	17.9**				3.4
Exchangeable Sodium (2)	ME%	2.9	16.3**	26.7**	8.1*	35.0**	8.7**	1.0	1.1	0.8	0.9
Exchangeable Potassium	ME%	3.1	1.8	1.1	2.0	1.0	0.3	4.1	2.7	3.8	2.5
Exchangeable Calcium	ME%	77.7	45.5	46.5	65.8	37.7	83.2	89.6	84.8	81.8	76.1
Exchangeable Magnesium	ME%	16.4	36.5	25.7	24.1	26.2	7.8	5.2	11.4	13.6	20.5
Exchangeable Aluminium	ME%										
Ca/Mg (ME%)	Ratio	4.8	1.2*	1.8*	2.7	1.4*	10.6	17.1	7.4	6.0	3.7

Notes:

- x Non-dispersive but natural air dry aggregates prone to rapid slaking in water.
- * Med. to High levels - may restrict plant growth potential.
- ** High to Very High levels - possible toxicity.
- + Values indicate potential soil structure problems.
- (1) Tucker's Method (Tucker 1971)
- (2) Quantum Standard Method.

For location of sample sites refer Drawing 4.2.

TABLE 3.A (Cont'd)
COAL PROJECT - SOIL

[illegible]

Notes:

- x Non-dispersive but natural air dry aggregates prone to rapid slaking in water.
- ** Med. to High levels - may restrict plant growth potential.
- ** High to Very High levels - possible toxicity.
- + Values indicate potential soil structure problems.
- (1) Tucker's Method (Tucker 1971)
- (2) Quantum Standard Method.

For location of sample sites refer Drawing 4.2.

TABLE 3.B

ENSHAM COAL PROJECT - OVERBURDEN ANALYSES

LOCATION NO:-	F1199	F1199	F1199	F1199	F1198	F1198	F1198	F1197	F1197	F1197
SAMPLE DEPTH (mm)	29m	35.2m	42m	48.2m	26.4m	41m	41.2m	20.2m	30.3m	40m
SOIL TEXTURE	Mudstone inter- bedded Siltstone	Sandstone	Mudstone (Sideritic)	Mudstone	Mudstone	Mudstone	Mudstone inter- bedded Sandstone	Mudstone	Sandstone	Sandstone
TERRAIN/SOIL MAPPING UNIT NO:-	Overburden Sample									
SOIL TYPE (SOIL GROUP)	Overburden Sample									
P.F.F. (Northcote)										
U.S.C. CLASS										
DISPERSION RATING (Emerson Tech. Memo 15)	6m	6m	6m	2m	6m	6m	6m	2m	2m	2m
ACIDITY										
pH	7.4	8.1*	8.1*	7.9	7.2	7.9	7.5	7.6	8.4*	8.4*
Aluminium (Al)	ppm									
MAJOR ELEMENTS										
Nitrogen (N)	ppm	1	1	3	2	1	2	1	1	1
Phosphorus (P)	ppm	4	2	3	2	6	4	3	4	13
Potassium (K)	ppm	270	150	260	260	230	215	195	255	210
SECONDARY ELEMENTS										
Sulphur (S)	ppm	37	32	44	39	96	63	81	28	25
Calcium (Ca)	ppm	1550	2350	1475	1650	800	925	675	2700	3250*
Magnesium (Mg)	ppm	870*	745*	760	830*	730	610	655	945*	765
TRACE ELEMENTS										
Copper (Cu)	ppm	7.6	3.5	4.6	11.7	15.3	14.4	10.6	9.3	5.4
Zinc (Zn)	ppm	11.0	16.4	17.3	13.5	36.0	16.8	13.2	14.6	6.6
Manganese (Mn)	ppm	25	30	20	30	20	20	25	25	25
Iron (Fe)	ppm	700	645	555	790	610	890	640	650	630
Boron (B)	ppm	1.5	1.1	1.5	2.7	1.3	2.8	1.3	0.4	0.3
Molybdenum (Mo)	ppm	0.14	0.35	0.29	0.15	1.01	0.27	0.23	0.21	0.74
Organic Matter	%	2.1	1.3	2.0	4.2	3.7	4.9	2.7	0.8	1.3
SALINITY										
Electrical Cond. (EC)	mS/cm	0.125	0.235	0.246	0.212	0.687*	0.558*	0.510*	0.581*	0.334
Total Sol. Salts (TSS)	ppm	400	810	787	678	2198*	1786*	1616*	1859*	1069*
Sodium (Na)	ppm	445	470	800	740	930*	1600*	815*	1400*	850*
Chloride (Cl)	ppm	35	89	125	51	1100*	755*	452	327	190
CALCULATIONS										
Cation Exchange (CEC)	MEq	16.8	18.9	16.4	17.8	10.9	14.1	20.8	10.1	24.9
Capacity	MEq									
Exchangeable Sodium (1)	MEq		12.1*	15.1**	16.0**	27.6**	28.4**	11.2*	21.1**	19.5**
Exchangeable Sodium (2)	MEq	11.0*	10.1*	19.6**	17.0**	40.6**	40.6**	3.2	21.7**	13.8*
Exchangeable Potassium	MEq	3.9	1.9	3.7	3.5	4.0	3.2	3.2	2.3	2.0
Exchangeable Calcium	MEq	44.2	57.9	41.5	43.5	27.3	27.0	69.7	48.2	60.7
Exchangeable Magnesium	MEq	40.8	30.2	35.2	36.0	41.0	29.3	17.5	27.7	23.5
Exchangeable Aluminium	MEq									
Ca/Mg (MEq)	Ratio	1.1+	1.9*	1.2+	1.2*	0.7+	0.9*	4.0	1.7+	2.6
REMARKS	Pyritic Spot Test	-ve	+ve (slight)	-ve	-ve	-ve	-ve	-ve	-ve	-ve

Notes:

- x Non-dispersive but natural air dry aggregates prone to rapid slaking in water.
- * Med. to High levels - may restrict plant growth potential.
- ** High to Very High levels - possible toxicity.
- + Values indicate potential soil structure problems.
- (1) Tucker's Method (Tucker 1971)
- (2) Quantum Standard Method.

For location of sample sites refer Drawing 4.2.

The laboratory test methods used for the overburden analysis are identical to those used for the soil analysis.

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APPENDIX 4
LAND CAPABILITIES

TABLE 4.A
LAND CAPABILITY CLASSES
(Rosser et al 1974)

<u>CLASS I</u>	Land suitable for all agricultural and pastoral uses. (a) It is suited to a wide range of crops and is highly productive. (b) It presents no limitations to use of machinery or choice of implements. (c) Wind and water erosion hazard is low even under intensive cultivation.
<u>CLASS II</u>	Land suitable for all agricultural uses but with slight restrictions to use for cultivation in one or more of the following categories. (a) Land with some limitation to the choice of crops and/or slight restrictions to productivity. (b) Land with some impediment to the use of cultivation machinery which limits the choice of implements or restricts the conditions of successful operations. (c) Land which under cultivation requires simple conservation practices to reduce soil loss to an acceptable level. (Simple practices include contour working, strip cropping, stubble mulching).
<u>CLASS III</u>	Land suitable for all agricultural uses but with moderate restrictions to use for cultivation in one or more of the following categories: (a) Land with moderate limitation to the choice of crops and/or moderate restrictions to productivity. (b) Land with moderate impediment to the use of cultivation machinery which limits the choice of implements or restricts the condition for successful operation. (c) Land which under cultivation requires intensive conservation practices to reduce soil loss to an acceptable level. (Intensive conservation practices include contour banking systems and intensive residue management involving specialised implements).
<u>CLASS IV</u>	Land primarily suited for pastoral use but which may be safely used for occasional cultivation with careful management. Limitations arise from one of the following categories: (a) Land on which the choice of crops is severely restricted and/or conditions are such that productivity under cropping is severely limited. (b) Land with severe impediment to the use of cultivation machinery which limits the choice of implements or severely restricts the conditions for successful operation. (c) Land which cannot be used safely for permanent cultivation. (If cropped, a pasture phase must be the major component in the cropping programme to limit soil loss to an acceptable level).
<u>CLASS V</u>	Land which in all other characteristics would be arable but has limitations which unless removed make cultivation impractical and/or uneconomic.
<u>CLASS VI</u>	Land which is not suitable for cultivation but is well suited to pastoral use and on which pasture improvement involving the use of machinery is practicable.
<u>CLASS VII</u>	Land which is not suitable for cultivation but on which pastoral use is possible only with careful management. Pasture improvement involving the use of machinery is not practicable.
<u>CLASS VIII</u>	Land which has severe limitations that it is unsuited for either cultivation or grazing.

TABLE 4.B
LAND CAPABILITY CLASSIFICATION FOR AGRICULTURE - LIMITING FACTORS
(Rosser et al 1974)

TYPE OF LIMITATION	LIMITING FACTOR	DEGREE OF LIMITATION	SUB-CLASS
FACTORS LIMITING CHOICE OF CROPS OR CROP PRODUCTIVITY	Climatic limitation other than rainfall "c"	Slight restriction to choice of crops or slightly restricted production potential.	c2
		Moderate restriction to choice of crops or moderately restricted production potential.	c3
		Severely restricted choice of crops and severely reduced production potential.	c4
		Climatic limitation too severe to allow cropping.	c6
	Moisture availability for	Occasional limitation to crop production; 7 - 8 crops possible in 10 years.	m2
		Regular limitation to crop production; 5 - 7 crops possible in 10 years.	m3
		Occasional cropping possible. Less than 5 crops possible in 10 years.	m4
		Moisture availability too unreliable to allow cropping.	m6
	Effective soil depth "d"	Effective soil depth >60cm.	d2
		Effective soil depth 46 - 60cm.	d3
		Effective soil depth 25 - 45cm.	d4
		Effective soil depth <25cm.	d6
	Soil physical factors affecting crop growth "p"	Degree of limitation imposed on crop production from soil physical factors affecting the growth of crop plants eg. surface crusting, hard pans, cementation etc. Slight restriction	p2
		Moderate restriction	p3
		Sever restriction	p4
	Soil nutrient fertility "n"	Moderate deficiencies which may be economically corrected with careful management.	n2
		Severe deficiencies, difficult to correct and which require special management practices.	n3
		Very low fertility; continuous cultivation precluded by structural decline.	n4
	Soil Salinity or sodicity "s"	Soil water availability slightly restricted or slight structural decay affecting crop production.	s2
		Soil water availability moderately restricted or moderate structural decay with some toxic effect on crops.	s3
		Soil water availability severely restricted or severe structural decay with moderate to severe toxicity.	s4
		Salinity or alkalinity too severe for crops.	s6
		Tolerant improved species available.	
		Salinity or alkalinity too severe for pasture improvement; tolerant herbage available.	s7
		Bare salt pan; not practical to vegetate.	s8
	Topography "t"	Severe relief or major gullies preclude contour cultivation. Occasional cropping possible.	t4
		Slopes 15 - 20% or severe relief or gullying preventing cultivation.	t6
		Slopes 20 - 45% or extreme gullying but accessible to grazing animals.	t7
		Slopes or topography too severe for grazing animals.	t8

TABLE 4.B (Cont'd)

LAND CAPABILITY CLASSIFICATION FOR AGRICULTURE - LIMITING FACTORS

(Rosser et al 1974)

TYPE OF LIMITATION	LIMITING FACTOR	DEGREE OF LIMITATION	SUB-CLASS
FACTORS LIMITING THE USE OF AGRICULTURAL MACHINERY	Soil Workability "k"	Soil properties affecting machinery & thus reducing average production potential eg. stiff clay, columnar structure, compaction, narrow moisture range for working.	Slight restriction k2
			Moderate restriction k3
			Severe restriction k4
	Rockiness or stoniness "r"	Tillage restricted with some types of machinery.	r2
		Tillage restricted with most types of machinery.	r3
		Tillage difficult with all machinery, occasional use possible.	r4
		Use of all machinery for cropping impractical.	r5
	Surface microrelief gilgai and gullying "g"	Tillage restricted with some types of machinery.	g2
		Tillage restricted with most types of machinery.	g3
		Tillage difficult with all machinery; occasional use possible.	g4
		Use of all machinery for cropping impractical.	g5
	Wetness "w"	Use of implements delayed occasionally and slightly reduced production potential.	w2
		Use of implements delayed regularly and moderately reduced production potential.	w3
		Use of implements very difficult and occasional crops only possible.	w4
		Permanently wet; cultivation impractical.	w5
FACTORS CONTROLLING LAND DETERIORATION	Susceptibility to water erosion "e"	Simple practices required to reduce water erosion under cultivation to the acceptable level.	e2
		Intensive practices required to reduce water erosion under cultivation to the acceptable level.	e3
		Required inclusion of a pasture phase to reduce average water erosion losses to the acceptable level.	e4
		Continuous pasture required to reduce water erosion losses to the acceptable level.	e6
	Susceptibility to flooding "f"	Special practices or grazing restrictions required to reduce water erosion losses to the acceptable level.	e7
		Under grazing water erosion losses are in excess of the acceptable level.	e8
		Subject to occasional overflow flooding.	f2
		Subject to regular overflow flooding.	f3
		Subject to severe overflow flooding; permanent cultivation not possible.	f4
		Flood frequency and/or severity precludes any cropping.	f5
	Susceptibility to wind erosion "a"	Slightly susceptible to wind erosion.	a2
		Moderately susceptible to wind erosion.	a3
		Severely susceptible to wind erosion.	a4
		Potential for wind erosion too severe to allow cropping.	a6 - 8

TABLE 4.D
LAND SUITABILITY CLASS - LIMITING FACTORS
(For Irrigated Lands)

LIMITATION	CRITERIA FOR DEGREE OF LIMITATION	SUITABILITY CLASS	SUB-CLASS SYMBOL
<u>Topography</u> (Influences water management and erosion control)	0.1 - 0.5% Slope	1	-
	0.5 - 1.0% Slope	2	+2
	1.0 - 2.0% Slope	3	+3
	2.0 - 6.0% Slope	4	+4
	>6.0% Slope	5	+5
<u>Flooding</u> (Crop losses due to flooding may occur)	No flooding	1	-
	Frequency < 1 in 10 years (occasional)	2	f2
	Frequency 1 in 5 - 10 years (infrequent)	3	f3
	Frequency > 1 in 5 years (frequent)	4	f4
	Subject to erosive flooding	5	f5
<u>Micro-relief</u> (Gilgai and gullying, surface levelling required)	No surface micro-relief	1	-
	Vertical interval of surface micro-relief <250mm	2	g2
	Vertical interval of surface micro-relief 250 - 600mm	3	g3
	Vertical interval of surface micro-relief >600mm	4	g4
<u>Stoniness</u> (Limitations to cultivation)	No cobble, stone or rock	1	-
	Some stone picking may be required for certain crops	2	r2
	Tillage restricted; stone picking required	3	r3
	Tillage difficult; stone/cobble picking necessary	4	r4
	Tillage impractical; not practicable to remove stone	5	r5
<u>Soil Physical Properties</u> (1) Depth to hard impermeable subsoil - restricted root development and water entry.	>450mm to subsoil with extremely hard dry consistence	1	-
	200 - 450mm to subsoil with extremely hard dry consistence	2	pb2
	100 - 200mm to subsoil with extremely hard dry consistence	3	pb3
	<100mm to subsoil with extremely hard dry consistence	4	pb4
(2) Surface crust/hard setting surface condition.	No surface crust and surface horizon is not hard setting	1	-
	Hard setting surface with mod. hard dry consistence	2	pc2
	Hard setting surface with hard dry consistence	3	pc3
	Hard setting surface with very hard dry consistence	4	pc4
(3) Soil Type Distribution	Surface textures differ by >1 texture group; boundaries occur on average:		
	150 - 300m apart <150m apart	3 4	pd3 pd4
(4) Soil Texture	Soils of texture groups 1 (sands) and 2 (sandy loams) to depths of:		
	<450mm	2	pt2
	450 - 900mm	3	pt3
	>900mm	4	pt4
(5) Gravel Beds	Gravel beds >150mm thick <450mm from the surface	4	pg4
<u>Effective Depth</u> (Depth to rock or hardpan)	Deep (>1000mm)	1	-
	Mod. deep (600 - 1000mm)	2	d2
	Mod. shallow (450 - 600mm)	3	d3
	Shallow (250 - 450mm)	4	d4
	Very shallow (<250mm)	5	d5
<u>Salinity/Sodicity</u>	E.C. 1:5 soil/water suspension >1mS/cm at depths of:		
	300 - 900mm	3	Sa3
	<300mm	4	Sa4
	ESP >15% at depths of:		
	300 - 900mm	3	So3
	<300mm	4	So4

TABLE 4.D (Cont'd)
 LAND SUITABILITY CLASS - LIMITING FACTORS
 (For Irrigated Lands)

LIMITATION	CRITERIA FOR DEGREE OF LIMITATION	SUITABILITY CLASS	SUB-CLASS SYMBOL
<u>Soil Fertility</u>	Based on standard soil analyses, major soil nutrients are: - low - very low	2 3	n2 n3
<u>Wetness</u> (Trafficability/handling)	Areas remain wet and cannot be used for: - limited periods (some levelling required) - long periods - months (special drainage works necessary) - very long periods, permanently water logged (major drainage works necessary).	3 4 5	w3 w4 w5
<u>Erosion</u> (Soil susceptibility to water erosion)	Soil conservation measures required to control erosion: - simple practices (maintenance of surface cover) - intensive practices (graded banks) - pasture phase or permanent pasture - severe gully erosion (requires reclamation)	2 3 4 5	e2 e3 e4 e5
<u>Note:</u> Where there two or more Class 3 Limitations evident the land concerned may be down-graded to Capability Class 4 for example.			

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APPENDIX 5
SURFACE WATER QUALITY ANALYSES RESULTS

TABLE 5.A

QWRC WATER QUALITY DATA - UPPER NOGOA RIVER & THERESA CREEK

		FAIRBAIRN DAM OUTLET CHANNEL		SELMA WEIR	THERESA CREEK VALERIA
pH		Min	7.1	7.0	7.1
		Max	9.0	8.2	8.5
		Average	7.7	7.7	7.7
		Count N	54.0	11.0	44.0
		STD (pop)	0.3	0.4	0.3
Dissolved Ions	(mg/l)	Min	122.9	88.0	95.2
		Max	342.6	254.2	1030.5
		Average	162.9	164.0	245.1
		Count N	54.0	11.0	44.00
		STD (pop)	36.2	43.0	209.1
Hardness	(mg/l)	Min	51.0	35.0	32.0
		Max	142.0	109.0	369.0
		Average	69.2	68.4	101.8
		Count N	54.0	11.0	44.0
		STD (pop)	16.9	19.3	78.3
Alkalinity	(mg/l)	Min	67.0	37.0	48.0
		Max	160.0	124.0	390.0
		Average	87.4	82.7	106.4
		Count N	54.0	11.0	44.0
		STD (pop)	16.6	21.6	65.8
Na	(mg/l)	Min	9.4	9.0	8.0
		Max	42.0	29.0	183.0
		Average	15.2	18.3	32.2
		Count N	54.0	11.0	44.0
		STD (pop)	6.1	6.2	39.9
K	(mg/l)	Min	0.0	0.0	0.0
		Max	5.6	4.3	4.8
		Average	3.2	1.8	2.4
		Count N	54.0	11.0	44.0
		STD (pop)	1.9	2.1	1.7
Ca	(mg/l)	Min	12.0	9.3	8.0
		Max	29.7	24.0	60.0
		Average	16.4	16.4	20.6
		Count N	54.0	11.0	44.0
		STD (pop)	3.5	4.1	10.4
Mg	(mg/l)	Min	4.0	2.9	3.0
		Max	17.7	12.0	68.0
		Average	6.9	6.6	12.2
		Count N	54.0	11.0	44.0
		STD (pop)	3.1	2.5	14.1
HCO ₃	(mg/l)	Min	81.0	45.0	59.0
		Max	195.0	151.0	465.0
		Average	105.7	100.9	128.1
		Count N	54.0	11.0	44.0
		STD (pop)	20.3	26.3	77.2
CO ₃	(mg/l)	Min	0.0	0.0	0.0
		Max	14.0	0.2	24.0
		Average	0.6	0.1	1.1
		Count N	41.0	6.0	43.0
		STD (pop)	2.1	0.1	3.9
Cl	(mg/l)	Min	5.5	8.0	0.0
		Max	40.0	26.0	296.0
		Average	10.9	14.4	43.9
		Count N	54.0	11.0	44.0
		STD (pop)	5.5	6.4	68.4
F	(mg/l)	Min	0.1		0.0
		Max	0.6		0.9
		Average	0.3		0.2
		Count N	54.0		44.0
		STD (pop)	0.1		0.2
NO ₃	(mg/l)	Min	0.0	0.0	0.0
		Max	3.1	3.0	2.0
		Average	0.7	0.6	0.2
		Count N	54.0	11.0	44.0
		STD (pop)	0.9	1.0	0.4

TABLE 5.A (Cont'd)

QWRC WATER QUALITY DATA - UPPER NOGOA RIVER & THERESA CREEK

			FAIRBAIRN DAM OUTLET CHANNEL	SELMA WEIR	THERESA CREEK VALERIA
SO ₄	(mg/l)	Min	0.0	0.0	0.0
		Max	19.0	15.0	24.0
		Average	3.1	4.5	4.1
		Count N	54.0	11.0	44.0
		STD (pop)	4.0	5.4	6.7
Sodium Absorption Ratio		Min	0.5	0.5	0.4
		Max	1.5	1.3	4.2
		Average	0.8	1.0	1.2
		Count N	54.0	11.0	44.0
		STD (pop)	0.2	0.3	0.9
Residual Alkalinity	(mg/l)	Min	0.0	0.0	0.0
		Max	0.6	0.7	1.8
		Average	0.4	0.3	0.4
		Count N	54.0	11.0	44.0
		STD (pop)	0.1	0.2	0.3
Suspended Solids	(mg/l)	Min	0.0	0.0	0.0
		Max	265.0	615.0	1147.0
		Average	22.4	126.0	149.1
		Count N	53.0	6.0	38.0
		STD (pop)	41.7	240.3	262.0
Dissolved Silica	(mg/l)	Min	0.0	0.0	0.0
		Max	24.0	14.0	120.0
		Average	8.2	4.6	13.2
		Count N	53.0	11.0	43.0
		STD (pop)	6.1	5.6	18.7
Iron	(mg/l)	Min	0.0	0.0	0.0
		Max	5.9	2.7	1.2
		Average	0.4	0.9	0.2
		Count N	21.0	3.0	32.0
		STD (pop)	1.3	1.6	0.3
Manganese	(mg/l)	Min	0.0	0.0	0.0
		Max	0.0	0.0	0.0
		Average	.0	0.0	0.0
		Count N	36.0	9.0	35.0
		STD (pop)	.0	0.0	0.0
Boron	(mg/l)	Min	0.0	0.0	0.0
		Max	0.9	0.0	0.1
		Average	0.0	0.0	0.0
		Count N	39.0	9.0	34.0
		STD (pop)	0.1	0.0	0.0

199200

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199200 e

5 September 1986

APPENDIX 6
WATER BALANCE

SITE WATER BALANCE - PLANT AREA

1) Basic Parameters

. Evaporation

- Average Annual Pan Evaporation = 6.0mm/day.

. Rainfall

- On basis of Bureau of Meteorology rainfall predictions, 100 year 24 hour rainfall is 216mm/day.
- For catchment runoff assessment, it is assumed that 80% of rainfall is converted to runoff.

2) Water Demands & Inputs

2.1 Coal Preparation Plant

Processing 4 million tonnes of coal per year, at 250L/tonne requires 1000ML/year water usage. Operating 50 weeks per year, 6 days per week, requires a water usage of 3330kL/day.

2.2 (a) Coal Stockpiles

Assumed that 4% of wash-water is retained in the coal sent to the stockpile, implies $.04 \times 3330$, equals say 130kL/day.

(b) Coarse Rejects

Assuming $200,000\text{m}^3/\text{year}$ with 20% moisture gives a total of $40,000\text{m}^3/\text{year}$ water = 65kL/day (assuming 6 day week for 50 weeks).

2.3 Tailings Pond

Pond Area is 340,000m

Catchment Area is 350,000m

Input from process plant is $3330 - 130 - 65 = 3135\text{kL/day}$

Reclaim pipeline capacity is 670kL/day.

On a dry day (assuming half pond area is covered):

$$\begin{aligned}\text{evaporation} &= 170,000\text{m} \times 6\text{mm} \\ &= 1020\text{kL}\end{aligned}$$

On a wet day:

$$\begin{aligned}\text{rainfall} + \text{runoff} &= 350,000\text{m} \times 216\text{mm} \times 0.8 \text{ rainfall in 24hr.} \\ &= 60,500\text{kL}\end{aligned}$$

$$\text{Reserve Airspace} = 360,000\text{kl.}$$

2.4 Haul Road Watering

Wet Day - Watering not required.

Dry Day - 250ML per year

- On basis of 50 weeks per year, 6 days per week,

$$\text{- Water Usage} = 830\text{kL/day.}$$

2.5 Raw Water Storage

Pond area is 14,000m .

Catchment area is 190,000m

On a dry day:

$$\begin{aligned}\text{evaporation} &= 14,000\text{m} \times 6\text{mm} \\ &= 84\text{kL}\end{aligned}$$

On a wet day:

$$\begin{aligned}\text{rainfall} + \text{runoff} &= 190,000\text{m} \times 216\text{mm} \times 0.8 \text{ rainfall in 24hr.} \\ &= 32,800\text{kL}\end{aligned}$$

$$\text{Reserve Airspace} = 490,000\text{kL.}$$

2.6 Domestic Consumption

Construction Phase: 95ML/year

Operating Phase: 25ML/year

Water balance is based on operating phase, when 25ML/year is equivalent to 80kL/day for a 7-day week, 45 weeks per year.

It is assumed that the domestic consumption comprises 10kL/day for watering of lawns and gardens on dry days, and 70kL/day will be transmitted to the sewage pond.

2.7 Sewage Disposal

Sludge will be disposed of adjacent to treatment plant. Liquid wastes (70kL/day) will be pumped to the tailings pond.

APPENDIX 7
GROUNDWATER QUALITY ANALYSES RESULTS

Simmonds & Bristow Pty. Ltd. (Inc. in Qld)

Analysts & Consultants to the Water Industry
 30 Shottery Street,
 Yeronga, Queensland,
 Australia, 4104.
 Telephone: (07) 848 7699.



TABLE 7.A

WATER ANALYSIS REPORT

MUNRO JOHNSON & ASSOCIATES
 ENSHAM COAL PROJECT

REF NO: 10148

REGD NO	SAMPLE DESCRIPTION	COLLECTED	RECEIVED	TESTED	
A: 38925/3 B: C: D:	COMPOSITE #1 TO #12 - SUPERNATANT	17-5-86	20-5-86	22-29/5	
S&B METHOD	PHYSICAL ANALYSIS	SAMPLE A	SAMPLE B	SAMPLE C	SAMPLE D
WP110. WP040. WP090.	Total Dissolved Salt (Calc'd) mg/L Conductivity @ 20°C uS/cm pH Value	417. 555. 7.80			
CHEMICAL ANALYSIS					
MAJOR ELEMENTS					
WC025.111	Calcium	as Ca	mg/L	8.	
WC055.111	Magnesium	as Mg	mg/L	9.	
WC090.111	Sodium	as Na	mg/L	108.	
WC075.111	Potassium	as K	mg/L	2.	
WC205.	Hydroxide	as OH	mg/L	<1.	
WC205.	Carbonate	as CO ₃	mg/L	<1.	
WC205.	Bicarbonate	as HCO ₃	mg/L	196.	
WC280.2	Sulphate	as SO ₄	mg/L	17.	
WC220.1	Chloride	as Cl	mg/L	77.	
CARBONATE EQUILIBRIUM					
WC205.	Hydroxide Alk'y	as CaCO ₃	mg/L	<1.	
WC205.	Carbonate Alk'y	as CaCO ₃	mg/L	1.	
WC205.	Bicarbonate Alk'y	as CaCO ₃	mg/L	161.	
WC205.	Total Alkalinity	as CaCO ₃	mg/L	162.	
WC215.	Free Carbon Dioxide	as CO ₂	mg/L	4.	
WP010.	pH _s at CaCO ₃ Sat'n @ 25°C	mg/L	8.35		
WC215.	Free CO ₂ at Sat'n	as CO ₂	mg/L	1.	
WC215.	Aggr. Carbon Dioxide	as CO ₂	mg/L	3.	
WC025.	Calcium Hardness	as CaCO ₃	mg/L	20.	
WC055.	Magnesium Hardness	as CaCO ₃	mg/L	38.	
WC247.	Total Hardness	as CaCO ₃	mg/L	58.	
SUM (ANIONS) - SUM (CATIONS):					
Actual		mEq/L	-0.13		
Acceptable +/-		mEq/L	0.20		
WP130.	Sodium Adsorption Ratio		8.		
WP105.	Residual Alkali	mEq/L	2.1		
WP055.	Irrigation Classification		Cl-S3		



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per.....
 Date.

John Johnson

GOMTER ASSOCIATES
ENVIRONMENTAL WATER QUALITY TESTING

SIMMONDS & BRISTOW P/L
30 SROTTERY ST., TERONGA, QLD 4104 Ph (07) 848 7699

WATER ANALYSIS REPORT

REF NO: 9398

REGD NO		SAMPLE DESCRIPTION		COLLECTED	RECEIVED	TESTED	
A:36616		G 1840 @ 1415		30-7-85	15-8-85	15/28-8-8	
B:36617		G 1840 PUMP TEST @ 71 HRS 0930		2-8-85	15-8-85	15/28-8	
C:				ALLUVIUM	ALLUVIUM		
D: -							
S&B METHOD		PHYSICAL ANALYSIS		SAMPLE A	SAMPLE B	SAMPLE C	SAMPLE D
WP030.		Colour:	Apparent	PtCoU	4.	3.	
			True (0.45um)	PtCoU	1.	<1.	
WP170.		Turbidity:	Raw	NTU	0.8	0.7	
			Filtered (20um)	NTU	0.8	0.6	
WP110.		Total Dissolved Salt (Calc'd)		mg/L	709.	782.	
WP040.		Conductivity @ 20°C		uS/cm	805.	890.	
WP090.		pH Value			7.25	7.45	
CHEMICAL ANALYSIS							
MAJOR ELEMENTS							
WC025.111		Calcium	as Ca	mg/L	29.	33.	
WC055.111		Magnesium	as Mg	mg/L	32.	36.	
WC090.111		Sodium	as Na	mg/L	125.	135.	
WC075.111		Potassium	as K	mg/L	<1.	1.	
WC205.		Hydroxide	as OH	mg/L	<1.	<1.	
WC205.		Carbonate	as CO ₃	mg/L	<1.	<1.	
WC205.		Bicarbonate	as HCO ₃	mg/L	438.	456.	
WC280.2		Sulphate	as SO ₄	mg/L	9.	11.	
WC220.1		Chloride	as Cl	mg/L	75.	110.	
MINOR ELEMENTS							
WC045.123		Iron: Total	as Fe	mg/L	0.13	0.21	
WC060.123		Manganese: Total	as Mn	mg/L	0.16	0.15	
WC250.23		Nitrate + Nitrite	as N	mg/L	0.01	0.02	
WC245.2		Fluoride	as F	mg/L	0.70	0.70	
WC275.5		Silica	as SiO ₂	mg/L	66.	65.	
CARBONATE EQUILIBRIUM							
WC205.		Hydroxide Alk'y	as CaCO ₃	mg/L	<1.	<1.	
WC205.		Carbonate Alk'y	as CaCO ₃	mg/L	<1.	2.	
WC205.		Bicarbonate Alk'y	as CaCO ₃	mg/L	359.	373.	
WC205.		Total Alkalinity	as CaCO ₃	mg/L	360.	375.	
WC215.		Free Carbon Dioxide	as CO ₂	mg/L	32.	21.	
WP010.		pH _s at CaCO ₃ Sat'n	@ 25°C	mg/L	7.45	7.40	
WC215.		Free CO ₂ at Sat'n	as CO ₂	mg/L	20.	23.	
WC215.		Aggr. Carbon Dioxide	as CO ₂	mg/L	13.	<1.	
WC025.		Calcium Hardness	as CaCO ₃	mg/L	73.	83.	
WC055.		Magnesium Hardness	as CaCO ₃	mg/L	133.	150.	
WC247.		Total Hardness	as CaCO ₃	mg/L	206.	233.	
SUM (ANIONS) - SUM (CATIONS):							
Actual				mEq/L	-0.04	0.32	
Acceptable +/-				mEq/L	0.25	0.27	
WP130.		Sodium Adsorption Ratio			5.	5.	
WP105.		Residual Alkali		mEq/L	3.1	2.9	
WP055.		Irrigation Classification			C2-S6	C2-S6	



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per
Date. 2.9.85

TABLE 7.B

A.Q.C. COAL SEAM WATER QUALITY

Sample	A.Q.C. PACIFIC BORE NO.							
	L1161R	R1481	R1484	C1504	C1505	R1508	R1510	R1523
pH	8.35	8.06	7.91	7.90	6.70	7.88	8.13	8.04
Acidity to pH 8.3	0.0	0.70	21.6	34.2	36.2	11.6	5.5	13.1
Alkalinity (mg/l) (as CaCO ₃)	315	443.8	573.8	621.9	578.0	417.5	248.8	416.3
Chloride (mg/l) (as Cl)	109	4313	6181	11193	11854	6742	4473	5161
Sulphate (mg/l) (as SO ₄)	83.1	276.5	431.5	852.6	913.5	708.6	288.9	365.4
Sodium (mg/l) (as Na)	140	2200	3100	6000	6250	3600	2250	2550
Potassium (mg/l) (as K)	2.3	18.0	22.3	37.0	43.0	43	19.3	21.8
Calcium (mg/l) (as Ca)	26	354	460	540	560	500	320	500
Magnesium (mg/l) (as Mg)	27	450	650	900	970	620	480	450
Filterable Residue (180°C) (mg/l)	376	7404	10410	18287	20120	11882	7702	9164
Non Filterable								
Residue (105°C) (mg/l)	69	2967	6327	10554	1902	11095	5294	587
Specific Conductance								
at 20°C (μS/cm)	9.0x10 ²	1.51x10 ⁴	1.5x10 ⁴	2.57x10 ⁴	2.67x10 ⁴	1.61x10 ⁴	1.17x10 ⁴	1.32x10 ⁴
Strontium (mg/l) (as Sr)	0.4	15	21	25	21	14	15	26

TABLE 7.B

A.Q.C. COAL SEAM WATER QUALITY

Sample		R1525	L1533	C1751	C1760	C1854	C1613	R1730
pH		8.35	8.06	8.10	8.33	8.33	7.95	8.33
Acidity to pH 8.3		0.0	0.70	14.9	-	-	11.9	-
Alkalinity (mg/l)	(as CaCO ₃)	315	443.8	166	188.3	220.5	173	135.5
Chloride (mg/l)	(as Cl)	109	4313	518.8	4243.9	2654.5	6115.1	1915
Sulphate (mg/l)	(as SO ₄)	83.1	276.5	123.5	238.8	49.4	572.9	224.6
Sodium (mg/l)	(as Na)	140	2200	860	810	780	820	730
Potassium (mg/l)	(as K)	2.3	18.0	24	21.5	17.5	40.0	10.0
Calcium (mg/l)	(as Ca)	26	354	395	135	89.5	370	98
Magnesium (mg/l)	(as Mg)	27	450	435	290	60	540	185
Filterable Residue (180°C) (mg/l)		376	7404	9190	7400	4886	10888	3925
Non Filterable								
Residue (105°C)	(mg/l)	69	2967	308	15350	84981	574	41283
Specific Conductance								
at 20°C	(μS/cm)	9.0x10 ²	1.51x10 ⁴	1.37x10 ⁴	1.21x10 ⁴	8.56x10 ³	1.61x10 ⁴	6.72x10 ³
Strontium (mg/l)	(as Sr)	0.4	15	16	7	11	7	1

G.S.Q. COAL SEAM WATER QUALITY

[illegible]

APPENDIX 8
SPECIES LISTS

TABLE 8.A
FLORA SPECIES LIST

Family	Scientific Name	Common Name
<u>Ferns</u>		
Marsileaceae	<u>Marsilea drummondii</u>	nardoo
<u>Gymnosperms</u>		
Cupressaceae	<u>Callitris columellaris</u>	white cypress pine
<u>Monocotyledons</u>		
Commelinaceae	<u>Commelina cyanea</u>	wandering sailor
Cyperaceae	<u>Cyperus bifax</u>	downs nutgrass
	<u>C. gunnii</u>	flecked flat sedge
	<u>C. gracilis</u>	
	<u>C. tuberosus</u>	
Orchidaceae	<u>Cymbidium canaliculatum</u>	black orchid
Poaceae	<u>Ancistrachne uncinulata</u>	hooky grass
	<u>Aristida benthamii</u>	Bentham's wire grass
	<u>A. calycina</u>	dark wire grass
	<u>A. caput-medusa</u>	many headed wire grass
	<u>A. contorta</u>	kerosene grass
	<u>A. jerichoensis</u>	jericho wire grass
	<u>A. latifolia</u>	feather top wire grass
	<u>A. leptopoda</u>	white speargrass
	<u>A. longicollis</u>	bull wire grass
	<u>A. ramosa</u>	purple wire grass
	<u>Astrebla lappacea</u>	curly mitchell grass
	<u>Bothriochloa bladhii</u>	forest blue grass
	<u>B. decipiens</u>	pitted blue grass
	<u>B. ewartiana</u>	desert blue grass
	<u>Calypochloa gracillina</u>	
	<u>Cenchrus ciliaris</u>	buffel grass
	<u>Chloris divaricata</u>	slender windmill grass
	<u>C. ventricosa</u>	tall windmill grass
	<u>Cymbopogon refractus</u>	barbed wire grass
	<u>Dactyloctenium radulans</u>	button grass
	<u>Dichanthium sericeum</u>	Queensland blue grass
	<u>Diplachne parviflora</u>	beetle grass
	<u>Echinochloa colonum</u>	awnless barnyard grass
	<u>Enneapogon lindleyanus</u>	nine awn
	<u>E. polyphyllus</u>	leafy nine awn
	<u>Enteropogon acicularis</u>	curly windmill grass
	<u>Eragrostis elongata</u>	clustered lovegrass
	<u>E. parviflora</u>	weeping love grass
	<u>E. sororia</u>	love grass
	<u>Eriachne mucronata</u>	mountain wanderrie grass
	<u>Hermanthria uncinata</u>	mat grass
	<u>Heteropogon contortus</u>	black or bunch spear grass
	<u>Leptochloa decipiens</u>	slender canegrass
	<u>L. digitata</u>	umbrella canegrass
	<u>L. neesii</u>	
	<u>Panicum larcomianum</u>	
	<u>P. maximum</u>	Guinea panic
	<u>Paspalidium caespitosum</u>	brigalow grass
	<u>P. distans</u>	
	<u>P. globoideum</u>	shot grass
	<u>P. jubiflorum</u>	Warrego summer grass
	<u>Pseudoraphis spinescens</u>	spiny mud grass
	<u>Rhynchelytrum repens</u>	red natal grass
	<u>Setaria verticellata</u>	whorled pigeon grass
	<u>Sorobolus actinocladus</u>	ray grass
	<u>Sporobolus caroli</u>	fairly grass
	<u>S. contiguous</u>	

TABLE 8.A (Cont'd)

FLORA SPECIES LIST

Family	Scientific Name	Common Name
	<u>S. diander</u>	tussocky sporobolus
	<u>Themeda triandra</u>	kangaroo grass
	<u>Tragus australianus</u>	small burr grass
	<u>Urochloa mosambicensis</u>	Sabi grass
Typhaceae	<u>Typha orientale</u>	cumbungi, bulrush
Xanthorrhoeaceae	<u>Lomandra longifolia</u>	spinyheaded matrush
<u>Dicotyledons</u>		
Amaranthaceae	<u>Alternanthera denticulata</u>	less joy weed
Apocynaceae	<u>Alstonia constricta</u>	quinine bush
	<u>Carissa ovata</u>	currant bush
	<u>Parsonia lanceolata</u>	
Asclepiadaceae	<u>Sarcostemma australe</u>	caustic vine
Asteraceae	<u>Helipterum</u>	paper daisy
Cactaceae	<u>Opuntia</u> sp.	prickly pear
Caesalpinaceae	<u>Cassia brewsteri</u>	Leichhardt bean
	<u>Cassia nemophila</u>	butterbush, desert cassia
	<u>Lysiphyllum carronii</u>	red Bauhinia
	<u>L. hooker</u>	white Bauhinia
	<u>Parkinsonia aculeata</u>	Jerusalem thorn
Casuarinaceae	<u>Casuarina cristata</u>	belah
	<u>C. cunninghamiana</u>	riveroak
Capparidaceae	<u>Apophyllum anomalum</u>	broombrush
	<u>Capparis canescens</u>	warrior brush, wild orange
	<u>Capparis lasiantha</u>	splitjack, nipan
	<u>Capparis lauranthifolia</u>	narrow leaf bumble
	<u>Capparis mitchellii</u>	native pomegranate
Celastraceae	<u>Denhamia oleaster</u>	
	<u>D. pittosporoides</u>	
Chenopodiaceae	<u>Maytenus cunninghamii</u>	yellow berry bush
	<u>Atriplex nummularia</u>	oldman saltbush
	<u>Einadia</u> sp.	
	<u>Enchylaena tomentosa</u>	ruby saltbush
	<u>Salsola kali</u>	blue bush, rolypoly
	<u>Sclerolaena birchii</u>	galvanised burr, blue burr
Combretaceae	<u>Terminalia oblongata</u>	yellowwood
Ebenaceae	<u>Diospyros ferea</u> var. <u>humilis</u>	ebony
Ehretiaceae	<u>Eretia membranifolia</u>	peach bush
Erythroxylaceae	<u>Erythroxylum australe</u>	
Euphorbiaceae	<u>Acalypha eremorum</u>	acalypha
	<u>Croton insularis</u>	
	<u>Croton phebaloides</u>	warrel
	<u>Petalostigma pubescens</u>	quinine berry
Fabaceae	<u>Hovea longipes</u>	
	<u>Indigophora</u> sp.	
Labiatae	<u>Plectranthus parviflorus</u>	
Loranthaceae	<u>Amyema maidenii</u>	pale leaf mistletoe
Malvaceae	<u>Abutilon tubulosum</u>	
	<u>Sida cordifolia</u>	
	<u>Sida</u> spp.	
Meliaceae	<u>Owenia acidula</u>	emu apple
Mimosaceae	<u>Acacia burrowii</u>	Burrow's wattle, currawong
	<u>A. excelsa</u>	ironwood
	<u>A. fasciculifera</u>	rosewood, scrub ironbark
	<u>A. harpophylla</u>	brigalow
	<u>A. leiocalyx</u>	early flowering black wattle
	<u>A. oswaldii</u>	nelia tree
	<u>A. salicina</u>	willow wattle, sally wattle
	<u>A. shirleyi</u>	lancewood
	<u>Archidendropsis basaltica</u>	dead fish
Moraceae	<u>Ficus coronata</u>	fig tree

TABLE 8.A (Cont'd)

FLORA SPECIES LIST

Family	Scientific Name	Common Name
Myoporaceae	<u>Eremophila mitchellii</u>	budda, false sandalwood
Myrtaceae	<u>Eucalyptus camaldulensis</u>	river red gum
	<u>E. cambageana</u>	blackbutt, Dawson gum
	<u>E. crebra</u>	narrow leaved ironbark
	<u>E. drepanophylla</u>	grey ironbark
	<u>E. melanophloia</u>	silver leaved ironbark
	<u>E. microtheca</u>	coolibah
	<u>E. papuana</u>	ghost or cabbage gum
	<u>E. peltata</u> spp. <u>leichhardtii</u>	Leichharts rusty jacket
	<u>E. polycarpa</u>	long fruited bloodwood
	<u>E. populnea</u>	poplar box, bimbale box
	<u>E. tereticornis</u>	blue gum, forest red gum
	<u>E. tessellaris</u>	Morton Bay ash, carbeen
	<u>E. thozetiana</u>	mountain yapunyah, Thozets box
	<u>Melaleuca bracteata</u>	black teatree
Oleaceae	<u>Jasminum lineare</u>	desert jasmine
	<u>Jasminum simplicifolium</u>	
Pittosporaceae	<u>Notolaea microcarpa</u>	
	<u>Bursaria incana</u>	blackthorn, box
	<u>Citriobatus spinescens</u>	
	<u>Pittosporum phylliraeoides</u>	weeping pittosporum, berrigan
Portulacaceae	<u>Portulaca oleracea</u>	common pigweed
Proteaceae	<u>Hakea fraseri</u>	bootlace oak
Rhamnaceae	<u>Alphitonia excelsa</u>	red ash, soap bush
	<u>Ventilago viminalis</u>	vinetree, supplejack
Rubiaceae	<u>Canthium oleifolium</u>	myrtle tree
	<u>Canthium vacciniifolium</u>	
	<u>Diplospora ixoroides</u>	
Rutaceae	<u>Eremocitrus glauca</u>	limebush, native cumquat
	<u>Flindersia dissosperma</u>	
	<u>Geijera parviflora</u>	wilga
Sapindaceae	<u>Alectryon connatus</u>	
	<u>Atalaya hemiglauca</u>	whitewood
	<u>Dodonaea stenophylla</u>	hop bush
	<u>D. viscosa</u> var <u>spatnolata</u>	
	<u>Heterodendrum diversifolium</u>	scrub boonaree
	<u>H. oleifolium</u>	rosewood, boonaree
Sterculiaceae	<u>Brachychiton rupestris</u>	narrow leaved bottle tree
Stylidiaceae	<u>Stylidium eglandulosum</u>	trigger plant
Tiliaceae	<u>Corchorus tomentellis</u>	
	<u>Grewia retusifolia</u>	
Vitaceae	<u>Cissus opaca</u>	

APPENDIX 8.B

BIRD SPECIES LIST

Family	Scientific Name	Common Name	Habitat*
Dromaiidae	<u>Dromaius novaehollandiae</u>	Emu	G
Podicipedidae	<u>Podiceps novaehollandiae</u>	Little grebe	D
Pelecanidae	<u>Pelecanus conspicillatus</u>	Pelican	D
Phalacrocoracidae	<u>Phalacrocorax sulcirostris</u>	Little black cormorant	D
Ardeidae	<u>Ardea novaehollandiae</u>	White-necked heron	D
"	<u>Egretta alba</u>	Large egret	D
"	<u>Nycticorax caledonicus</u>	Nankeen night-heron	D
Plataeidae	<u>Threskiornis spinicollis</u>	Straw-necked ibis	D/C
"	<u>Dendrocygna eytoni</u>	Grass whistling duck	D
Anatidae	<u>Anas superciliosa</u>	Black duck	D
"	<u>Anas gibberifrons</u>	Grey teal	D
"	<u>Malacorhynchus membranaceus</u>	Pink eared duck	D
"	<u>Aythya australis</u>	White eyed duck	D
Falconidae	<u>Falco berigara</u>	Brown Falcon	G
Phasianidae	<u>Coturnix pectoralis</u>	Stubble quail	C/G
Otididae	<u>Ardeotis australis</u>	Bustard (plain turkey)	C/G
Gruidae	<u>Grus rubicunda</u>	Brolga	C/D
Charadriidae	<u>Vanellus miles</u>	Masked plover	C/G
Columidae	<u>Geopelia placida</u>	Peaceful dove	C/G/W
"	<u>Ocyphaps lophotes</u>	Crested pigeon	C/G/W
"	<u>Phaps chalcopterus</u>	Common bronzewing	C/G/W
Cacatuidae	<u>Cacatua galerita</u>	Sulphur-crested cockatoo	W
Psittacidae	<u>Trichoglossus chlorolepidatus</u>	Scaly breasted lorikeet	W
"	<u>Aprosmictus erythropterus</u>	Red-winged parrot	W
"	<u>Nymphicus hollandicus</u>	Cockatiel	G/W
"	<u>Platycerus adscitus</u>	Pale headed rosella	G/W
Cuculidae	<u>Centropus phasianinus</u>	Pheasant coucal	G/W
Alcedinidae	<u>Dacelo gigas</u>	Kookaburra	W
ampephagidae	<u>Coracina novaehollandiae</u>	Black faced cookoo shrike	G/W
Muscicapidae	<u>Rhipidura leucophrys</u>	Willie wagtail	G/W
Timalidae	<u>Pomatostomus temporalis</u>	Grey crowned babbler	G/W
Muluridae	<u>Malurus lamberti</u>	Variegated wren	G
"	<u>Malurus melanocephalus</u>	Red-backed wren	G
Meliphagidae	<u>Manorina melanocephala</u>	Noisy miner	G/W
Corcoracidae	<u>Struthidea cinerea</u>	Apostle bird	G/W
Grallinidae	<u>Grallina cyanoleuca</u>	Mudlark	C/G/W
Cracticidae	<u>Cracticus torquatus</u>	Grey butcher bird	G/W
"	<u>Cracticus nigrogularis</u>	Pied butcher bird	G/W
"	<u>Gymnorhina tibicen</u>	Magpie	C/G/W
"	<u>Corvus orru</u>	Torresian crow	C/G/W

- * G = Grazing Land
D = Dam
C = Cultivated Land
W = Woodland

199200 c
5 September 1986

APPENDIX 9
DEMOGRAPHIC STATISTICS

TABLE 9.A

POPULATION FIGURES AND INTERCENSAL GROWTH RATES 1966 - 1986

Population and Growth Rates	Emerald	Emerald Shire	Fitzroy ¹ Statistical Division	Queensland
<u>1966</u>				
Population	2193	3504	-	1 663 685
<u>1971</u>				
Population	2923	5815	119 320	1 881 400
<u>1966 - 1971</u>				
Intercensal Growth Rate	5.9%	10.7%	-	2.5%
<u>1976</u>				
Population	3161	5950	129 970	2 092 400
<u>1971 - 1976</u>				
Intercensal Growth Rate	1.6%	0.5%	1.7%	2.2%
<u>1981</u>				
Population	4628	7940	145 520	2 345 200
<u>1976 - 1981</u>				
Intercensal Growth Rate	7.9%	5.9%	2.3%	2.3%
<u>1986</u>				
Population	5982	9462	158 471	2 587 315
<u>1981 - 1986</u>				
Intercensal Growth Rate	5.3%	3.6%	1.7%	2.0%

Source: Australian Bureau of Statistics

1 Prior to 1971 the Emerald Shire was in the Central Western Statistical Division.

TABLE 9.B

AGE AND SEX STRUCTURE STATISTICS 1976-1981

Age Last Birthday	Emerald								Emerald Shire								Queensland							
	1976				1981				1976				1981				1976				1981			
	♂%	♀%	Total	%	♂%	♀%	Total	%	♂%	♀%	Total	%	♂%	♀%	Total	%	♂%	♀%	Total (,000)	%	♂%	♀%	Total (,000)	%
0 - 4	52.6	47.4	363	11.5	54.9	45.1	488	10.5	55.3	44.7	597	9.9	52.8	47.2	762	9.0	51.0	49.0	187.2	9.1	51.4	48.6	180.4	7.9
5 - 9	49.0	51.0	288	9.1	52.0	48.0	448	9.7	50.6	49.4	539	9.0	51.3	48.7	798	9.5	51.4	48.6	192.9	9.5	51.2	48.8	202.0	8.8
10 - 14	48.1	51.9	318	10.1	50.3	49.7	384	8.3	49.8	50.2	552	9.2	49.6	50.4	770	9.1	51.3	48.7	191.8	9.4	51.2	48.8	205.0	8.9
15 - 19	45.6	44.4	375	11.9	51.1	48.9	458	9.9	55.5	44.5	645	10.7	54.7	45.3	730	8.7	51.2	48.8	183.7	9.0	50.9	49.1	198.4	8.7
20 - 24	53.2	46.8	327	10.3	55.0	45.0	578	12.5	57.2	42.8	526	8.7	55.0	45.0	806	9.6	51.0	49.0	165.5	8.1	51.1	48.9	198.7	8.7
25 - 29	59.6	40.4	275	8.6	59.2	40.8	534	11.5	56.1	43.9	503	8.4	58.0	42.0	786	9.3	50.9	49.1	164.3	8.0	50.9	49.1	183.1	8.0
30 - 34	57.8	42.2	204	6.5	54.2	45.8	402	8.7	58.5	41.5	410	6.8	53.3	46.7	709	8.4	51.0	49.0	137.7	8.8	50.9	49.1	182.1	7.9
35 - 39	47.2	52.8	248	7.8	57.6	42.4	311	6.7	51.0	49.0	443	7.4	55.1	44.9	597	7.1	51.1	48.9	117.4	5.8	51.4	48.6	151.6	6.6
40 - 44	55.4	44.6	186	5.9	55.6	44.4	286	6.2	54.9	45.1	339	5.6	57.1	42.9	511	6.1	51.4	48.6	103.8	5.1	51.7	48.3	124.5	5.4
45 - 49	51.2	48.8	174	5.5	54.3	45.7	188	4.1	59.5	40.5	351	5.8	54.3	45.7	383	4.5	51.4	48.6	108.5	5.3	51.4	48.6	108.5	4.7
50 - 54	56.2	43.8	130	4.1	56.3	43.7	167	3.6	58.3	41.7	326	5.4	61.9	38.1	388	4.6	50.9	49.1	107.7	5.2	50.8	49.2	113.6	5.0
55 - 59	65.9	34.1	88	2.8	54.5	45.5	121	2.6	62.0	38.0	250	4.1	54.0	46.0	394	4.7	49.3	50.7	95.1	4.7	50.1	49.9	112.1	4.9
60 - 64	46.1	53.9	76	2.4	56.3	43.7	87	1.9	52.4	47.6	233	3.9	54.9	45.1	308	3.7	48.3	51.7	89.2	4.4	48.3	51.7	100.2	4.4
≥65	52.2	47.8	111	3.5	45.4	54.6	174	3.8	59.7	40.3	310	5.2	59.0	41.0	493	5.8	44.5	55.5	192.3	9.4	44.1	55.9	235.1	10.2
TOTAL	52.0	48.0	3161	100.0	54.2	45.8	4628	100.0	55.3	44.7	6024	100.0	54.7	45.3	8435	100.0	50.3	49.7	2037.2	100.0	50.3	49.7	2295.1	100.0

TABLE 9.C

POPULATION STATISTICS 1976 - 1981

Statistical Parameter	Emerald			Emerald Shire			Queensland		
	1976	1981	1986	1976	1981	1986	1976	1981	1986
<u>Marital Status</u>									
Married	44.9%	42.4%	40.2%	46.1%	45.1%	42.3%	45.5%	44.9%	44.1%
Never Married	19.4%	22.0%	23.7%	20.1%	19.9%	22.9%	18.0%	19.8%	21.3%
Separated, Widowed & Divorced	5.1%	7.1%	7.4%	5.8%	7.4%	8.5%	8.5%	9.8%	10.6%
Usual Residence Since Last Census	37.9% (1971-76)	26.6% (1976-81)	27.7% (1981-86)	37.7% (1971-76)	31.8% (1976-81)	31.6% (1981-86)	47.7% (1971-76)	47.6% (1976-81)	43.1% (1981-86)
<u>Nationality</u>									
Australian ¹	82.8%	90.0%	91.5%	89.4%	87.4%	88.4%	86.9%	84.2%	83.6%
United Kingdom ²	39.5%	37.3%	31.1%	37.2%	38.2%	29.8%	50.9%	44.5%	35.7%
New Zealand ²	12.2%	22.8%	22.6%	13.0%	19.8%	18.9%	6.7%	14.6%	14.4%
Germany ²	1.3%	3.4%	2.6%	5.9%	5.7%	5.2%	4.1%	3.9%	3.7%
Italy ²	1.3%	2.6%	2.4%	1.0%	1.4%	1.3%	7.1%	5.4%	4.1%
United States ²	8.8%	5.5%	3.7%	9.1%	3.6%	3.6%	1.9%	1.6%	1.7%

Source: Australian Bureau of Statistics

1 % of Total Population

2 % of Total Overseas Born Population

TABLE 9.D
FAMILY INCOME 1981-1986

	Emerald	Emerald Shire	Queensland
<u>1981</u>			
≤ \$10 000 p.a.	21.4%	36.4%	39.3%
> \$22 000 p.a.	21.3%	13.6%	14.9%
<u>1986</u>			
≤ \$18 000 p.a.	21.0%	33.3%	33.6%
> \$40 000 p.a.	20.3%	19.2%	17.2%

Source: Australian Bureau of Statistics

TABLE 9.E

EMPLOYMENT STATISTICS 1976 - 1981

Statistical Parameter	Emerald			Emerald Shire			Queensland		
	1976	1981	1986	1976	1981	1986	1976	1981	1986
<u>Labour Force</u>									
% Population in Labour Force	49.2%	51.2%	47.9%	46.4%	45.9%	42.8%	43.1%	44.1%	39.8%
% Labour Force Unemployed	2.1%	3.5%	6.0%	3.0%	5.2%	10.4%	4.6%	6.0%	11.1%
<u>Workforce Marital Status</u>									
Married	66.4%	56.0%	55.3%	65.4%	58.5%	55.3%	64.8%	60.0%	58.1%
Never Married	28.5%	36.3%	36.5%	29.0%	33.3%	35.9%	28.5%	32.1%	32.9%
Separated, Widowed & Divorced	5.1%	7.7%	8.1%	5.5%	8.2%	8.8%	6.6%	8.0%	9.0%
<u>Employment in Industry Sectors</u>									
Australian Government	5.7%	3.3%	3.6%	3.9%	3.1%	3.2%	6.5%	6.4%	6.6%
State Government	28.2%	22.9%	27.0%	23.6%	20.4%	24.9%	16.0%	15.1%	15.9%
Local Government	3.0%	2.7%	2.0%	2.3%	2.2%	1.9%	2.8%	2.4%	2.6%
Non Government	63.2%	71.0%	67.4%	70.2%	74.3%	70.1%	74.8%	76.1%	74.9%

Source: Australian Bureau of Statistics

TABLE 9.F

EMPLOYMENT BY INDUSTRY AND OCCUPATION GROUPINGS - 1981

Employment		Emerald			Emerald Shire			Queensland		
		Male (% of sector)	Female (% of sector)	Persons (% of workforce)	Male (% of sector)	Female (% of sector)	Persons (% of workforce)	Male (% of sector)	Female (% of sector)	Persons (% of workforce)
Occupation	Agriculture	79.1	20.9	4.1	75.3	24.7	14.0	73.8	16.2	8.1
	Mining	95.7	4.3	11.3	90.1	9.9	11.8	91.5	8.5	2.0
	Manufacturing	77.4	22.6	4.6	77.7	22.3	4.8	79.7	20.3	13.0
	Utilities	92.2	7.8	2.2	91.0	9.0	2.1	89.3	10.7	1.6
	Construction	93.4	6.6	7.3	91.5	8.5	6.1	88.7	11.3	7.5
	Wholesale & Retail	62.2	37.8	21.6	60.6	39.4	16.8	58.2	41.8	18.4
	Transport & Storage	94.9	5.1	12.0	94.8	5.2	10.5	86.4	13.6	6.1
	Communications	87.8	12.2	1.8	81.7	18.3	1.6	75.5	24.5	2.2
	Finance etc.	57.0	43.0	5.4	56.2	43.8	3.9	55.6	44.4	7.9
	Pub. Admin., Defence etc.	84.2	15.8	4.2	82.4	17.6	3.4	77.8	22.2	5.7
	Community Service	33.8	66.2	8.9	38.0	62.0	8.4	37.6	62.4	13.8
	Entertainment & Recreation	30.0	70.0	6.9	31.7	68.3	5.5	41.7	58.3	5.5
	Other	52.7	47.3	9.8	49.5	50.5	11.0	51.3	48.7	8.2
	TOTAL	69.6	30.4	100.0	69.3	30.7	100.0	64.5	35.5	100.0
Industry	Professional & Technical	61.0	39.0	8.1	60.6	39.4	7.2	52.0	48.0	11.6
	Admin & Executive	90.0	10.0	4.8	83.5	16.5	3.8	84.8	15.2	4.9
	Clerical	31.7	68.3	13.8	30.6	69.4	10.5	31.0	69.0	15.9
	Sales	55.8	44.2	10.1	53.5	46.5	7.8	49.8	50.2	9.4
	Farmers, Fishermen etc.	84.8	15.2	4.0	77.6	22.4	13.9	76.8	23.2	8.3
	Miners etc.	100.0	0	2.3	83.9	16.1	5.1	98.2	1.8	0.8
	Transport & Communications	96.3	3.7	9.5	92.9	7.1	7.6	87.8	12.2	5.4
	Tradesmen & Labourers	96.3	3.7	29.3	95.0	5.0	26.5	92.5	7.5	27.1
	Service, Sport & Recreation	28.4	71.6	8.9	29.6	70.4	7.3	38.1	61.9	8.5
	Armed Forces	50.0	50.0	0.2	100.0	0	0.1	94.9	5.1	1.4
	Other	50.5	49.5	9.0	47.6	52.4	10.1	46.3	53.7	6.8
	TOTAL	69.5	30.5	100.0	69.3	30.7	100.0	64.5	35.5	100.0

Source: Australian Bureau of Statistics

TABLE 9.G

EMPLOYMENT BY INDUSTRY AND OCCUPATION GROUPINGS - 1986

	Emerald			Emerald Shire			Queensland		
	No.	% Pop.	% Males	No.	% Pop.	% Males	No. (,000)	% Pop.	% Males
<u>Occupation</u>									
Managers & Administrators	232	8.1	75.4	634	15.7	71.8	128	12.4	73.4
Professionals	257	9.0	61.1	311	7.7	60.1	102	9.9	59.8
Para-Professionals	164	5.7	76.2	195	4.8	73.3	64	6.2	59.3
Tradespersons	510	17.8	91.0	622	15.4	89.9	162	15.7	90.1
Clerks	365	12.8	27.4	451	11.1	25.3	165	16.0	26.7
Sales & Personal Services	367	12.8	36.2	452	11.2	36.5	136	13.2	39.0
Plant & Machine Operators	422	14.7	96.4	546	13.5	96.5	84	8.2	89.3
Labourers & Related Workers	488	17.1	73.6	757	18.7	76.5	162	15.7	67.9
Other	30	1.0	93.3	47	1.2	72.3	14	1.4	71.4
Total	2862	100.0	68.7	4049	100.0	68.7	1029	100.0	61.9
<u>Industry</u>									
Agriculture, Forestry, Fishing & Hunting	107	3.7	75.7	555	13.7	73.0	79	7.7	69.6
Mining	344	12.0	91.5	428	10.6	91.4	21	2.0	90.5
Manufacturing	116	4.1	73.3	165	4.1	75.8	120	11.7	76.7
Electricity, Gas, Water	63	2.2	92.1	72	1.8	91.7	16	1.6	87.5
Construction	215	7.5	87.4	280	6.9	88.6	75	7.3	86.7
Wholesale & Retail Trade	571	20.0	56.7	676	16.7	55.0	205	19.9	55.6
Transport & Storage	437	15.3	91.5	581	14.3	91.6	64	6.2	84.4
Communication	62	2.2	83.9	72	1.8	81.9	23	2.3	73.9
Finance, Property & Business Services	196	6.8	55.1	231	5.7	52.4	92	8.9	53.3
Public Administration, Defence	78	2.7	70.5	111	2.7	67.6	62	6.0	72.6
Community Services	375	13.1	40.5	489	12.1	41.5	169	16.4	36.1
Recreational, Personal, Other Services	206	7.2	31.6	264	6.5	33.0	68	6.6	44.1
Other	30	1.0	93.3	36	0.9	91.7	9	0.9	66.7
Total	2 862	100.0	68.7	4050	100.0	68.7	1029	100.0	61.9

APPENDIX 10
STUDY GUIDELINES

GUIDELINES FOR IMPACT ASSESSMENT STUDY

ENSHAM COAL PROJECT

PREMIER'S DEPARTMENT

SEPT 1985

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GUIDELINES FOR IMPACT ASSESSMENT STUDY

ENSHAM COAL PROJECT

PART A - GENERAL REQUIREMENTS

1. INTRODUCTION

In February, 1984 the Queensland Department of Mines issued Authority to Prospect 426C to a consortium of seven companies to prospect for coal within the Bowen Basin in Central Queensland near the towns of Emerald and Blackwater.

The Company, A.Q.C. - Pacific Pty. Ltd. has been set up to manage the project and in February, 1985 it submitted an outline of the project in a report titled "Ensham Coal Project - Preliminary Environmental Advice".

These Guidelines for an impact assessment study of the proposed development have been prepared from advice obtained from Advisory Bodies based on the project outline provided by the Company.

The Company shall prepare an impact assessment study report setting out the beneficial and adverse impacts of the proposed project together with any actions proposed by the Company to mitigate the adverse impacts. In particular the report shall cover the items set down in Part B although the report need not necessarily follow the same format.

Data shall be sufficient to enable the State Government and local bodies to determine accurately the likely impact, both direct and indirect, of the proposed project.

Where appropriate, use may be made of information provided by impact studies of other projects or by reports concerning specific matters referred to in the Guidelines, but the source should be acknowledged clearly. In areas where relevant information has not been compiled already, appropriate investigation should be undertaken.

2. ADDITIONAL INFORMATION

The State Government or a local body from which the Company requires approvals shall retain the prerogative to request additional information upon any matter not adequately dealt with in the report.

Should the Company require any information in the report to remain confidential, this should be clearly indicated.

3. COPIES OF REPORT

The Company shall provide forty copies of the impact assessment study report to the Co-ordinator-General, for distribution to State Government departments, local bodies and other relevant organizations.

4. USE OF CONSULTANTS

The Company should, where possible, make use of expertise available within Queensland in the preparation of material for the report on the impact of the proposed project.

GUIDELINES FOR IMPACT ASSESSMENT STUDY

ENSHAM COAL PROJECT

PART B - REPORT SCOPE

1.0 EXISTING ENVIRONMENT

1.1 Natural Environment

1.1.1 Climate and Meteorology

Provide details on the following:

- (a) Wind speed and direction presented as average annual, seasonal, and monthly wind roses and tables.
- (b) Diurnal wind speed and direction on a monthly basis.
- (c) Mixing heights and ambient temperatures on a twenty-four by one hour basis to show typical daily variations for each of the four seasons.
- (d) Data on rainfall, humidity, insolation, and fog conditions (where applicable).

Ideally, field data should be presented for a minimum one year period and Bureau of Meteorology data for a minimum of five years.

1.1.2 Terrain

Provide details on the following:

- (a) Topography - Describe the area in terms of landform and slopes with reference to a contour map at a suitable scale.
- (b) Geology - Describe and map the geology of the area with particular reference to physical and chemical properties of materials which may influence the rehabilitation programme or the quality of waste water leaving the proposed lease area.
- (c) Soils - Prepare a soils map at suitable scale and comment on the physical and chemical properties of the soil types that may render a soil layer either useful or hazardous to a rehabilitation programme. Factors of salinity and sodicity and erodibility must be specifically addressed. Soils suitable for removal and replacement in the rehabilitation programme should be identified and their distribution shown.
- (d) Identify areas susceptible to water or wind erosion under current land use and assess the stability of the banks of the Nogoa River.

1.1.3 ✓ Flora

- (a) Identify any species of economic importance.
- (b) Identify rare or endangered species.
- (c) Undertake a botanical survey of the proposed lease area and produce a vegetation map at a suitable scale.
- (d) Describe the units mapped, and where appropriate, estimate the populations of significant species within the map units. The description should contain an estimate of the degree of which the vegetation is regionally or nationally significant.

1.1.4 ✓ Terrestrial Fauna

- (a) Identify permanent and migratory species, native and exotic species, and rare or endangered species.
- (b) Describe the populations on the proposed lease area and their significance to National Park, public, scientific or historical purposes.
- (c) Discuss the sensitivity of the ecosystem.

1.1.5 Surface Waters

Describe the surface water quality and quantity in the region of the project with an outline of the significance of these waters to the river catchment system in which they occur. In particular:

- (a) Describe existing surface drainage patterns, flows, likelihood of flooding and present water uses including a summary of the magnitude and type of water use along the Nogoa-Mackenzie Rivers from Fairbairn Dam to Bingegang Weir.
- (b) Assess existing water quality in surface waters likely to be affected by the proposed development. The basis for this assessment should be a monitoring programme, consisting of a number of surveys which are representative of both dry and wet season conditions. The programme should include an adequate number of storm events, with sampling stations located upstream and downstream of the proposed lease area, and should be designed to enable adequate description of water quality throughout both rising and falling stages of streamflows. Complementary streamflow data should also be obtained to aid in interpretation. Details of the proposed programme should be discussed with the Director of Water Quality before commencing.

1.1.6 Groundwater

Review the quantity, quality and significance of groundwater that will be disturbed during the development, operation and abandonment of the proposed mine.

- (a) Prepare maps, text, cross-sections where appropriate to describe the physical and chemical parameters of the groundwater resource.
- (b) Detail local groundwater use characteristics including projected demand and identify recharge areas especially where these lie inside of or within one kilometre of the mine site area.

The review should include a determination of the design of a network of observation points which would monitor satisfactorily the groundwater resources before, during and after the commencement of operations. Data pursuant to these surveys and monitoring program should include depth, water bed, intervals, standing water level below natural surface, pump inlet level, normal pumping rate, drawdown at normal pumping rate, elapsed time to achieve drawdown quoted, pump type, strata log, registered number of facility or description of location (real property, co-ordinates etc.).

The data should be such to enable specification of the major ionic species present in the groundwaters. Determination of Sodium, Potassium, Calcium, Magnesium, Iron (total), Manganese (total), Chloride, Bicarbonate, Carbonate, Sulphate, Nitrate (total) and Fluoride are required, together with Total Dissolved Salts (sum of all ions), Hardness, Alkalinity, pH, Silica, Residual Alkalinity, Sodium Absorption Ration, Electrical Conductivity @ 25°C and Radionuclides. If Total Dissolved Solids is quoted the method of calculation or determination should be stated. Analytical methods should be briefly outlined.

1.1.7 Air Quality

- (a) Describe the existing local air quality with respect to pollutants to be emitted from the proposed plant.
- (b) Identify the location of and distance to existing and proposed future habitable buildings in and around the proposed mine lease and works area.

1.1.8 Acoustic Environment

A comprehensive description should be given of the existing noise climate at the proposed development site. Key monitoring sites should be located at the site boundary and near noise-sensitive areas, e.g. at site of existing and proposed residences likely to be affected.

Noise level measurements are required in terms of L_{10} , L_{90} and L_{50} and should be taken during the day and night over periods of 30 minutes duration. Major sources of ambient noise should be stated.

1.1.9 Land Use

Describe the location and owner/custodian of all tenures, reserves, roads, and the like, over and around the project area along with a description of the actual use to which the areas are allocated or have been used historically. Particular attention should be paid to any existing dwellings, their associated developments and the zoning of all adjacent lands according to any existing town plan.

1.1.10 Land Capability

Develop a land capability map at a suitable scale setting out the potential land use of the area based on the existing soil and water resources.

1.2 Physical Infrastructure

Describe the existing physical infrastructure in the region with particular reference to:

- (a) Rail
- (b) Port and Shipping
- (c) Roads
- (d) Air Facilities
- (e) Power Supply
- (f) Local Authority Infrastructure - including water supply, stormwater drainage, sewerage, solid waste.

1.3 Socio-Economic Environment

1.3.1 Demography

- (a) Provide figures on the age and sex distribution of the township population in which it is proposed to house the project workforce.
- (b) Provide figures for the age and sex distribution for the region.

1.3.2 Workforce and Employment

Provide details on employment levels and on the occupational structure of the labour force for both the township in which it is proposed to house the project workforce and the region generally.

1.3.3 Housing and Accommodation

Detail the availability of developed land and housing for purchase or rental together with other forms of accommodation in the township in which it is proposed to house the project workforce.

1.3.4 Commercial and Industrial Structure

Overview the commercial and industrial structure of the township in which it is proposed to house the project workforce.

1.3.5 Government/Community Services and Facilities

For the township in which it is proposed to house the project workforce provide details on the following facilities:

- (a) Health/Medical
- (b) Educational
- (c) Welfare
- (d) Recreational
- (e) Social
- (f) Cultural

1.3.6 Archaeology

No archaeological survey has been specifically undertaken for the proposed lease area. To the immediate north of the proposed lease area there exists a major art region including engravings, hand stencils and other forms of rock art, and to the south-east of the proposed lease area there are large numbers of artifact scatters.

An initial archaeological survey shall be undertaken by the Company to determine potential impacts, following which, determination can be made as to any mitigation or conservation measures necessary.

The Company should contact the Department of Community Services concerning the survey and appointment of a consulting archaeologist.

2.0 PROPOSED DEVELOPMENT

2.1 Mine

Provide information on the following matters:

2.1.1 General

- (a) Mine location, extent and nature.
- (b) Times at which various stages will be completed.
- (c) Quantity and quality of coal to be mined.

2.1.2 Mining Method

- (a) Method of working and times of operation.
- (b) Equipment to be used.
- (c) Extent of excavations to be left following mining and areas disturbed at each stage of development.

2.1.3 Overburden Disposal

- (a) The location and expected final contours of waste dumps and method of construction.
- (b) The physical and chemical nature of the waste material.
- (c) The location and dimensions of any waste dump runoff ponds.
- (d) Erosion control measures to ensure stability of the dumps and dams.

2.1.4 Rehabilitation

Proposals to rehabilitate waste dumps including revegetation, recreation of the soil profile and restoration of the land mass.

2.1.5 Mine Industrial Area

- (a) Services and facilities for operating the mine and maintaining equipment.
- (b) Proposals for disposal of all wastes generated including any contaminated runoff.

2.1.6 Waste Water Management

- (a) The likely quantity and quality of seepage, direct precipitation and stormwater runoff to be pumped from the pit and methods of minimising and disposing of this water. Relevant quality characteristics may include salinity, non-filtrable residue, chloride, sulphate, phenols, pH, alkalinity, dissolved oxygen, temperature, turbidity, nitrogen compounds, heavy metals and major cations.

The effects of disturbed land areas (including haul roads) on the quality of surface runoff should be examined, and ways of minimising contamination proposed. Quantities of runoff under different weather conditions (including extremes of wet weather) should be investigated, together with means of minimising the quantities of contaminated runoff requiring disposal.

Intended methods for disposal and rehabilitation of overburden should be described, together with proposals for minimising the impacts of these operations by way of erosion and leaching.

If evaporation ponds or long term storages for wastes are proposed, their behaviour under extremes of climatic conditions should be predicted.

- (b) The wastes liable to be produced as a result of coal handling (crushing, screening, preparation, blending, etc.) - including quantity and quality aspects. Wash-down and maintenance of conveyors and other handling equipment should be covered in the discussion. The report should include details of methods intended to be used for collection and disposal of drainage from coal and reject stockpiles - including any treatment considered necessary. Means of minimising the escape of spillages to surface waters should be proposed.

All sources of waste from any proposed coal preparation plant should be evaluated and methods of treatment and disposal discussed. An estimated water and solids balance around the plant should be provided, showing how the water requirement and raw materials input are expected to be accounted for in product, by-products (if any) and wastes. If settling ponds or other storages which would collect rainfall are to be used their performance over a wide climatic range should be forecast.

- (c) Equipment servicing and storage arrangements for fuels and oils and proposals for treatment and disposal of wastes. Means of preventing accidental escape of oils, fuels, chemicals etc., to surface waters should be discussed.

The report should discuss the disposal of other industrial liquid and solid wastes as well as the treatment and disposal of sewage and domestic refuse.

- (d) In addition to material balances for any proposed coal washing plant, the report should provide estimated overall water balances for the site, taking account not only of water obtained by artificial means such as pumping, but also of rainfall, and losses by evaporation and percolation. Realistic ranges of values, and of annual rainfall patterns, should be examined.

Wastes which may need to be considered would include:-

- . Runoff from haul roads, industrial infrastructure area, other disturbed areas.
 - . Drainage (i.e. runoff plus any seepages or leachate) from dumps or stockpiles.
 - . Seepages from tailings dams or similar areas.
 - . Domestic sewage.
 - . Water treatment plant backwash and sludge.
 - . Mine pit water - groundwater, runoff, direct precipitation.
- (e) Principles proposed to be used in hydrological design of any dams and other structures intended for collection or containment of wastes on site, in connection with the water management and/or water pollution control systems proposed.
- (f) The need or otherwise for each discharge to be licensed under the Clean Waters Act should be discussed.

2.2 Physical Infrastructure

2.2.1 Railways

Provide the following information:

- (a) A complete description of all new rail facilities required as well as existing facilities that may need to be upgraded as a result of the project during both the construction and operational stages. Of specific interest are the type and location of all road/rail intersections.
- (b) The anticipated number of train movements and the rollingstock required for the project.

2.2.2 Port and Shipping

The Company has indicated it proposes to export coal through either the Clinton coal facility at Gladstone or through the Dalrymple Bay Coal Terminal. For the chosen export point the following matters shall be addressed:

- (a) Planned staged throughput, including details of potential annual export tonnage and possible ports and countries of destination.
- (b) Estimated ship size.

- (c) Reasons for selection of proposed facility export terminal and port.
- (d) Requirement for area and tonnage of stockpile and marketable dimension of coal size and any specific handling requirement.
- (e) Rail access and capacity including that of unloading station.
- (f) Plan of port showing area to be allotted for Company's stockpile.
- (g) Provision of additional infrastructure items:
 - (i) general terminal usage;
 - (ii) particular to Company's operations.

2.2.3 Roads

Provide details on:

- (a) Proposed routes, volumes of traffic and loadings associated with transportation of construction equipment and other items to construction sites of various parts of the project.
- (b) Estimates of the volume and composition of traffic generated on existing roads through the construction and operation of the mine, township, railway, etc.
- (c) Proposed locations, standards, etc. of proposed new roads, connections to existing roads, upgrading of existing roads, etc.
- (d) Details of proposed movements of any extra heavy loads, together with details of intended haul routes.

2.2.4 Air Facilities

The report shall discuss the anticipated usage of air transport services and describe any proposals for upgrading existing facilities or constructing new facilities.

2.2.5 Power Supply

For the mine site provide details of:

- (a) Power demand and annual energy consumption.
- (b) Maximum instantaneous power demand.
- (c) Minimum instantaneous power demand or maximum instantaneous power regeneration as appropriate.

- (d) Maximum and average levels of harmonic current generation.
- (e) Maximum and average phase imbalance.
- (f) Details of any on-site generation plant.
- (g) Power requirements during mine construction.
- (h) Proposed source of supply.

For the power line provide details of:-

- (a) Route.
- (b) Line capacity.
- (c) Connections to existing system and any improvements to supply.
- (d) Possible benefits to existing properties.

2.2.6 Water Supply

Provide details on:

- (a) Water requirements of the project together with a description of sources of supply, intake works and pipelines and any proposed use of groundwater.
- (b) A description of dams to be constructed including the type of construction, storage capacity and size of structure with a discussion on the need or otherwise for licensing of any dams as referable dams under the Water Act.

2.3 Project Workforce, Population and Housing

2.3.1 Construction Workforce

Details shall be provided on the number of workers to be employed on construction of the project by:

- (a) Identified stage of project development.
- (b) Quarterly time intervals (if possible).
- (c) Occupational groupings as follows:
 - . professional and managerial
Engineers
Others
 - . semi-professional
(inc. technicians, draftsmen etc.)

- . skilled trades
 - Metal/Engineering
 - Electrical and Instrumentation
 - Building
 - Apprentices
- . semi-skilled and unskilled
 - Plant and Equipment Operators
 - Others.

2.3.2 Operational Workforce

The number to be employed should be identified on an annual basis for the period to full development of the project for the same occupational groupings specified in 2.3.1 above.

2.3.3 Housing

Provide details of Company proposals to finance, subsidize or arrange accommodation for the workforce required to construct and operate the project including:

- (a) the standard of accommodation i.e. houses, hostels, caravan parks, existing houses, private boarding;
- (b) numbers and type of workers to be housed in the different forms of accommodation;
- (c) timing for the provision of accommodation;
- (d) location of accommodation;
- (e) provision of services to temporary construction housing;
- (f) arrangements for removal of temporary construction housing.

3.0 ENVIRONMENTAL IMPACTS AND PROPOSED CONTROL MEASURES

3.1 Natural Environment

3.1.1 Rehabilitation and Land Use

- (a) All potential erosion hazard areas created during construction and operation phases should be defined, mapped and proposals for their control outlined.
- (b) A description and projected contour map is required illustrating the proposed reinstated landform and drainage system for the disturbed areas after completion of the proposed mining operations.

- (c) Describe potential post-mining land use options including the limiting factors to the establishment of potential land uses and the selection and implementation of a preferred option. Detail the rehabilitation technique proposed to achieve and maintain the preferred option.
- (d) Detail suitable top soil storage areas and rehabilitation techniques proposed to seal off hostile subsoil and recreate a suitable soil profile to achieve and maintain the preferred land use. Soil conservation measures to protect the proposed land uses should be designed and located. The reinstatement of the Nogoia River channel, banks and flood plain should receive detailed attention.
- (e) Discuss the impact of the proposed development on land use outside the proposed lease area through the movement of pollutants into the Nogoia River and change of flows in the river. In particular the impact of water withdrawal from the Nogoia River on the water supplies available for irrigation of crop land both in the Emerald Irrigation Area and for riparian usage.
- (f) Discuss the impact of changes in land use within the proposed lease area on existing district infrastructure, for example cotton processing and roads to railheads.

3.1.2 Groundwater

Assess the impact of the proposed development on the groundwater hydrology and water quality of these resources with particular reference to the use of these waters for irrigation, and the impact of mine dewatering and project generated pollution on the resources.

3.1.3 Surface Water

- (a) Discuss the effects which any discharges resulting from the development are likely to have upon the flow (or quantity) and the quality of surface waters, with particular reference to their suitability for both current and likely future beneficial uses. Quality characteristics discussed should be those appropriate to the water uses, but should include at least Non-Filtrable residue, turbidity, Filtrable residue (or electrical conductivity), pH, phenols, alkalinity, heavy metals, nitrogen compounds and major cations.
- (b) Examine the impact of any stream diversion works on water quality and quantity particularly in the Nogoia River, and propose means of minimising this impact. Mining adjacent to the river bed should be given special attention.

- (c) Analyse the effects that any stream diversion or obstruction in the flood plain might have on:
- . flooding of riparian holdings upstream and downstream of the proposed lease.
 - . flooding of Emerald Irrigation Area farms upstream of the proposed lease.
 - . interference with supplies to riparian holdings downstream of the proposed lease.
- (d) Discuss the consequences of an extreme flood event in the Nogoa River during the period of excavation and the proposed safeguards against such an event such as the structural integrity of containing walls and erosion control structures.

It should be noted that approval is necessary for any diversion works that cause significant changes to drainage patterns or alter the bed and banks of any watercourse. For the case of the diversion of the Nogoa River, a detailed study of the effects of the river diversion would be necessary before consideration could be given to approving the diversion and it is likely that proposed diversion would be the subject of an inquiry under Section 73A of the Water Act.

In order to assess the effects of the development after commissioning, an on-going water quality monitoring programme should be proposed, aimed at providing a basis for comparison with the pre-development conditions and confirming impact assessments. This should include monitoring of not only surface waters but also the wastes (including runoff): in the case of wastes, quantities should be monitored as well as quality.

3.1.4 Air Quality

- (a) Information should be submitted on the projected generation of any fumes, odours or particulates including where appropriate, their projected concentrations and effects in adjacent areas as well as on the area for which application has been made and all measures and techniques proposed to avoid, eliminate or control such emissions. Matters of particular concern include generation of dust from clearing operations, overburden handling, blasting, vehicular movement, and stockpiled topsoil or overburden. Refer to coal dust suppression during rail transfer, at the coal receival area, and coal handling at the export terminal. Consideration should be given to the construction and operational stages of the development. For each emission source, indicate the mass emission rate, volumetric flow rate, temperature and, where applicable, proposed stack height and exit diameter.

- (b) Predict maximum one hour, 24 hour, monthly and annual average ground level pollutant concentrations downwind of the plant for various stability categories, wind speeds, and wind directions. Predictions are required for normal and atypical plant operating conditions and worst case meteorological conditions. The model used in predicting ground level concentrations should be fully described and the sensitivity of the model to variations in the input parameters should be analysed.
- (c) Describe the monitoring programme to be established by plant management for the detection of pollutants at the source and in the ambient air, and meteorological conditions. (Monitoring should commence at least twelve months prior to start-up.) Distinguish between monitoring performed before and after start-up and include a description of the monitoring programme to be employed at the port facility.

3.1.5 Acoustic Environment

- (a) Predictions of noise at key monitoring sites from construction and operating activities at the site should be given in terms of L_{10} , L_{90} and L_{eq} . A list of major noise sources with their noise levels anticipated times of operation, frequency of occurrence and tonal components (if any) would be of value. Details of proposed noise control measures such as enclosures, barriers and mufflers should be stated. Predictions are required of noise levels in any noise-sensitive areas resulting from road traffic associated with site operations.
- (b) Assess the impact of the predicted noise levels in any residential areas near the site and along selected traffic routes. A justification for the choice of access routes on noise grounds would be valuable. Proposed residential areas associated with the project should also be included in the impact statement and any proposals to establish and maintain good public relations with nearby communities should be given. If the amenity of any community is to be seriously impaired, the Company should give serious consideration to compensating affected residents.

3.1.6 Flora and Fauna

The likely effects of the project on terrestrial and freshwater flora and fauna should be assessed and proposed mitigating measures set out. Particular attention should be given to:

- (a) the effects of clearing on vegetation distribution, fauna habitat distribution, regional significance of vegetation types and rare and endangered species for various aspects of the project;
- (b) rehabilitation/revegetation proposals;
- (c) the possible effects of dust and coal debris;
- (d) process plant and leachate discharge;
- (e) domestic sewage discharge;
- (f) mine drainage water discharge.
- (g) possible deleterious or advantageous effects of runoff ponds and dams on population levels of both native and introduced fauna species.

3.2 Physical Infrastructure

In addition to the information provided under Section 2.2, the report shall discuss the impact of the Project on existing infrastructure facilities and shall describe proposals to minimise adverse impacts as appropriate. Impacts should be discussed in relation to:

- . The effect of increased coal train movements on the operation of any level crossings of declared roads. Recommendations should be made about any improvements required;
- (a) Roads - The following points in particular shall be addressed:
 - . The effects on the Hay Point Road during the period of construction of the expansion of the port facilities at Dalrymple Bay if this is the chosen point of export;
 - . The effects on the road system of transporting any substantial amounts of equipment and materials;
 - . The impact of the Project on the regional road network. Consideration shall be given to the increased usage of this road network by the increased population resulting from the Project.
- (b) Rail - The benefits of rail transportation over other modes shall be considered.
- (c) Port Facilities.
- (d) Air Facilities.

- (e) Power Supply - The Capricornia Electricity Board has advised that the Company will be required to bear all costs associated with modifications or relocation of existing Board power lines affected by the project.
- (f) Local Authority Infrastructure - Including:
 - . water supply and stormwater drainage
 - . sewerage
 - . solid waste
 - . local road network.

3.3 Socio-Economic Environment

3.3.1 Demography

Analyse the growth in population likely to occur in the region as a result of the proposed project for both the construction and operational phases. The population figures should be broken down into project workers and their dependants, and, the service workforce and their dependants. Comment should be provided on:

- (a) permanency rate/turnover of the workforce;
- (b) proportion of the workforce married;
- (c) the number of dependants per married worker;
- (d) the age and sex profiles of the population;
- (e) the timing for the influx of the forecast population growth.

3.3.2 Employment and Training

In addition to the workforce directly employed by the project during the construction and operational phases, discuss the magnitude of employment generated in the local area and elsewhere in the State to support and serve the project. In particular provide data on the following:

- (a) Employment generated to directly service the project e.g. off site construction, supply of materials including equipment and services for both constructional and operational phases.
- (b) Employment generated to service the project workforce and their dependants.
- (c) Discuss likely recruitment sources for occupations directly employed by the project during the construction and operation stages. The developer should comment on the effect on local and State labour markets resulting from the recruitment in each of these occupations.

The Company is required to make adequate arrangements for apprenticeship and worker training schemes to service the proposed development.

The phrase "adequate arrangements" used above refers to the following aspects:

- (i) A quantitative level of training effort for tradesmen and all occupations that require training. A number of factors will impinge on the required quantitative level and the Company may wish to list any special circumstances applying to the project in this regard. For occupations where training is fully institutionalised the criteria may be a commitment to employ a number of new graduates (also cadetships, scholarships, etc. may be appropriate);
- (ii) Commencement of training at a substantial level before operations commence (i.e. when final commitment is made);
- (iii) A substantial level of training on the construction site;
- (iv) Qualitative aspects, including training facilities, training staff, etc.

The report shall provide details (for all occupations) on how the Company intends to comply with the above decision.

This requirement is most critical for occupations where skills are occupationally general and the occupation is in short supply and expected to remain so.

3.3.3. Occupational Health and Hygiene Measures

Discuss intended occupational health and hygiene measures and particular proposals for company provision of occupational health services.

3.3.4 Housing and Accommodation

Discuss the impact of the project on the local housing and accommodation market and outline Company proposals to minimise adverse impacts.

3.3.5 Commercial and Industrial Structure

Discuss the impact of the project on the local commercial and industrial structure.

3.3.6 Government/Community Services and Facilities

Discuss the project impacts in relation to the following facilities:

- (a) Health/Medical
- (b) Educational
- (c) Welfare
- (d) Recreational
- (e) Social
- (f) Cultural.

3.3.7 Economic Impact

The report shall present a balanced view of the project's impact on the regional, State and National economies in terms of direct and indirect effects on employment, income, and production and the extent to which Queensland services and goods might be utilized.



17 JUN 1986

12 JUN 1986

Mr P.G. Hughes
General Manager
AQC-Pacific Pty Ltd
410 Queen Street
BRISBANE QLD 4000

Dear Sir

ENSHAM COAL PROJECT - ENVIRONMENTAL REQUIREMENTS

I refer to your letter of 10 January 1986 regarding the above project.

Following the designation of Ensham Coal Associates as proponent of the project in accordance with the Administrative Procedures under the Environment Protection (Impact of Proposals) Act, this Department is now able to provide formal comments on the "Guidelines for Impact Assessment Study" issued by the Queensland Premier's Department. These comments are attached. Provided the additional information requested in the attachment is incorporated in the Impact Assessment Study report being prepared to satisfy State requirements, it is unlikely that a separate Commonwealth environmental impact statement will be required.

I have forwarded a copy of this letter and attachment to the Queensland Coordinator-General and the Department of Trade for information.

Yours faithfully

T.R. O'Brien

T.R. O'Brien
for Secretary

2.2.2 Port and Shipping

- The EIS should include a discussion of both alternatives for an export facility leading to the reasons for selection of the preferred choice. The discussion should cover environmental as well as economic and engineering matters.

2.2.5 Power Supply

- for the power line provide details of how the route was selected and any alternative routes considered and reasons for their rejection. The environmental impact of the selected route and alternatives should be briefly described. If the route selection is to be the subject of separate detailed environmental assessment this should be stated.

2.2.6 Water Supply

- details should be provided on any alternatives considered for the provision of a water supply, (e.g. alternative locations for any dams, use of groundwater) and the environmental impacts discussed.

3.1.2 Groundwater

- the discussion should include a prediction of any long term effects (e.g. after mine closure) and possible remedial measures if an adverse effect occurs.

3.1.3 Surface Water

- the discussion should provide details of any releases possible during low-flow conditions in the surface drainage system and the likely impact on water quality. Measures proposed to minimise such releases should be described.
- a discussion of the impact on downstream water quality of the flushing of any evaporation - or waste water-retention ponds during extreme flood events should be included.

3.1.5 Acoustic Environment

- assess the impact of predicted train noise levels at any sensitive sites along the rail line. Include an assessment of whether rail operations from the proposed development will cause a significant increase in noise levels along the full route from the mine to the selected part.

3.3.6 Government/Community Services and Facilities

- in discussing the impacts of the development on the various services and facilities, any expansions or improvements required to cater for the increased population should be identified.

ENSHAM COAL PROJECT

-Additional information required.

(Numbers refer to sections of the guidelines prepared by the Co-ordinator-General, Queensland Premier's Department)

1.1.5 Surface waters

- provide a detailed description of the flow regime of surface streams likely to be affected by the proposed development. Particular attention should be given to the Nogoa River. Details should be provided of predicted extreme flows as well as of normal seasonal variations.

1.1.7 Air Quality

- particular attention should be given to ambient dust levels, on a seasonal basis, to enable the collection of adequate baseline data for comparison with dust levels generated by the proposed development. It would be preferable for measurement locations for baseline data to be the same as for ongoing monitoring.

1.2 Physical Infrastructure

- identify any deficiencies or surpluses in the capacities of existing infrastructure relevant to the proposed development. Also indicate if any items are at or near full capacity.

1.3.5 Government/Community Services and Facilities

- indicate any existing deficiencies or spare capacity available for each service/facility. Also indicate if any items are at or near full capacity.

1.3.6 Archaeology

- it would be preferable if the results of a thorough, detailed survey could be presented in the EIS.

2. A detailed description of proposed and alternative diversion works for the Nogoa River should be included.

2.1.3 Overburden Disposal

- an assessment should be made of the potential of the waste to generate acid drainage or other noxious leachates.
- the description of any waste dump run-off ponds should include climatic design standards adopted, as well as of any water quality controls which may be required.

APPENDIX 11
STUDY TEAM

APPENDIX 11 STUDY TEAM

Study Director	Peter Hollingsworth	Hollingsworth Dames & Moore
Study Manager	Chris Pigott	Hollingsworth Dames & Moore
Terrain/Soils	Gavan Renfrey	Terrain Analysis (Qld)
Flora and Fauna	Margaret Greenway	Hollingsworth Dames & Moore
Rehabilitation	Mark Evans	Mark Evans & Assoc
Water Quality	Paul Smith	Hollingsworth Dames & Moore
Surface Water Hydrology	Mike Wilke	Blain Johnson
Groundwater	Paul Smith	Hollingsworth Dames & Moore
Noise and Dust	Robin Ormerod	Hollingsworth Dames & Moore
Social and Community	Allen Reid David Morgans	Hollingsworth Dames & Moore Hollingsworth Dames & Moore
Economics	Guy West	University of Queensland
Archeology	Gillian Alfredson	Alfredson Consulting