Please Note:

The original material for this request is very tightly bound.
The following scans are the best quality possible.

MINERAL SANDS IN THE WIMMERA AND POSSIBLE IMPACT OF MINING IN THE RUPANYUP AREA

A Report Commissioned by the Dunmunkle Land Protection Group

March 1999

Compiled by Christine Joannides and John Petheram from documents

supplied by the Dunmunkle Land Production Group

MINERAL SANDS IN THE WIMMERA AND POSSIBLE IMPACT OF MINING IN THE RUPANYUP AREA

A report commissioned by the Dunmunkle Land Protection Group

1st Edition July 1999

ISBN 0 7340 1743 X

Compiled by Christine Joannides and John Petheram from documents supplied by the Dunmunkle Land Production Group

FOREWORD

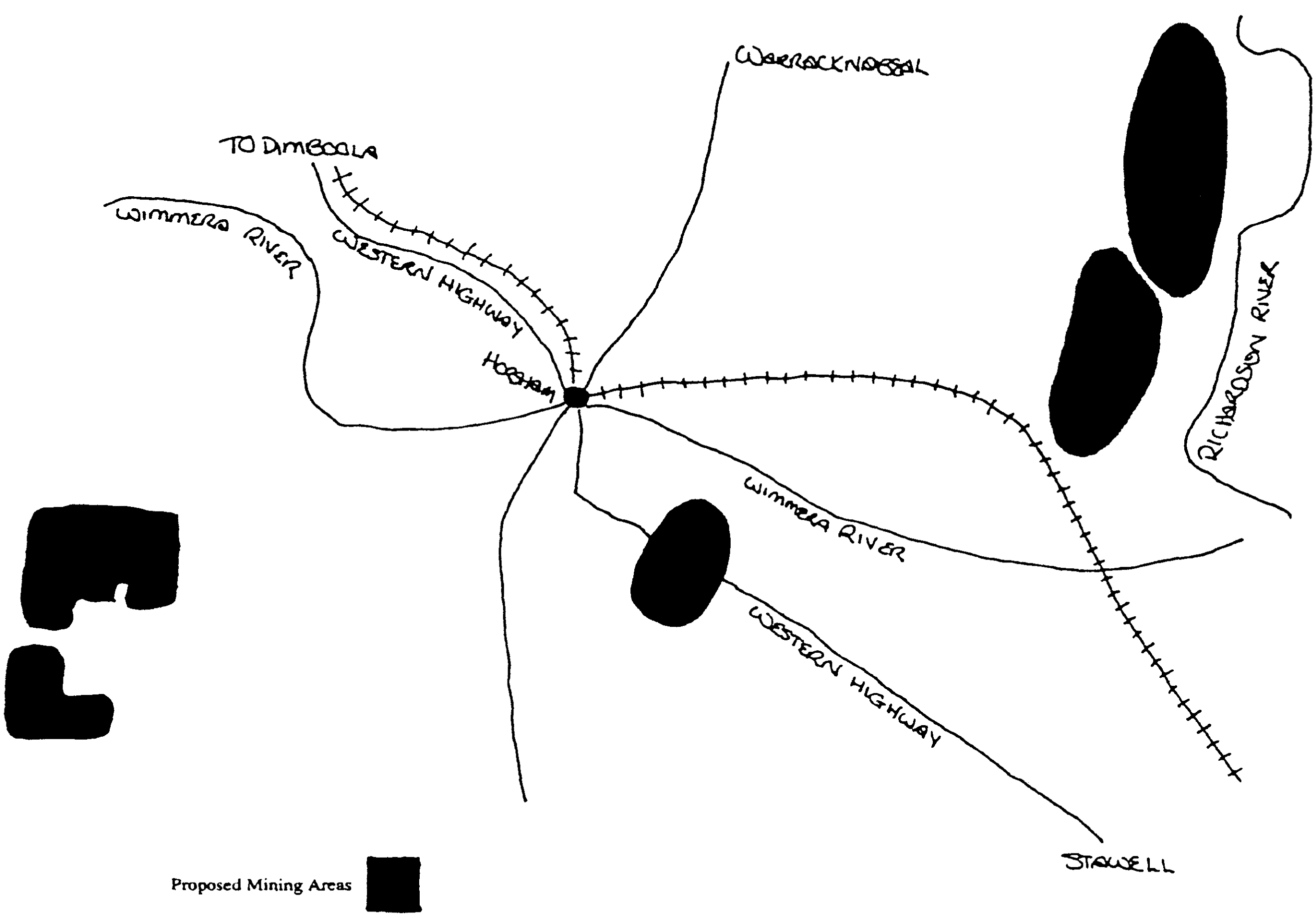
The Dunmunkle Land Protection Group (or DLPG) was formed as a direct result of Wimmera Industrial Minerals (parent company, C.R.A.) discovering large amounts of fine-grained mineral sands in the Rupanyup, Burrum, Banyena areas. Public meetings elected an executive of J. Starbuck, A. Mathews, S. Petering, F. Drum, D. Mathews, M. Burchell and I. Morgan. This executive was given the power to act on behalf of some eighty landowners who initially became members of the DLPG. The executive has, continuously since 1990, fought to present the Group's views to the appropriate government departments , shire councils and C.R.A. In particular, ground water and land rehabilitation issues were strongly defended from the DLPG's point of view.

The DLPG commissioned this report because it had concerns that a record of proceedings should be available for public perusal, should mining ever go ahead. This report outlines most of the major issues that were dealt with during the period June 90-92. The DLPG would like to sincerely thank Christine Joannides for compiling this report, and also John Petheram for his constant support and co-operation.

PREFACE

A Brief Background by Michael Burchell, Rupanyup

The Dunmunkle Land Protection Group was formed in June 1990. In April 1990, Wimmera Industrial Minerals (W.I.M.), now a subsidiary of Conzinc Riotinto Australia, announced it had made major new discoveries of mineral sands in the Wimmera. W. I. M. had declared four sites, all within 55 km of Horsham, as having extensive quantities of mineral sands. Two of these sites were in the old Dunmunkle Shire (now Northern Grampians and Yarriambiack Shires) and covered extensive areas of land.



Sketch showing approximate locations of mineral claims

The proposed mining areas contained up to 24800 ha in the old Dunmunkle Shire and were located entirely within the East and North Ridings, between the Richardson River and Dunmunkle Creek. Because a great many farming families stood to be affected by the claims, the Dunmunkle Land Protection Group (D.L.P.G.) was set up so that landowners' interests might be protected. The D.L.P.G. hired a noted resources advocate to represent it in negotiations with W. I. M.

One of the major concerns of the proposed mining project arose from the fine grained texture of the mineral bearing sands, which make the usual process of recovery of heavy materials ineffective. W.I.M. proposed a radical new method of mining which involved flooding the area to be mined and using a dredge to recover the minerals. The company claimed that although the Parilla sands that contained the rare earths were some 6 metres below the surface, they could leave the land in exactly the same condition as it was before mining.

W.I.M.'s claim that it could rehabilitate the land to its former state became the sticking point and also the major concern of the D.L.P.G. The D.L.P.G. believed that once soil structures in the Dunmunkle Shire were altered through mining, the land could never be fully restored to the same condition as before mining. The land contained about 12 cm (5") of topsoil in a lot of areas and between 6-9 metres (20-30 ft) of clay subsoil beneath this topsoil. Members of the D.L.P.G. and many noted soil scientists maintained that, due to the variability of the soils in the areas which would be mined, it would be impossible to rehabilitate the land to the same state as it was before mining.

Other concerns of the landholders included the fear that rehabilitated land would not retain the same amount of moisture in the topsoil, which is critically important in a crop growing region with a rainfall of only 400-450mm (16"-18") per year.

It was also noted that rehabilitated land would be left some 3 metres higher than untouched land as a result of what was known as the "dumping" effect. Effectively this meant that clay soils would not compact to what they were before mining (and the landscape and drainage would be changed) . The end result of this was the genuine fear that production levels would not be the same as before mining.

On top of all these concerns was the fact that this type of mining posed a severe threat of rising water tables and increased salinity problems, particularly along the shire's eastern boundary.

The National Party formed a Parliamentary Mining Committee which aimed to hear all sides of the debate. One of the key recommendations in its report on mineral sands mining was that W.I.M. run a test demonstration project on a reasonable sized area to demonstrate the standard at which rehabilitation would occur. However, even though landowners were prepared to arrange land for a site, W.I.M. would not undertake such a demonstration.

In April of 1992, after much lobbying from the Dunmunkle Shire Council, the then Minister for Manufacturing and Industry Development, Mr. David White, announced the following monetary package in order to address some of the concerns which were being raised. An amount of $16425 was given to the Department of Food and Agriculture to compile a report on farm productivity issues and land management systems within the Shire. A further $5625 was given for the supply of farm record books to affected landowners so that further monitoring of productivity levels could be carried out. In addition $10000 was given to the Dunmunkle Shire for professional advice on mining and rehabilitation.

In June 1992 W.I.M. announced that it was shelving plans to extract the mineral sands because of the high costs involved and the poor world wide resource prices of the current time.

ACKNOWLEDGMENTS

Many people assisted with this report. Thanks to the farmers in the Dunmunkle Land Protection Group, particularly Jim Starbuck, Ian Morgan, Stewart Petering and Frank Drum for sharing their story and parting with all the documentation that they have gathered over the years of their concern over this important issue. Graham Gooding, who spent time explaining the mining legislation and the geology of the Murray Darling Basin, and for copies of documents, maps and figures, some of which appear in this report. John Smart for his time explaining the, history of WIM 150, and showing me around the site. I also appreciate John's permission to peruse various WIM documents which were important background. Alan Bedggood patiently spent many days preparing the soil association and parish diagrams, and the ABS area of production statistics and diagrams. The staff at Longerenong College for their assistance, and especially Theresia O'Loughlin for her work on copying and collating. Finally I wish to thank my family for their moral and other support, without which this report would not have been possible.

Christine Joannides

A TIMELINE OF EVENTS

1985	CRA announced the discovery of Titanium minerals, Zircon and rare earth minerals at Drung South.
1987	
December	CRA announced that they had decided to commence the evaluation of commercial mining.
1988	Preliminary Environment Report (PER) given to the Minister for Planning and Environment. WIM sought approval for Pilot Plant on company land (WIM 150). Public comment invited on PER and Planning Permit application.
4th October	Administrative Appeals Tribunal hearing; Conservation Council of Victoria appealed against the Shire of Wimmera and WIM.
9th December	Shire of Wimmera resolved to proceed with the site specific amendment to the Planning Scheme (L2) to allow for the Demonstration Project. Planning Permit issued by the Shire of Wimmera to allow for the Demonstration Project at WIM 150 (Drung).
1989	
January	Environmental Effects Statement (EES) put out.
	Panel that had been appointed to consider EES and Planning Scheme amendment approved Demonstration Project.
1990	
June	Mineral Resources Development Act replaced Mines Act 1958.
	Dunmunkle Land Protection Group (DLPG) formed.
1991	
June	DLPG met with David White, Minister for Manufacturing and Industry Development (DMID) to discuss concerns.
July 24	Wimmera hearings, National Party Parliamentary Mining Committee.
August	DLPG had discussions with soil scientists L. Walker and P. Van der Graaf, with a view to contracting their services if costean and trial/ demonstration project proceeded.
September	Shire of Dunmunkle gave submission to Minister David White seeking $40,000 for information on farm productivity
1992	
March	DMID General Manager for Project Facilitation Division, Keith Bowen writes to Minister David White advising him to approve Shire of Dunmunkle request for funding, for $26,425
June	CRA announced activities at WIM 150 to be phased down
1992-98	DLPG members gather data, commission soil study and visit mining areas in other states
1998/99	DLPG commission Report to compile/summarise information relevant to exploration/mining of mineral sands in Rupanyup area

CONTENTS

ABBREVIATIONS USED IN THIS REPORT

DCE	Department of Conservation and Environment
DFA	Department of Food and Agriculture
DLPG	Dunmunkle Land Protection Group
DMID	Department of Manufacturing and Industry Development
DPC	Department of Premier and Cabinet
EES	Environmental Effects Statement
Gla	Gigalitres per hectare
PER	Preliminary Environmental Report
WIM	Wimmera Industrial Mining Pty Ltd
VCM	Victorian Chamber of Mines
VFF	Victorian Farmer's Association

LIST OF FIGURES

LIST OF APPENDICES

Appendix 1	Press release and article on mineral sands exploration in the Wimmera 1998 a) Deputy Premier opens up Wimmera's sand mining exploration area for competition and hastened development. 11 September 1998 b) Sands decision sets stage for scramble (The Age, 14 September 1998)
Appendix 2	Environmental Effects Statement : WIM 150 Demonstration Project. Wimmera Industrial Minerals Pty Limited, January 1989
Appendix 3	WIM 150 Project, Drung South, Shire of Wimmera near Horsham, Victoria: Brief Project Description", Wimmera Industrial Minerals Pty Limited, 28 June 1991.
Appendix 4	National Party Parliamentary Mining Committee, Investigation and Report on a Proposal to Mine Heavy Mineral Sands in the Wimmera, National Party, October 1990.
Appendix 5	Wimmera Catchment Authority (1998) Wimmera Catchment Region, Demographic and Socio-Economic Profile: A strategic review of the social and economic character of the Wimmera Catchment Region, TBA Planners Pty Ltd with SGS Consulting, McGuinness and Associates and Neil Clark and Associates, November 1998.
Appendix 6	Reports by DLPG members on Visits to other Mines
Appendix 7	Meycheck Paddock Report, 1994, Rupanyup, Department of Agriculture.
Appendix 8	Raw data from Australian Bureau of Statistics, on Area by Commodity, 1992 – 1994. Rupanyup Shire (former boundary). Summary of Statistical Data, Area by Commodity, 1961 - 1994.
Appendix 9	Preliminary Study of Soils Associated with the WIM 200 and WIM 250 Mining Sites in the Yarriambiac Shire Alan Bedggood (1999) Victorian Institute of Dryland Agriculture, Dept of Natural Resources & Environment, Horsham.
Appendix 10	Map of Resource Management Units. Wimmera Regional Catchment & Land Protection Board (1997) Wimmera Regional Catchment Strategy, DNRE, Horsham, Victoria.

MINERAL SANDS IN THE WIMMERA AND POSSIBLE IMPACT OF MINING IN THE RUPANYUP AREA

PURPOSE AND SCOPE OF THIS REPORT

This report has been commissioned by the Dunmunkle Land Protection Group (DLPG) with the aim of placing on record:

- the events relating to the exploration and possibility of mining mineral sands in the Wimmera
- the views of local people on the impact on farming and on the community, should mining take place
- information gathered by the DLPG relating to land, agriculture and the community in the Rupanyup area
- information gathered by the DLPG on mining in other areas

The task of the compiler was to assemble this document and the accompanying appendices from information provided by the DLPG, rather than to conduct independent study of the issues involved. In attempting to better understand the situation, contact was made with various other people and organisations and various documents were viewed from W.I.M. and other sources (such as Minerals and Petroleum Victoria). Some of the material viewed was unpublished or did not represent the views of the DLPG, so has been omitted from this report. Much of the information provided by the DLPG members has only been mentioned or summarised and is not otherwise included in the Report or the Appendix, but was returned to the members.

INTRODUCTION

In 1985, as a result of extensive exploration, Wimmera Industrial Minerals Limited (WIM, a subsidiary of CRA Limited – now Conzic Riotinto Australia) announced the discovery of a substantial mineral sand deposit of titanium, zirconium and other minerals at Drung South, south of Horsham, which it called WIM 150. Later, the discoveries of further deposits were announced. These were WIM 50, WIM 100 and WIM 200 and 250 in the former Shires of Kowree, Arapiles and Dunmunkle respectively (Fig 1). In all, these areas covered approximately 32 000 hectares of predominantly cropping and grazing land.

There were mixed reactions to the possibility of mining in the area. A report on a study conducted by the National Party Parliamentary Mining Committee (1990) summarised farmer/ landowner and community concerns about the proposed mining as:

1. Uncertainty concerning the effects of mining and the lack of predictability with respect to the future of farming families.
2. Whether rehabilitation of mined areas will return the land to its former productive capacity.
3. The level of compensation payable for mining of farm land, disruption and other impacts.
4. The effects of mining on water price, supply and quality and the possible effects on salinity.
5. The impact of the industry on local employment, clubs and facilities.
6. The possible effects of any increase in radiation levels due to mineral extraction.
7. Whether the proponents would be required, or willing, to contribute funds to the municipalities to help pay for any financial burden their activities may place on the area.

The Dunmunkle Land Protection Group formed in June 1990, as a result of community concern about mining. This group was vocal and active in lobbying government, and working to represent the position of landholders and the community to ensure that the land would be rehabilitated to a satisfactory level.

Although the deposits found in the Wimmera are large, they are very fine grained. This poses difficulties in the concentration and separation of minerals, as current techniques are unsuitable. The small grain size and mineral chemistry has made it difficult to market the product. Despite significant progress made, the project was wound back in 1992, and currently operates on a small scale Approximately $60 million has been spent since 1985, on exploration, property access and developing technology to process the mineral sands.

Wimmera Industrial Minerals (WIM) currently hold the Exploration Licenses for WIM 100 and 150. In 1998 the State Minister for Agriculture and Resources announced that "The Rio Tinto Exploration License Area has now been reduced to 316 sq km with the balance of the area placed under temporary exemption from exploration and mining license applications. This exemption will be lifted, and the area released for exploration bids after the area has been marketed to the national and international industry.

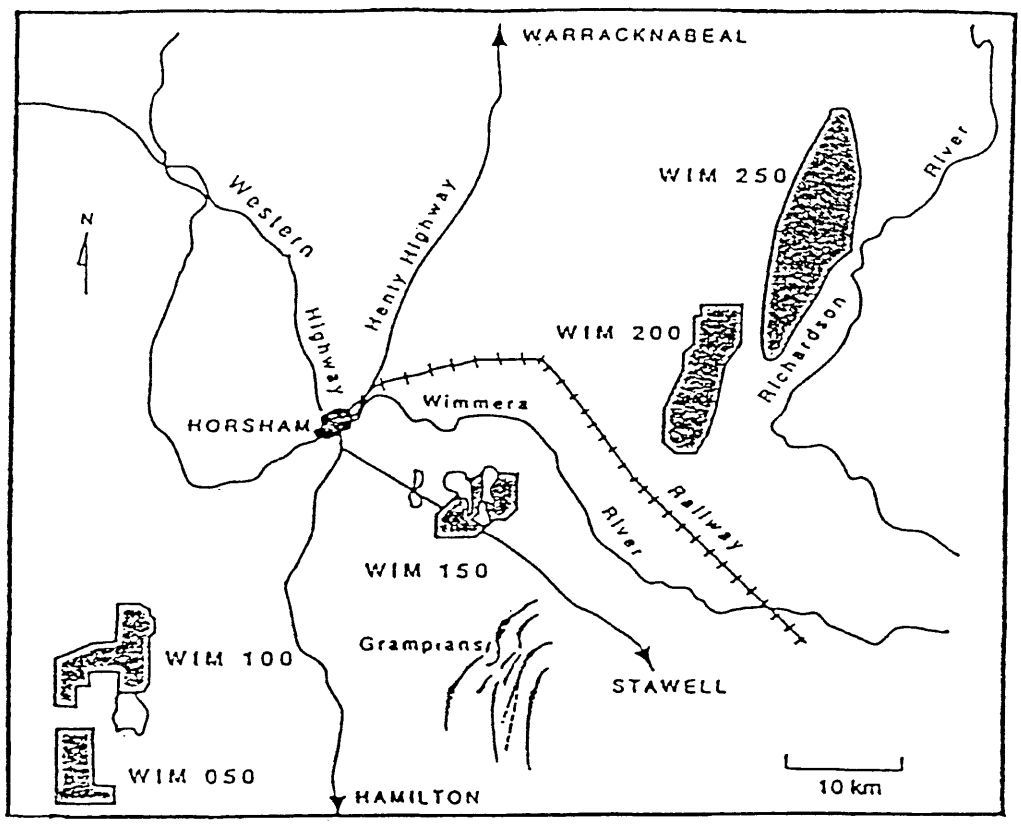


Fig 1 Locality map - Wimmera Mineral Sand Resources

MINERAL RESOURCES, MINING LEGISLATION AND WIMMERA INDUSTRIAL MINERALS

The Mineral Resource

Murray Darling Basin mineral sands

About 5 million years ago, parts of Victoria, South Australia and NSW were an inland sea. The sea stretched from the Coorong in South Australia, to the area South of Broken Hill and to the Mallee and Wimmera in Victoria., an area of about 300 000 sq km. Mildura was the geographical centre of this sea.

The land then uplifted and the sea retreated to the present shoreline. Dunes and lakes from this sea still remain. When the sea retreated, strand lines of minerals were left behind, which were heavier than the silica sand. The minerals were titanium and zircon.

The whole of the Murray Darling Basin is covered by exploration licenses, and companies are currently exploring for mineral sands. Fig 2 shows the location of heavy mineral deposits in the Murray Darling Basin.

Mining Legislation

When the initial mineral sand resource was discovered in late 1980, legislation that controls the exploration and exploitation of minerals was the *Mines Act 1958*. This act was changed in 1990 to the *Mineral Resources Development Act 1990 (MRDA)*, to reflect and update the legislation. Some sections of the new Act incorporate concerns raised in the Environmental Effects Statement (EES) enquiry. The current Act is administrated by the Department of Natural Resources and Environment, and allows two types of license - Exploration Licenses and Mining Licenses:

EXPLORATION LICENCE	- covers search for minerals
MINING LICENCE	- covers excavation for, extraction, production

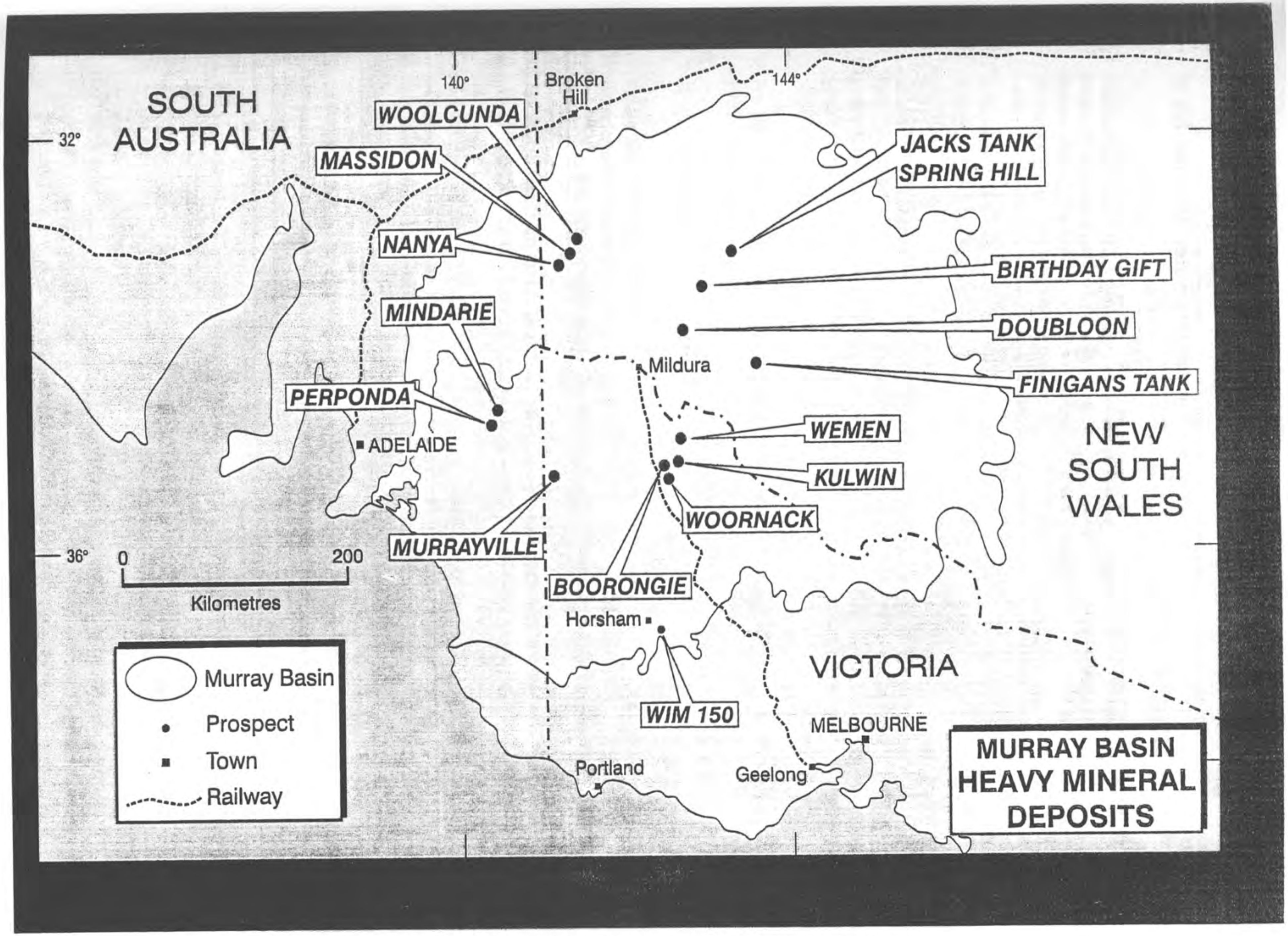


Fig 2 Location of heavy mineral deposits in the Murray Darling Basin

WIM in the Wimmera: 1988 to 1999

The following information is from "Environmental Effects Statement: WIM 150 Demonstration Project", Wimmera Industrial Minerals Pty Limited, January 1989 (Appendix 2) and "WIM 150 Project, Drung South, Shire of Wimmera near Horsham, Victoria: Brief Project Description", Wimmera Industrial Minerals Pty Limited, 28 June 1991 (Appendix 3)

Although WIM had exploration licenses for WIM 50, 100, 150. 200 and 250 issued under the *Mines Act 1958*, exploration never progressed to mineral extraction.

An Environmental Effects Statement (EES) was prepared for WIM 150 only. This was for approval to set up a Demonstration Project, which would involve a small mine and processing plant. The information gained would help determine whether full scale commercial mining would be viable. The Pilot Project (Planning Permit No. 299) was issued 8th November 1988. This permit allowed "Mineral Evaluation/ Development",

For the WIM 150 site, the Pilot Project (Planning Permit No. 299) was issued 8th November 1988. This permit allowed "Mineral Evaluation/ Development".

1. Mining approvals and the lease area

Under the *Mines Act* 1958, the principal mineral titles were the Exploration License (EL), Development Lease (DL) and Mining Lease (ML). One of the prior requirements to the grant of a Lease was appropriate authorisation under the *Planning and Environment Act*, 1988.

The transition from an EL to an ML entailed a concentration of activity on a particular area which was proven or likely to have economically recoverable grades of the target mineral(s).

Exploration in the WIM 150 Study area was conducted under the terms of an Exploration License (EL1257). The Pilot Project was covered by a Development Lease (DL301) which was issued on 6 December 1988. It covered an area of about 1365 ha, of which the company owned 1100 ha.

WIM had other Exploration licenses, for WIM 50, 100, 200 and 250. Under the *Minerals Resources Development Act* 1990, all the Exploration Licenses held by WIM were amalgamated into Exploration License 3330.

WIM planned to have a demonstration phase at WIM150 between the Pilot and Commercial phases. The sequence of events was to be followed was:

- exploration - discovery of the deposit and delineation of reserves
- laboratory testwork - investigation of the methods for separation of the minerals on a very small scale
- pilot phase - providing the technical feasibility of selected methods and developing a process to allow continuous extraction of minerals
- demonstration phase - continuous production of minerals in quantities suitable for shipping to potential customers for process evaluation
- commercial phase - full scale mining, production, upgrading, marketing of concentrates

2. Planning approvals

The 1365 ha in the WIM 150 Lease area was zoned Rural A under the Wimmera Planning Scheme, which came into effect February 1988. Permission was obtained to build two costeans at this site (Planning Permit No. 244, issued 14th August 1987) for "Mineral Working", involving outline exploration, research sampling and environmental studies (EES - Appendix 2).

In 1988 WIM sought approval to operate a Pilot Plant on company owned land at WIM 150. A Preliminary Environmental Report was prepared in support of that application and following assessment by the Minister for Planning and Environment, a Planning Permit was issued by the Shire of Wimmera. The Pilot Plant was to be used to develop new methods for the concentration and separation of minerals.

In 1989 WIM sought approval to further its development of appropriate mineral processing technologies by the installation and operation of a Demonstration Project at the site. A planning scheme amendment (No. L2 to the Wimmera Planning Scheme) and Environmental Effects Statement (EES) were prepared as well as an application for a mining lease. A panel was appointed to consider the EES and planning scheme amendment. Approval was granted for the Demonstration Project, subject to the recommendations of the Panel and the Minister, at the end of 1989. The Project Area is shown in Fig 3.

3. Minerals to be mined and uses

Compiled from Huntley (1998) and WIM (1991a)

"Mineral sands" are sand deposits which contain significant levels of the commercially important titanium minerals (rutile, leucoxene and ilmenite), zircon and rare earth minerals (monazite and xenotime).

<u>Ilmenite</u> & <u>rutile</u> - raw materials mainly used for manufacture of titanium dioxide pigments.

<u>Titanium dioxide</u> - for paint, coatings, plastics and paper. Some used for titanium metal production and welding fluxes. Titanium metal is used in high strength alloys in aircraft.

<u>Zircon</u> is used in the refractory, foundry and as a ceramic glaze, TV glass and zircon metal.

<u>Monazite and Xenotime</u> have a range of applications including electronics, high strength magnets, automotive emission reduction catalysts, steel alloys, and high strength ceramics.

When the project began, it was estimated that mineral production would be approximately 400,000 tonnes, achieved by the extraction of approximately 15 m tonnes of ore per annum.

The life of the WIM 150 ore body was estimated to be approximately 30 years. The life of the processing plant was expected to be much longer and could be used to process mineral deposits within the Wimmera Region.

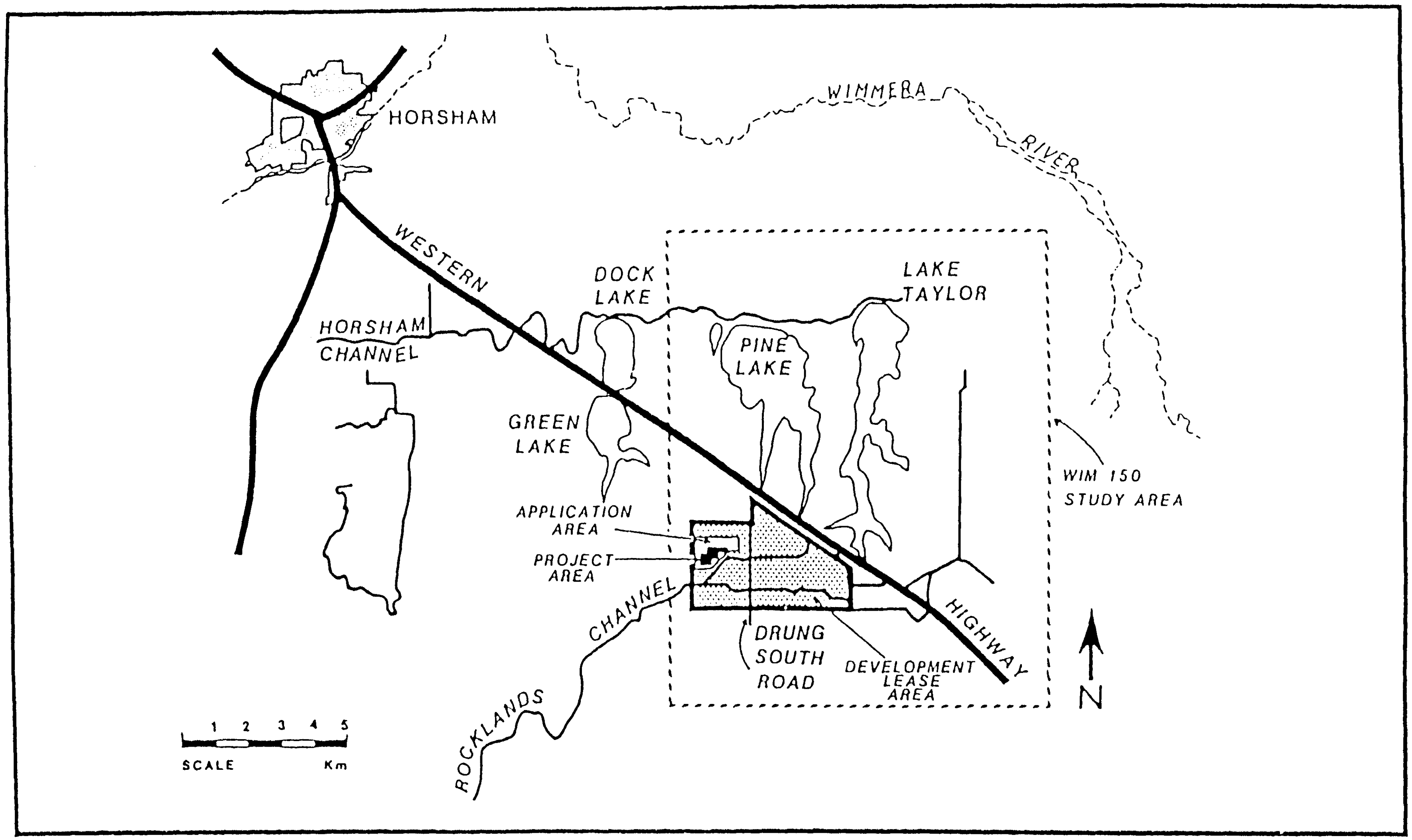


Fig 3 Locality map - WIM 150, showing Development Lease and Project areas.

4. Extraction method and processing

The minerals are contained in the Parilla sands (see under HYDROGEOLOGY AND MINING). The Parilla is a marine sand formation of Miocene to Pliocene age (5 to 2 million years ago) present over much of the western Murray Basin. Within the core of the WIM 150 deposits the sand varies in depth from 10 to 15 metres, and is underneath 4 to 5 metres of heavy sand clay overburden.

For the proposed mining method for the Demonstration Project at Drung South (WIM 150) see Appendix 2 - "Environmental Effects Statement: WIM 150 Demonstration Project", Wimmera Industrial Minerals Pty Limited, January 1989 and Appendix 3 - "WIM 150 Project, Drung South, Shire of Wimmera near Horsham, Victoria: Brief Project Description", Wimmera Industrial Minerals Pty Limited, 28 June 1991.

The Current Situation

The 3785 square kilometres area for which WIM had an exploration license was very recently reduced by the Minister's hand to 316 square kilometres (see Appendix 1). WIM now only hold the mining tenements for WIM 100 and WIM 150. "The balance of the area has been placed under temporary exemption from exploration and mining license applications. "This exemption will be lifted, and the area released for exploration bids after the area has been marketed to the national and international industry" (2) Figs 4 and 5 show the suggested areas for tendering. The two contained white areas in Fig 5 show the areas maintained by Rio Tinto in 1999.

Outlook for Titanium and Zirconium minerals

Huntly (1998) made the following statements in "Murray Basin Mineral Sands Review" about the outlook for minerals of titanium and zircon on the world market:

Conclusions from the Australian Bureau of Agricultural and Resource Economics 1998 Outlook Conference brief review of the medium term outlook for titanium minerals and zircon follow below:

- *recovery in titanium dioxide pigment prices from 1997 onwards, as demand gathers momentum and should maintain over three per cent a year growth;*
- *stabilisation of bulk zircon prices in the real price range of A$500-570 a tonne, as projected supply limitations force the use of zircon to be increasingly restricted to areas where its key nonsustainable characteristics are required;*
- *increased Australian production and export revenue;*
  and
- *strengthening competition, particularly from South Africa*

Australia is dominant in the world production of rutile at 186,000 tonnes per annum (45% of 1997 world production), ilmenite at 2.1 million tonnes per annum (24% of 1997 world production), zircon at 425,000 tonnes per annum (47% of 1997 world production) and synthetic rutile at 544,000 tonnes per annum (73% of 1997 world production).

Figure 4

Minerals and Petroleum Victoria

EXPLORATION STATUS

- AREA CURRENTLY UNDER EXPLORATION (LICENCE TENURE OR APPLICATION)
- AREA UNDER EXEMPTION
- AREA AVAILABLE FOR EXPLORATION APPLICATION
- AREA UNAVAILABLE FOR EXPLORATION

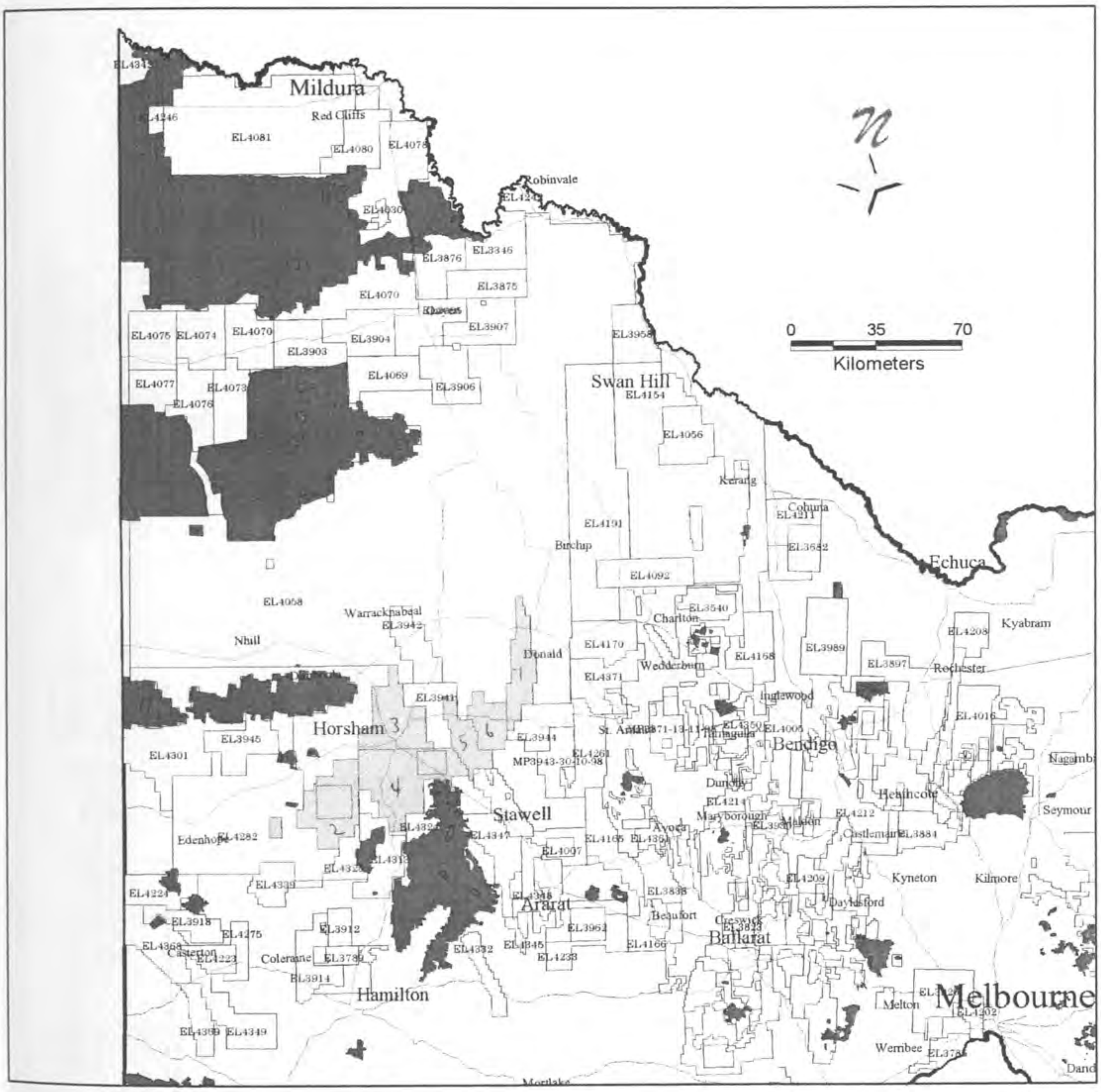
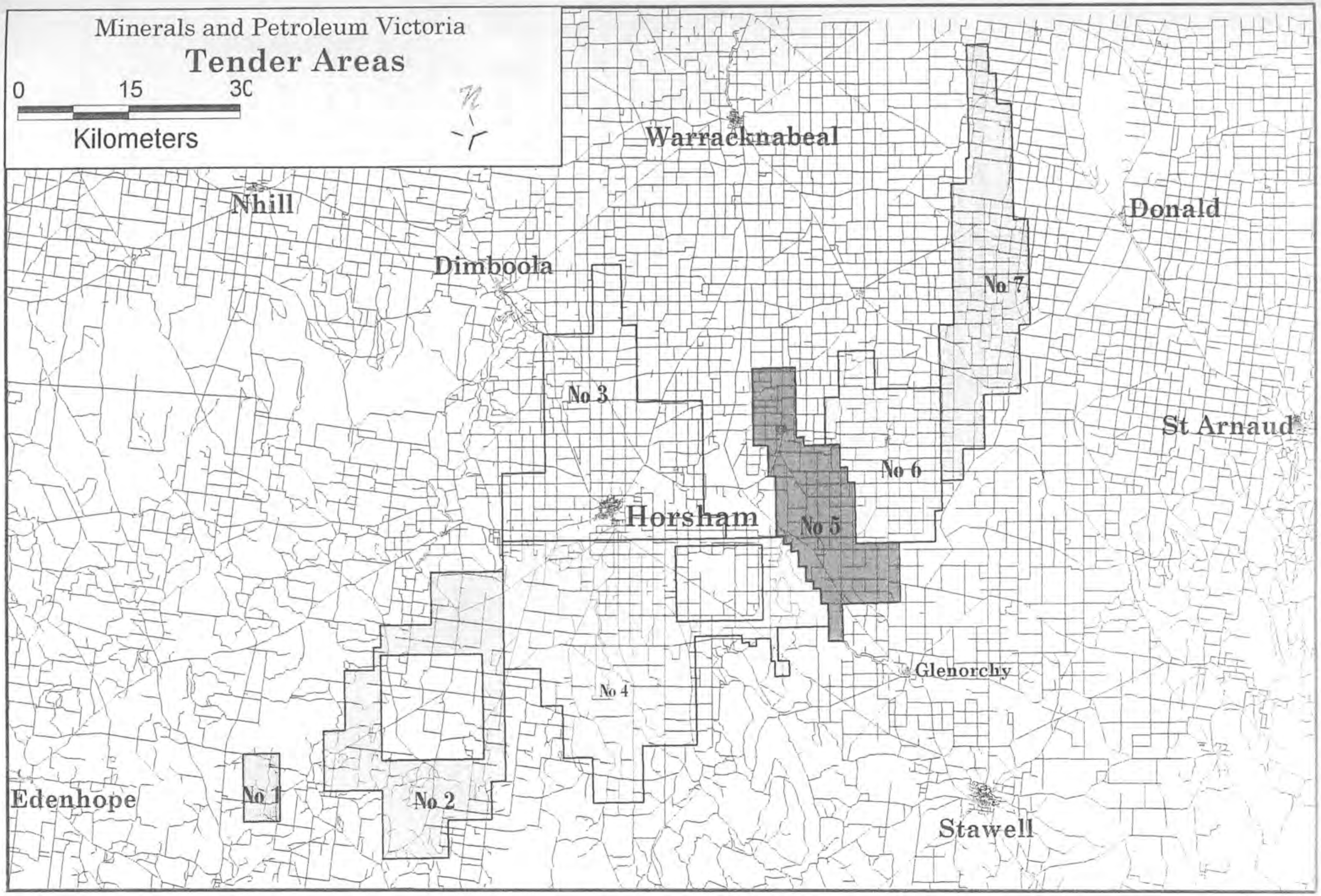


Figure 5



Minerals and Petroleum Victoria
Tender Areas
0
15
30
Kilometers
N
Warracknabeal
Nhill
Donald
Dimboola
No 7
No 3
St Arnaud
No 6
Horsham
No 5
Glenorchy
No 4
Edenhope
No 1
No 2
Stawell

HYDROGEOLOGY AND MINING

As HYDROGEOLOGY of the region is so critical to understanding the location of mineral sands, the likely mining processes and possible effects of mining, reasonable detail has been included in this section of the report.

The following is compiled from WIM 1991b on the Hydrology of WIM 150. This information is included on the assumption that the fundamental stratigraphy of the Dunmunkle area is similar to that in the WIM 150 area on which the study was based.

The surface geological unit is the Shepparton Formation which comprises clay containing lenses and shoestrings of sandy or gravelly material. The permeability of the Shepparton Formation is considered to be much lower than that of the underlying Parilla Sand formation. The vertical permeability of the Shepparton Formation is of significance to groundwater analysis as it is the property which controls the rate at which seepage into the underlying Parilla Sand can occur. The thickness of the Shepparton Formation varies from zero to 10 m.

The Parilla Sand consists of coarse to very fine grained, clayey sand and silt. It is a *beach sand* sequence, deposited principally during the regression of the sea in the late Tertiary. Heavy minerals were concentrated near the contemporary shoreline to form deposits such as those of WIM 150. From the results of previous permeability testing of the Parilla Sand by Coffey and Partners Pty Ltd, permeability is likely to be in the range of 1 to 2 m/d. The thickness of the Parilla Sand varies from zero to about 17m over this study area.

The Geera Clay is of low permeability and underlies the Parilla Sand. Some clay underlying the Parilla Sand has also been identified as belonging to the Bookpurnong Beds in some of the drilling records reported by Rockwater. Theses two units have similar characteristics. The Geera Clay typically separates the Parilla Sand from the lower Renmark Group aquifers. The low permeability is demonstrated by a large head difference between the Parilla Sand and the Renmark Group Aquifer. The Renmark Group Aquifer usually has heads several metres higher than that of the Parilla Sand. Measurements of the thickness of the Geera Clay are sparse compared with those for the Parilla Sand but thicknesses varying from zero to 15m have been recorded.

The Renmark Group Aquifer underlies the Geera Clay. This unit is regionally extensive and is present over most of the eastern half of the Murray Basin. Pump testing gives permeability values between 2 and 16m/d. A thickness of 29m was recorded in the Drung Drung 3 bore (near Gross' Bridge over the Wimmera River) drilled by the Department of Water Resources. The Renmark Group Aquifer is absent in the south west of the study area where high basement ridges have been encountered in drilling.

The Grampians Sandstone underlies the Renmark Group Aquifer. The hydraulic characteristics of the Grampians Sandstone have not been measured but they are fairly impermeable. It is possible that the upper part of the Grampians Sandstone is fractured and contained groundwater of connate origin. This may be a significant feature if the salinity of the Renmark Group Aquifer were modified by mining. Saline groundwater within the Grampians Sandstone would tend to diffuse into the Renmark Group Aquifer and therefore tend to reduce the magnitude of salinity changes within the Renmark Group Aquifer.

Fig 6 shows the Stratigraphy below the WIM 150 site.

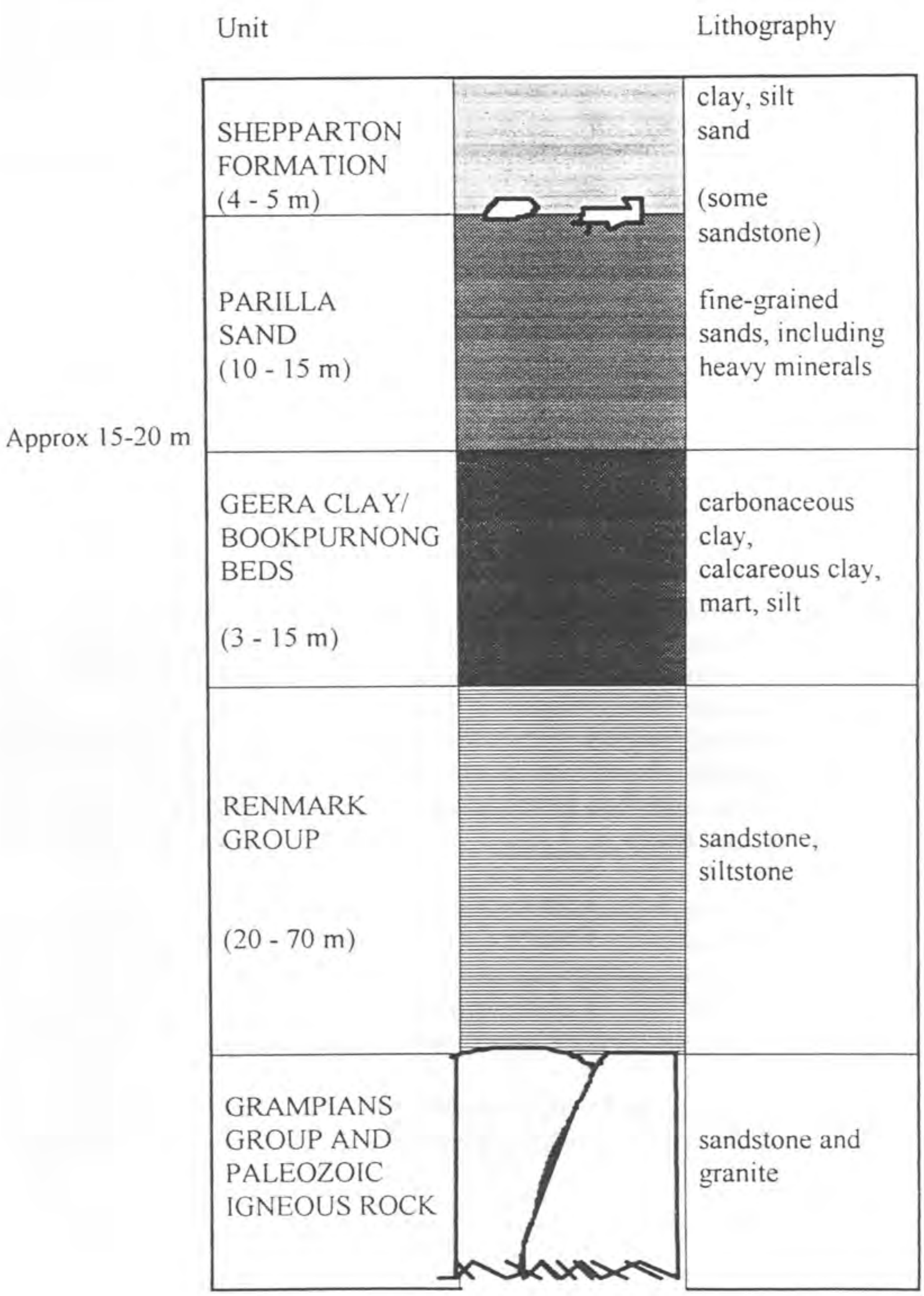


Fig 6 Stratigraphy of the WIM 150 area
(Adapted from various reports by Wimmera Industrial Minerals)

Regional Groundwater Boundaries

The Wimmera River to the north of the (WIM 150) study area acts as a discharge boundary to groundwater in the Parilla Sand aquifer. In the south west corner of the study area basement Grampian Sandstone levels are higher than groundwater levels. In this area the Renmark Group Aquifer is absent and the Parilla Sand is above the water table. Thus the line where the elevated basement intersects the groundwater level will behave as a no flow boundary.

Groundwater Levels

Monitoring of piezometric levels in the Parilla Sand and Renmark Group Aquifer has been carried out by Wimmera. Groundwater flows away from the lakes within the study area (Pine Lake, Lake Taylor, Dock Lake and Green Lake). To the south of the study area regional groundwater gradients is north toward the lakes and a groundwater trough to the south of the lakes exists.

To the north of the lakes groundwater levels approach the ground surface and waterlogging and land salinisation occurs where high groundwater levels in the Parilla Sand (generated from within the lakes) cause upward groundwater gradients through the Shepparton Formation.

Very steep groundwater gradients exist at the margins of the lakes. The lakes dominate the groundwater levels in the study area. The mechanism by which this steep gradient results may be simply from the effect that a recharge zone superimposes on a sloping groundwater table, or the steep gradients may result from high evapotranspiration losses around the margin of the lakes where groundwater levels are shallow. The possibility that development of a skin of low permeability over the floor of the lakes resulting in high exit gradients is discounted, as photographs of the condition of the lake floor taken in Pine Lake, while it was drained for maintenance, show a clean surface of the Parilla aquifer.

Regional monitoring of groundwater conditions since 1987 show a gradual rise in water level with time, superimposed on seasonal fluctuations in groundwater level. Long term rises are not observed to the north of the lakes where groundwater levels are limited by the ground surface. The largest rises are recorded in the vicinity of the lakes, suggesting that the water level in the lakes may have risen during the period for which monitoring records exist.

The Parilla Sand is saturated in the vicinity of Lake Taylor and Pine Lake but becomes unsaturated to the south of the lakes in the vicinity of the trial mine area.

Groundwater Recharge

Groundwater recharge to the Parilla Sand occurs through:

- lakes
- regional groundwater flow from the south
- surface in infiltration from irrigation and rainfall, and
- leakage from irrigation channels.

As average rainfall is only 416mm/y, it is expected that infiltration through the low permeability Shepparton Formation is relatively small. Similarly, leakage from irrigation channels into the Parilla Sand is expected to be small compared with inflow from lakes. The regional groundwater system is recharged in the foothills of The Grampians, near the southern boundary of the WIM150 Study Area.

Groundwater Chemistry

The dominant ions in waters tested from the Parilla Sand and Renmark Group Aquifer are sodium and chloride, as a result of the marine origin of the aquifer system. The range in dissolves solids in the Parilla Sand varies from 700 to 23000mg/l with an average of about 5000mg/L. The highest salinities are measured near the southern extremity of Taylor's Lake and north west of Pine Lake. The cleaner sands and gravels of the Renmark Group provide yields up to 3Ml/d with salinities below 1100mg/l.

Surface Water Features

Lakes
The lakes within the study area are man made and have existed for about 60 years. The lakes serve as water storage for irrigation. Prior to damming of the lakes, surface depressions containing swamps existed. Damming of the lakes has undoubtedly resulted in significant elevation of regional groundwater levels and subsequent waterlogging and salinisation. Weekly records of lake water levels are available.

Irrigation Channels
A network of open channels covers the study area. These are within the Shepparton Formation and are unlined. The low permeability of the Shepparton Formation means that leakage from channels is not likely to be an important factor in the regional hydrogeology.

Rivers and Creeks
The Wimmera River flows around the E and N boundaries to the WIM150 area. To the north of the lakes, the Wimmera River acts as a discharge boundary. The ephemeral creeks which drain to the lakes are within the Shepparton Formation and are not considered significant for groundwater modelling purposes.

Land Salinisation
Land salinisation occurs in areas of shallow water table to the north of the lakes and in low lying land along the banks of the Wimmera River.

Fig 7 shows the Hydrogeological Water Balance of the region.

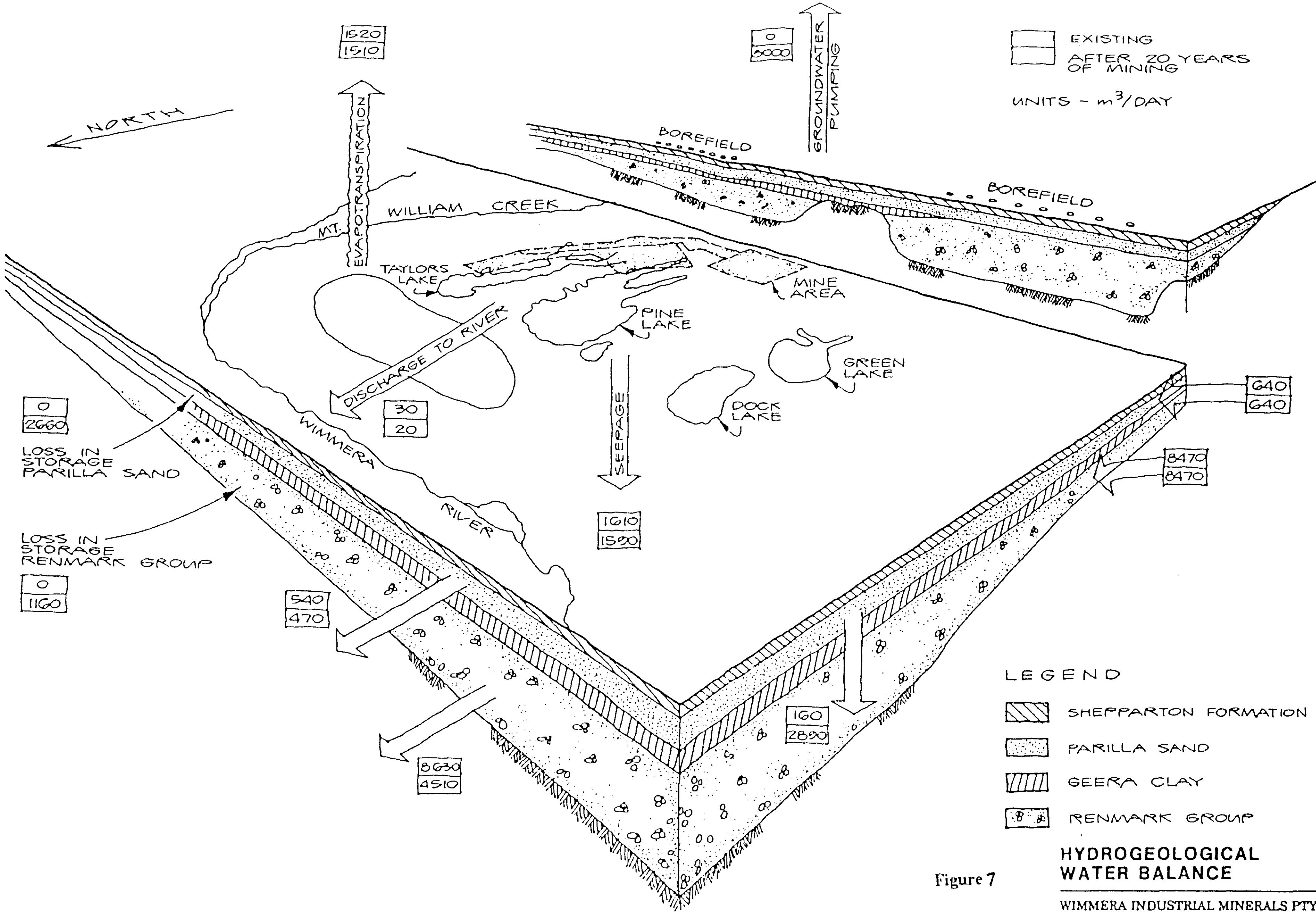


Figure 7

HYDROGEOLOGICAL WATER BALANCE

WIMMERA INDUSTRIAL MINERALS PTY LIMITED
WIM150 PROJECT

GHD

Mining Process and Effects

Compiled from : Environmental Effects Statement : WIM 150 Demonstration Project. Wimmera Industrial Minerals Pty Limited, January 1989 – see Appendix 2.

Dredge mining

Because the water table is generally well above the base of the ore zone, the deposit lends itself to dredging. The latter is a well established, low cost mining method which is widely used in the mineral sand industry. Its use is almost obligatory in lower grade deposits such as WIM150.

The principle is simple. Ore is broken by a revolving cutter, sucked up onto a barge by a powerful pump and piped as slurry in water to the primary plant. Here the desired minerals are concentrated and the tailing returned to the ground. The primary concentrate is separated into its individual constituent minerals at a secondary plant elsewhere.

In mineral sand mining, the primary plant (*wet plant*) typically floats behind the dredge, while the secondary plant (*dry plant*) is on land, perhaps many kilometres away.

Effects of Mining

There are two main effects of mining on groundwater which have to be considered:

- seepage
- tailings consolidations

Seepage

Flow from the dredge pond (or from saturated tailings) will occur if the level of water in the pond is above the level in the adjacent ground (whether the latter is natural or artificial). Conversely, a pond level below the surrounding ground will cause an inflow of water.

If one knows (or can estimate) the hydraulic properties of the adjacent ground one can calculate the seepage rate. However, in practice, the seepage losses are likely to be less than predicted because the water in the pond (and tailings) carries fine sediment in suspension which tends to clog the pores of the adjacent natural ground, greatly reducing the permeability (see footnote on p.17).

Seepage will only occur in areas of low natural watertable, which form a small part of the ore body. Over most of the area, the dredge pond would be maintained at about the natural water table so there will be little effective seepage.

Because of the low permeability of the Parilla Sand and the pore clogging effect of fine sediment, seepage is not expected to be a major factor either in water consumption or in effects on groundwater. Even in an area of low watertable, it might account for only 20 per cent of consummation.

Tailings consolidation

The major factor in water consumption will be the entrainment of the pores of tailings. In its natural state, saturated Parilla Sand contains about 20 per cent by weight water. Even after consolidation, one would expect the tailings to hold more, perhaps 20 per cent. This final figure is important and equally so is the rate at which it is achieved.

When tailings are initially returned to the ground, they may contain 40 per cent water. Unless water is added, the water table will be lower (there is more space to fill). If we assume[(1)] that the water level is maintained by the addition of water, then as the tailings consolidate, the water displaced by the reduction in pore space will, in the absence of lateral drainage, move upwards. This will raise the water table.

The consolidation process is complex, but computer modelling can help predict the rate and degree of consolidation as well as the hydraulic properties of the tailings during consolidation. This work is being carried out for WIM [(1)]

Tailings which remain above the water table will also contribute to the consumption of water. The moisture content of "dry" ore above the water table is less than half the specific retention of that ore. Therefore, even when tailings above the water table have drained, they will contain more water than the original ore. [(1)]

In general one would expect that tailings, having greater pore space, would have higher permeability than the original ore. However, preliminary testing of WIM150 ore suggests this effect is slight or negative, probably due to dispersion of clays during mineral dressing. [(1)]

Management of tailings and groundwater

As noted earlier, the present groundwater regime in the Parilla is dominated y the outward movement of water from the lakes and the water table is rising for this reason. To avoid any adverse effect from mining it will be necessary to control the water table at the present, or some other desired level. As long as the water table after mining remains below the level in the lakes, water cannot move from the mine area into the lakes.

To ensure that the final water table is at the desired level, there are two approaches:

a) immediately after mining, the water table is left at a level lower than the original. Then as the tailings consolidate, the water table will rise. If the original level is correctly chosen, the final result will be as it was before mining.

b) after mining, leave the water table at its original level, but make provision for the drainage of water that is displaced during compaction. In this way, water table can be controlled at desired level. Excess water would be re-used in mining operation.

Water consumption

It is possible to make an estimate of water consumption, given certain assumptions[(1)] about mining layout and tailings behaviour. For an operation mining 20 Mta ore, we are looking at something less than 10GL. This is a lot of water, but not astronomical; it is 5 per cent of the annual throughput of the RWC Wimmera - Mallee Stock and Domestic system.

[(1)] **The DLPG believes that many assumptions made above are without sound foundation, and that this gives reason for real concern by the community about possible effects of mining.**

We [WIM) would propose to purchase some of this water from the RWC because we will probably need some fresh make-up water for processing, and pump the remainder from the Renmark aquifer. The effects on the Renmark would be slight and not adverse. Water in the Renmark is saline and gets worse to the north. Its quality renders it of little value for the other purposes but it is more than adequate to fill the pores of our tailings. The use of this water is preferable to the use of fresh water, whenever the quality is acceptable.

Production of say, 5 Gla, from the Renmark in this area would reduce the aquifer head over a distance of some kilometres and again this is not seen as causing any problem. It may even be slightly advantageous. The high head in the Renmark is believed to exacerbate salinisation problems in the Parilla further north. The water levels and chemistry of all observation and production bores in the Renmark aquifer are currently monitored by CRA or RWC.

At present the RWC system is fully committed (or even over-committed) but losses from the system are very large, especially in the north. Studies by the commission have shown that as much as 70 Gla could be saved by reducing waste in the Mallee through piping parts of the open channel system. This concept forms the basis of the "Sale of Savings" philosophy, in which all additional supplies of water are derived form improvements in system efficiency. If a new consumer requires, say 2 Gla, this will be supplied by saving 2 Gla in an area where there are large losses at present. The connection fee and rates paid for this supply reflect the cost of the system improvements. No additional water need enter the system. There are environmental advantages in this because seepage from RWC channels in the Mallee contributes to the rising water table in the Parilla Sand.

Wimmera River

A commercial mining operation would have no surface discharges; all tailings and process water would be returned to the ground. Therefore there would be no effect on the Wimmera River.

Topographic changes due to the swell of excavated materials will require appropriate planning to ensure that there is no effect on the quality or quantity of the run-off. This is easily accomplished.

At present, the Wimmera River appears to receive seepage of saline groundwater from the Parilla Sand, either directly or indirectly via fluvial sediments adjacent to the river. This effect is probably natural but is increased, or will be increased, by the rising water table in the area caused by seepage from the RWC lakes. Proper management of tailings will ensure that the movement of groundwater is not increased; at worst, the situation will remain as at present.

Conclusions of WIM Report (on hydrogeology of WIM 150)

1. Mining the heavy minerals in the Parilla Sand will involve the excavation and replacement of that formation over an area of a few tens of square kilometres. The properties of the aquifer will be changed slightly; in particular, the pore space will increase. Initially the change will be substantial (perhaps + 100%) but decline with time (perhaps to + 25%).

2 Changes in permeability are unlikely to be major and may even by negative.

3 The changes with time in the pore space will require appropriate measures to ensure the long term water table is left at the desired leave. There are simple engineering solutions for this.

4 Seepage laterally will occur in areas of low water table but these areas are limited and, in any event, the seepage loses will be operate and the effect on groundwater minimal.

5 The estimated water consumption of the project can easily be met from the RWC system (under the Sale of Savings concept) and the Renmark aquifer. No adverse effects would arise from this usage; on the contrary there would be some environmental benefits.

6 The project will have no conceivable effect of the Wimmera River, directly or indirectly.

Note 1:
The relevance to the Rupanyup area of the conclusions in the above report (about a different area) is uncertain to the DLPG. Although the stratigraphy of the Rupanyup area is similar to that of the WIM 150 area, the presence of man-made lakes and other different features in the WIM 150 area mean that mining could have different effects in the two areas.

Note 2:
Some farmers, such as Mr Frank Drum of Rupanyup, are concerned that too few people in the Wimmera/ Mallee Region are educated in the principles of underground water hydraulics. These principles govern and influence many of our farming practices. Geological faults, either natural or man-made, can have disastrous / significant influence on the flow of underground water below our fertile agricultural land. Alteration of physics of the soil profile can also have serious consequences for soil-water-crop relations, which are the most critical aspect of our cropping systems.

INFORMATION ON THE SHIRE OF YARRIAMBIACK

Former and existing Shire Boundaries

Rupanyup is located in the Shire of Yarriambiack and was formerly in the Shire of Dunmunkle. Nearly 80% of the area of the former Shire of Dunmunkle is now in the Shire of Yarriambiack, and 80% of the population. Figs 8 and 9 show the former and current Shire boundaries of the Dunmunkle Shire and its parishes (From Wimmera Catchment Authority 1998).

The information on pages 22-26 following the maps in Figs 8 and 9 is from "Wimmera Catchment Region, Demographic & Socio-Economic Profile: A strategic review of the social and economic character of the Wimmera Catchment Region", Prepared by TBA Planners Pty Ltd with SGS Consulting, McGuinness and Associates and Neil Clark and Associates, November 1998 (Appendix 5).

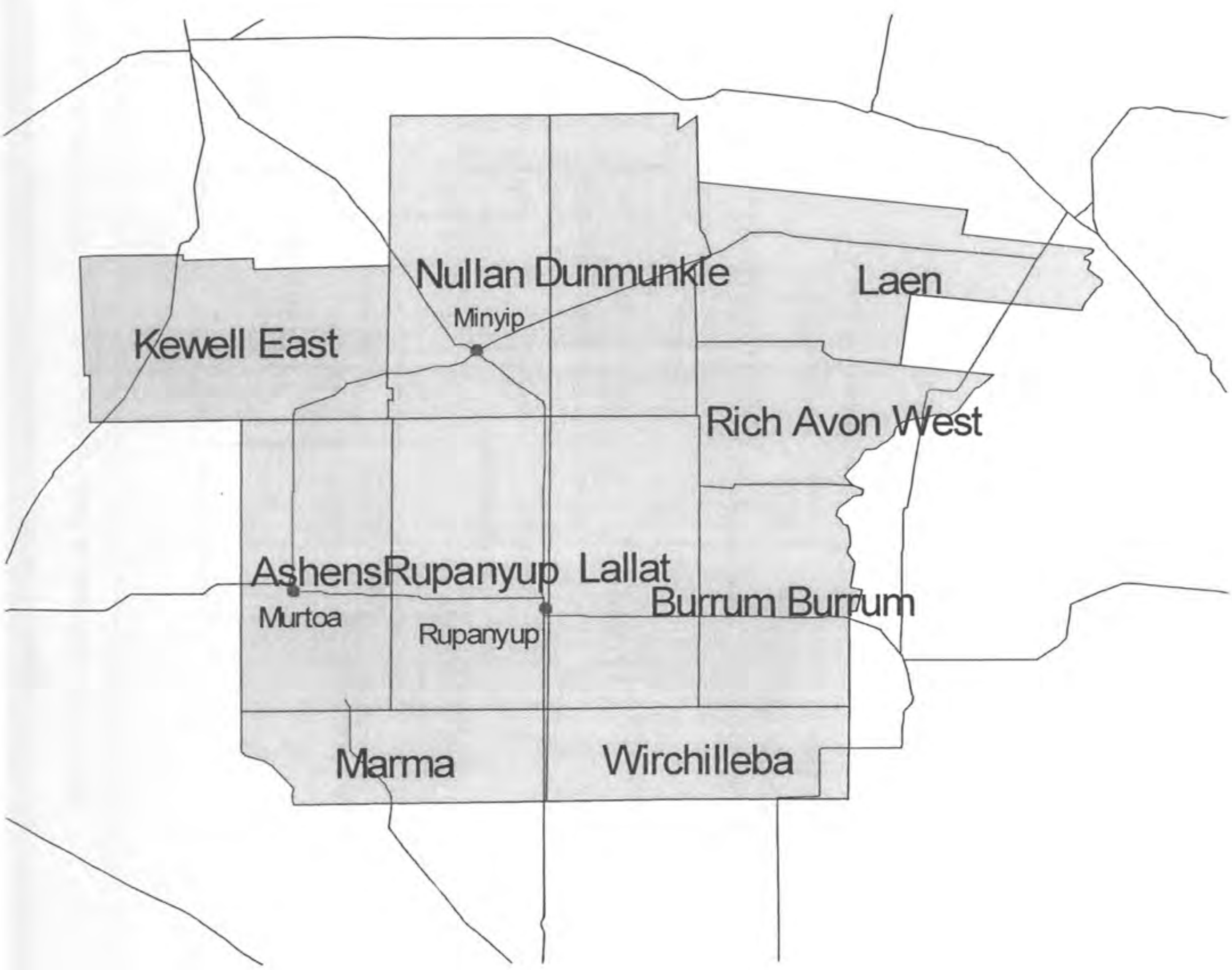
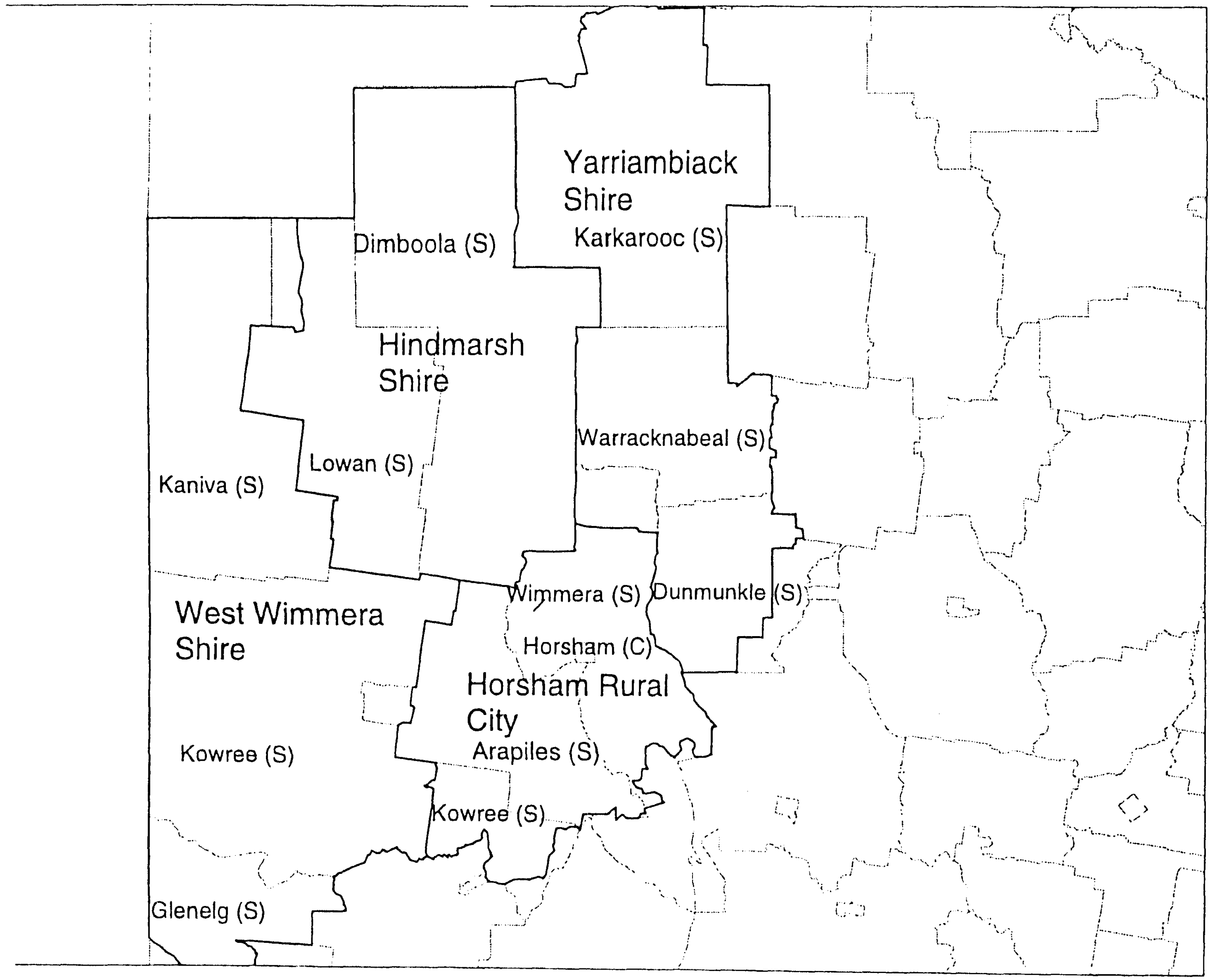


Fig. 8 The former shire of Dunmunkle, showing parish boundaries

Figure 9 Former and existing Shire Boundaries in the Wimmera

Source: The Wimmera: a Socie-Economic Profile, Wimmera Development Association



From: Wimmera Catchment Region, Demographic and Socio-Economic Profile: A strategic review of the social and economic character of the Wimmera Catchment Region, TBA Planners Pty Ltd with SGS Consulting, McGuinness and Associates and Neil Clark and Associates, Wimmera Catchment Authority, November 1998.

Yarriambiack

People

Yarriambiack Shire covers an area of 7,159 sq. km, with a population of 8,754. Most of the Shire's population lives in the southern areas of Yarriambiack, while the population of the northern Mallee region has a smaller population centred on the town of Hopetoun.*

Similarly to the region as a whole, rural population decline is a feature of population change in Yarriambiack. While all the key urban centres of Warracknabeal, Rupanyup and Hopetoun have all experienced some population loss, this has been less significant than the decline experienced in their rural hinterland.

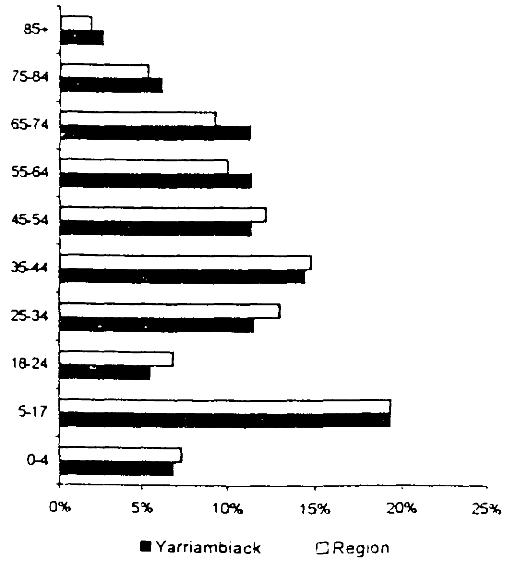
Population Change, 1986-1996

	1986	1991	1996	1986-96	1991-96	Avg. Annual
Hopetoun	750	704	670	-10.7%	-4.8%	-1.1%
Minyip	543	497	475	-12.5%	-4.4%	-1.3%
Murtoa	863	878	839	-2.8%	-4.4%	-0.3%
Rupanyup	446	422	407	-8.7%	-3.6%	-0.9%
Warracknabeal	2,689	2,689	2,493	-7.3%	-7.3%	-0.7%
Woomelang	275	221	217	-21.1%	-1.8%	-2.1%
Non-Urban	3,853	3,530	3,203	-16.9%	-9.3%	-1.7%
Yarriambiack (S)	9,419	8,941	8,304	-11.8%	-7.1%	-1.2%
Estimated Pop	9,883	9,466	8 831	-10.6%	-6.7%	-1.3%

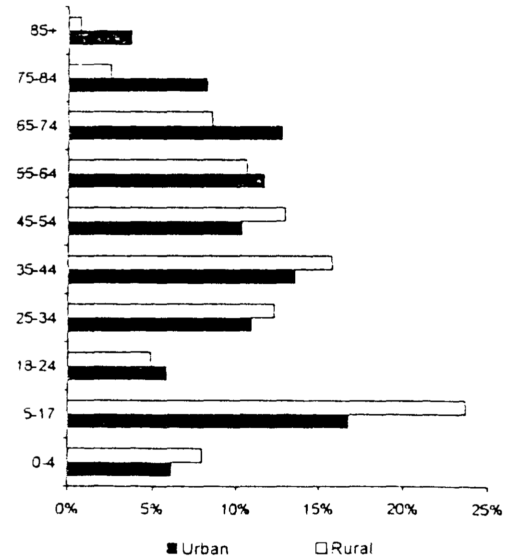
Source: ABS Enumerated and Estimated Populations

Converse to the patterns in the other municipalities in the Wimmera, Yarriambiack Shire has a younger rural population than the population of the urban areas. This has occurred despite a general pattern of ageing and population decline across the Shire as a whole.

Age Structure, 1996



Rural/Urban Age Structure, 1996



Source: ABS Enumerated Population

Age Structure, 1986-1996

	1986			1991			1996		
	Yarr'biack	*%*	*Region*	*Yarr'biack*	*%*	*Region*	*Yarr'biack*	*%*	*Region*
0-4	679	7.2%	7.4%	681	7.6%	7.5%	562	6.8%	7.3%
5-17	1,980	21.0%	21.6%	1,781	19.9%	20.2%	1,599	19.3%	19.3%
18-24	787	8.4%	9.6%	559	6.3%	8.0%	454	5.5%	6.8%
25-34	1,262	13.4%	14.1%	1,209	13.5%	14.5%	951	11.5%	13.0%
35-44	1,081	11.5%	12.5%	1,153	12.9%	13.9%	1,194	14.4%	14.8%
45-54	1,010	10.7%	10.5%	961	10.8%	10.9%	939	11.3%	12.2%
55-64	1,101	11.7%	10.7%	1,038	11.6%	10.2%	941	11.3%	10.0%
65-74	790	8.4%	7.6%	856	9.6%	8.2%	935	11.3%	9.3%
75-84	562	6.0%	4.7%	524	5.9%	5.2%	509	6.1%	5.4%
85+	161	1.7%	1.3%	173	1.9%	1.5%	216	2.6%	1.9%
	9,413	100.0%	100.0%	8,935	100.0%	100.0%	8,300	100.0%	100.0%

Source: ABS Enumerated Population

Compared to the region as a whole, Yarriambiack has a higher proportion of older people, although other age groups are represented at similar levels.

Workforce

Agriculture is the most significant component of Yarriambiack's labour force. Along with overall work force decline, this component is decreasing. Other sectors such as Education and Health Services, and Retailing are more significant components of the overall work force than they were in the past.

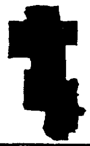
Industry of Employment, 1986-1996

	1986	*1991*	*1996*
Agriculture, Forestry & Fishing	40 6%	37 0%	36.1%
Mining	0.0%	0.1%	0.0%
Manufacturing	2 2%	2.3%	3.8%
Electricity, Gas & Water Supply	2.0%	1.7%	2.4%
Construction	4.1%	3.0%	2.0%
Wholesale & Retail Trade	14 4%	17.0%	19.9%
Transport & Storage	5 0%	4.2%	4.5%
Communication Services	1.3%	1.3%	1.3%
Finance & Insurance	3 1%	2.6%	2.2%
Property & Business Services	1 1%	1.3%	1.8%
Government Administration & Defence	4.0%	5.5%	4.6%
Education, Health & Community Health	17 1%	18.6%	18.6%
Cultural & Recreational Services	0.7%	0.8%	0.8%
Personal & Other Services	4.2%	4.5%	1.9%
Total Employed Population	***3,832***	***3,440***	***3,341***

Source: ABS Enumerated Population

Over 25% of the labour force is employed part time, although in the Shire's north this figure is closer to 20%. Work force participation is close to 45% in both areas.

Agriculture is a significant employers in the region, while other large employers include the Hospital and larger retailers.



Business Numbers and Employment Size, 1997

	Employees							
Industry	*N/A*	*<5*	*5-9*	*10-19*	*20-49*	*50-99*	*100+*	*Total*
Agriculture, Forestry and Fishing	27	753	5	-	-	-	-	785
Mining	-	-	-	-	-	-	-	-
Manufacturing	-	8	6	3	-	-	-	17
Electricity, Gas and Water Supply	-	4	2	-	-	-	-	6
Construction	-	14	2	-	-	-	-	16
Wholesale and Retail Trade	-	82	33	7	1	-	-	123
Accommodation, Cafes and Restaurants	-	18	5	2	-	-	-	25
Transport and Storage	-	52	9	2	2	-	-	65
Communication Services	-	1	1	-	-	-	-	2
Finance and Insurance	-	6	4	2	1	-	-	13
Property and Business Services	-	11	2	1	-	-	-	14
Government Administration and Defence	-	5	4	1	3	-	-	13
Education	-	32	8	2	4	-	-	46
Health and Community Services	-	27	3	3	7	-	1	41
Cultural and Recreational Services	-	20	-	2	-	-	-	22
Personal and Other Services	-	37	-	-	-	-	-	37

Source: ABS Business Location Counts

Agriculture

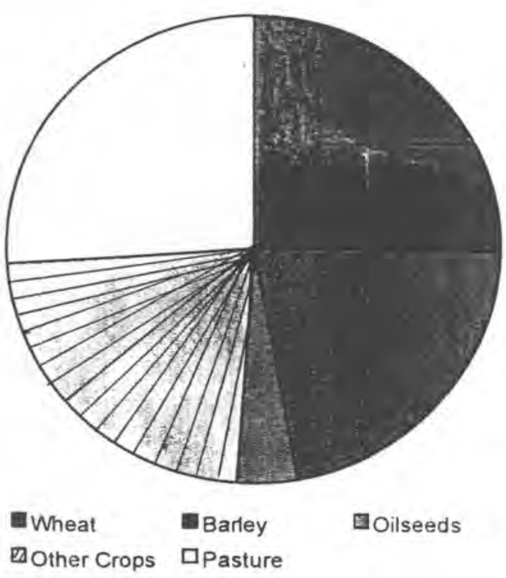
Yarriambiack Shire had a GVP for agriculture of $215,069,168 in 1995-96, the largest in the region, comprising 3.9% of the Victorian total. This is almost exclusively (89%) the product of cropping activity, particularly wheat, barley and chick peas. Wool ($9,891,891) and livestock production for meat ($11,970,575) together contributed less than 10% of the total GVP, although these contributions were not insignificant.

Gross Value of Production: Broadacre Crops, 1995-96

Canola	*$ 9,092,781*
Oilseeds	*$ 9,615,291*
Barley for grain	*$ 53,668,920*
Triticale for grain	*$ 2,195,758*
Wheat for grain	*$ 72,668,104*
Cereals for grain	*$130,101,680*
Cereal crops for hay	*$ 625,956*
Chick peas	*$ 28,739,976*
Faba beans	*$ 1,950,683*
Field peas for grain	*$ 13,700,398*
Pasture seed	*$ 318,606*
Other Crops	*$ 1,184,020*
TOTAL CROPS	*$193,105,424*
Wool	*$ 76,151,639*
Beef	*$ 9,729,401*
Sheep and Lamb Slaughterings	*$ 53,361,948*

Source: ABS

Agricultural Land Use, 1995-96

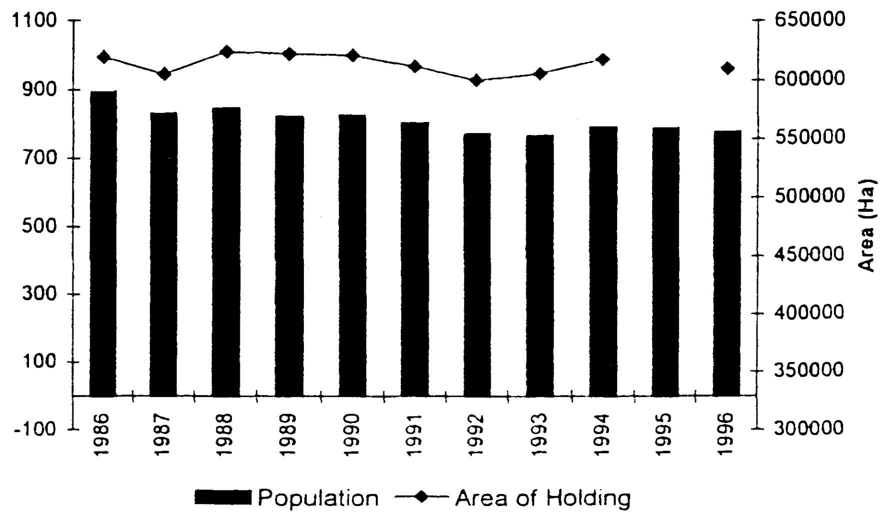


Crops, especially cereal crops and pulses, cover almost 75% of all agricultural land in Yarriambiack. Barley and wheat alone account for almost half of the land area.

Grazing land, including significant areas of native or naturalised (unimproved) pasture covered over a quarter of the Shire's agricultural land.

Importantly, during the same period the total area of Agricultural Holding has increased slightly. The declining role of Agriculture in labour force data would appear to reflect the emerging role of off-farm income in Yarriambiack, and in other municipalities in the region. Farm numbers have declined in Yarriambiack, although this trend is not too dramatic.

Total Area of Holding and Farming Population, 1986-1996



Source: ABS

COMMUNITY CONCERNS AND ACTION

Community Concerns: A Summary

From various reports and the views expressed by members of the DLPG, the main concerns of the community about the possibility of mining in the Rupanyup area can be summarised (in order of priority concern) under the headings of:

1. Whether mined areas would be rehabilitated to their former productive state. Some examples of items of concern are:
    * soil structure (refer to initial issues on page 28)
    * weeds from neighbouring paddocks being transferred
    * soil will be 3m higher after mining, which will affect which will affect water flow
    * impact on soil microflora

2. Uncertainty concerning the effects of mining and for long term farm planning. The uncertainty has also had a decided psychological impact on individuals and the community

3. The effects of mining on water price, supply and quality and possible effects on salinity

4. The loss of community that could result from people selling properties as a result of mining

5. The possible effects of any increases in radiation levels due to mining

6. Other areas visited by community members have never rehabilitated to a satisfactory level

7. The level of compensation payable

8. Experience of DLPG members from visits to other states shows that many mining companies will re-habilitate landscapes as cheaply as possible - and just enough to gain public acceptance (but in a way unlikely to satisfy the needs of farmers or real environmental improvement). [See photographs on following pages.]

PHOTOGRAPHS OF OTHER SAND MINING AREAS IN AUSTRALIA

Dredge mining at Raymond Terrace, similar to that planned by CRA for our area, except that in the Wimmera there are deep clay layers above the sand

First stage of rehabilitation at Raymond Terrace. Topsoil ready to be spread

First stage of regrowth of forest, which had been totally cleared during mining

Pasture growth some 6-7 years after mining at Taree, NSW

Example of pasture on unmined area adjacent to above

Wetland or lake near where the sand mining/dredging finishes

National Party Parliamentary Mining Committee

In June 1990, The National Party established a committee consisting of David Evans MLC, Bill McGrath MLA and Roger Hallam MLC - to "gain and foster a better understanding of the often competing interests of farming, mining and the community, particularly in the Wimmera Region".

A letter was sent to people and organisations concerning the proposed mining developments in the Wimmera, inviting written submissions and announcing that public hearings would be held to allow all interested parties to present their views on the proposed developments. Terms of reference for the inquiry included:

1. Any limitation on large scale exploration licenses, and the term for which they remain in force.

2. Requirements which need to be met in order to hold licenses for a particular term.

3. The effect on landholders and farming operations in the license areas.

4. The effect on land valuations of granting of an exploration license and exploration in the license areas.

5. Effect on possible sales of land.

6. Future of sustainable agriculture after mining operations are completed.

7. Water requirement for full scale mining and its effect on the Wimmera-mallee water supply.

8. Disposal of waste water.

9. Effect on municipalities, rating values, roads and demand for services.

10. Employment effects.

11. Comparison between economic value of mining and farming.

12. Effect of legislation restricting mining access to public land, and the resulting pressure on private land."

The Report resulting from the above-mentioned study is entitled "Investigation and Report on a Proposal to Mine Heavy Mineral Sands in the Wimmera", National Party Parliamentary Mining Committee, October 1990 (see Appendix 4). Some sections of the Report dealing with farmer/ landowner and community concern are quoted in italics below - although the DLPG is not in agreement with all of the points made.

5 Farmer/Landowner and Community Concerns

5.1 Uncertainty

Uncertainly was the most significant concern currently affecting the landowners and their families.

Confusion on the effects of mining and lack of predictability with respect to the future of their properties was a constant theme.

Submissions indicated that up to 90 families could be affected.

Ian Morgan illustrated the frustrating nature of this uncertainty by explaining that he can not make a reasonable decision whether to expand his farm to include his three sons until he knows which land may be required for mining and if so when. Meanwhile, he notes, time slips away.

George Bennet commented that "the farmers are in the dark" and that they do not even know the quality of minerals under their land and whether such minerals are of commercial value to the miners.

Added to this uncertainty is the feeling amongst the farmers that they no longer control their own destiny. David Matthews, a district farmer who also represented the Wimmera District Council of the Victorian Farmers Federation noted that the cherished independence of the affected farmers was lost. Errol Laverty made similar comments that the farmers' futures were not longer in their hands and that they now have little say in what happens to their land.

Some farmers such as Frank Drum were even uncertain as to whether their land would be returned to them after mining was complete and if so, in what state? The issue of rehabilitation adds to the uncertainty and is discussed below.

Many submissions argued that because farmers were living with uncertainty 24 hours a day it was affecting their whole family and their lives. Robert McDonald and Richard Hobbs noted that bed wetting by school children of affected families had become more prevalent. School teachers had also commented on the detrimental affect the uncertainty was having on the children. Doug McHenry commented on the traumatising affects the uncertainty was having on families. Dr Rod Sutherland confirmed that these could be the results of the existing lack of predictability facing families. Dr Michael Axtens added that depression and loss of self esteem could also result from farmers losing their livelihood.

Both Marshall Baillieu of WIM and the Victorian chamber of Mines acknowledged the problems associated with the lack of predictability. Suggestions were made by *these organisations and the landowners that a framework advising landowners of the likely sequence of mining would help reduce the uncertainty. The Company did however note that it was difficult to make any firm timing commitment until it overcomes the technical problems of processing the mineral sands.*

The VCM also argued that speedier granting of mineral titles would lessen the period of landowners uncertainly and that the proposed bill may facilitate such a reduction in application delays.

Another factor adding to the uncertainty is that few landowners know what their rights and obligations are when dealing with the representative of a mineral exploration company. The VCM noted that after consultation with the Victorian Farmers Federation it produced a booklet explaining landowners' rights, particularly in regard to compensation. The booklet is titled "Landowner Information on Mineral Exploration and Mining On Private Property"

5.2 Restoration/rehabilitation

Another major concern of farmers related to the restoration or rehabilitation of their land following mining.

Confusion over the meaning of these two words was apparent in submissions. The legislative obligations imposed on the mining companies with respect to rehabilitation also appeared to be unclear. To some, rehabilitation meant "digging a lake and planing trees around it", but this interpretation was vigorously denied by mining representatives.

As noted above, existing and proposed legislation requires the miners to "rehabilitate" the land. The Mineral Resources Development Bill requires that the rehabilitation plan, to be approved by the chief administrator, must take into account any special characteristics of the land, the surrounding environment and the need ..... the land.

The Acting Secretary of the Shire of Dunmunkle, Mr Robin Webb, noted in his submission that the standard of rehabilitation would depend on the decision of the chief administrator and that this mechanism was grossly inadequate for ensuring that appropriate rehabilitation takes place. He then suggested that Local Government's role should be expanded at this level to include setting and overseeing of the rehabilitation requirements and active involvement in the determination rather than just consultation by the Minister.

The general feeling amongst farmers, as indicated by Jim Starbuck and David Matthews, was that the "rehabilitation" requirement was insufficient and that only "restoration" was acceptable. This was based upon the belief that productive wheat and grazing land would be lost forever if mining was to proceed.

This view was adopted largely due to the soil composition of land in the area. It was generally accepted that the layer of top soil in the region was thin (three to five inches in most places), and that soil types varied significantly often in the same paddock. This led to the belief that spreading the top soil back over the land *following mining would be near impossible and accordingly returning the land to it s original productive capacity could not be achieved.*

Duncan Bell representing the VCM submitted that community attitudes with respect to mining were coloured by events of 50 or 100 years ago. Therefore farmers must be able to see what happens in today's rehabilitation before they can be confident. Mining companies now have expertise in hydrology and botany that is often more advanced than the expertise of Government departments. For example, mining industry technology has been used to overcome a eucalyptus die back problem at Healesville. Above all, the VCM submission noted that mining companies must be prepared to be good corporate citizens in returning land to an attractive, productive state.

Marshall Baillieu representing WIM noted the success of rehabilitation programmes along the East Coast of Australia after sand mining but also noted WIM's concern with respect to the exactitude of rehabilitation being demanded in the Wimmera.

Colin Bills, also representing WIM, noted that technology advances in land rehabilitation which will be described in the Environmental Effects Statement will also give a picture of the final condition of the land after mining. He also noted that whilst it will not be possible to "exactly" replace the trees and top soil, with planning requirements and expertise in soil and tree replacement, land will be both attractive and productive. Further, he stated that the trials were being prepared.

In support of the WIM submission, the VCM presented examples of successful rehabilitation following sand mining elsewhere in Australia. The AMC Wetlands Centre at Capel in Western Australia and the Myall Lakes region, north of Newcastle in New South Wales were both referred to. The VCM noted that neither of these projects dealt with the return of a site to farmland. However, areas in the Hunter Valley in New South Wales were discussed where several thousand hectares of coal mining operations have been returned to cattle grazing in the past decade.

Although there is no immediate precedent in rehabilitating country similar to the Wimmera to its original use, the VCM did not see this as an insurmountable problem. As noted by Colin Bills, work is being carried out by WIM to establish the base line data that any rehabilitation plan will need. Ultimately, the WIM Environmental Effects Statement that must precede commercial mining will analyse the options.

Dr Bob Creelman, representing Fidunu Mining Company, a fully owned subsidiary of Dennison Mines Ltd of Canada, also ventured that rehabilitation of mined land had been successful elsewhere. He did however acknowledge, along with WIM and VCM, that further research was required on the issue. This latter view was echoes by the farming community.

Frank Drum accepted that if the miners could restore the land to its original productive capacity then mining on the land would be more acceptable. Robert McDonald and Richard Hobbs also demanded that the land should be returned to it productive capacity following mining.

Gill Hopkins noted the general acceptance by the miners and farmers that further research concerning rehabilitation was required. He went on to say the results of any demonstration project would have to be near perfect.

The ability of the miners to return the land to its original productive capacity obviously affects the decision of farmers to sell to the miners. The uncertainty of both the miners and the farmers as the whether the miners could comply with these requirement led to the suggestion by Councillor John McHenry that a test site of at least 100 acres was imperative. He noted that only when the results of rehabilitation tests were known by farmers could they make an informed decision on whether to sell their land. This view was also raised by the Dunmunkle Land Protection Group which proposed that miners crop or graze the land following rehabilitation to prove its productive capacity was not reduced.

Another environmental issue of concern to Doug McHenry and the Toolondo and District Survival Committee was the permanent loss of old trees, particularly Buloke and red gum, and native species of flora and fauna. The group was also concerned that wetland in the mining area would be destroyed forever. This, they submitted, would destroy the natural habitat for particular wildlife (including the rare red tailed black cockatoo and the brolga) and upset the ecosystem. The Wimmera Branch of the Australian Conservation Foundation expressed similar concerns.

In raising the issue of the rehabilitation bond, David Matthews suggested the size of the bond should be substantial and secured before mining commences to ensure complete restoration will be carried out. The Shire of Dunmunkle also argued that more stringent controls were required prior to release of the bond. The VCM submission noted that a larger rehabilitation bond was a likely outcome under the proposed Bill due to concessions made by mining industry.

5.3 ***Water***

Concerns were raised about water supply, cost increases and contamination and on the effects of mining on the water table and salinity levels. Areas of equal concern were surface water, underground water and the Wimmera Mallee Domestic Stock Supply System.

Price
The potential for water price increases during mining was raised in a number of submissions. Such concerns do not appear to be based upon any predictions made by the Rural Water Commission (RWC) but rather upon the assumption that there would be greater demand of water but no more supply.

Supply
The Dunmunkle Land Protection Group submitted that the local people felt that there was insufficient water supply in the Wimmera-Mallee Domestic Stock Supply System to support both agriculture and mining in the area. This was supported by other landowner submissions. However, the possibility of an increased supply brought about by water saving through piping was not acknowledged.

The Land Conservation Council in 1986 recommended the implementation of a piping scheme in the Wimmera as a means of saving water currently lost through *extensive seepage in delivery channels. The Council at that time advocated the use of this water for environmental flows as a priority to mining.*

Marshall Baillieu of WIM told the Committee that WIM was prepared to consider financing the piping of significant sections of the Wimmera-Mallee system, and that the water saved would be sufficient for WIM's requirements. Losses of up to 90 per cent occur in some areas and farm water supplies could be unaffected if current negotiations between WIM and RWC can be satisfactorily concluded.

The Committee considers the additional cost of reticulation to individual farms, because of different land levels, will need to be satisfactorily addressed. It was submitted by Jenny Barnett of the National Parks Association that as a goodwill gesture to the community, WIM should ensure sufficient water is piped to supply the mining operations and a further 25 per cent for farmers and other users and environment flows.

Contamination

Contamination of surface water, underground water and the Wimmera Mallee Domestic Stock Supply System from mining in the area was a widely held concern.

The landlocked nature of much of the water supply in the area heightened the community fear of long term detrimental effects.

The disposal of waste or run off water was seen as a possible major cause of contamination. The possible exposure of shallow aquifers in the dredging process resulting in contamination was also regarded as a potential problem. The adequacy of potential safeguard measures was also queried particularly in the event of flooding.

Joan Bennet drew attention to the quality of water from limestone aquifers, and the long term effects of possible contamination, and the need to "cap" test bores to stop leakage between aquifers at different levels.

It was noted that insufficient information concerning the mineral extraction process resulted in a degree of uncertainty as to the precise nature of the contaminants. However, those of main concern were radioactive minerals, saline water and chemicals used in the extraction process.

WIM submitted that due consideration will be given to these concerns in any Environmental Effects Statement required prior to mining.

VCM submitted that the mining industry has experience in successfully operating in water catchment areas and in areas where nil discharge conditions are imposed.

Radioactivity is considered separately in this Report - see below.

Salinity

The effects of mining on salinity in the area was raised in most submissions. It was generally argued that salinity levels would rise during mining due to the disposal of saline waste water, the removal of trees, alteration of the soil profile and the greater volume of water flowing through the system with consequent increases in leakage.

It was also submitted that the height of the tailings dam above the ground level could also increase hydraulic pressure and cause salinity problems. The Avon Plains Landcare Group and the Dunmunkle Land Protection Group referred to a court case involving Lake Batyo Catyo. the facts of that case indicated that rises in water levels in lakes or dams above ground level causes the surrounding water table to rise in similar proportions.

While the deleterious effects of increased salinity levels on the productivity of farmland was the major concern, the Wimmera Anglers Association was concerned with the effect of salinity and contamination on fishing in the area. Peter and Debbie Funcke were similarly worried about the effects of poorer water quality on the productivity of their fresh water aquaculture venture near the Richardson River.

Generally most submissions called for more detailed information and research regarding the use and disposal of mine water.

In response to concerns about salinity and the environment, VCM argued that the Australian mining industry has gained a world reputation for rehabilitating mined areas. The use of salt resistant eucalypts, developed by Alcoa, to help fight salinity and protect the jarrah forests of the Darling Ranges, was one example given.

VCM also submitted that the mineral sands operation proposed for the Wimmera is one where rehabilitation poses relatively few problems. Because the mined areas would move progressively across the mineral deposit, it is possible to plan rehabilitation with greater precision than in the case of a less uniform ore body in more rugged terrain. the submission continued, it is anticipated that most of the land mined in the Wimmera would revert to agricultural use. Finally, before a detailed proposal for rehabilitation is drawn up, WIM would consult with landowners, relevant government departments, local councils and other interested bodies.

John Mc Henry referred to the need for continuing assessment and monitoring to ensure that rehabilitation was satisfactory.

5.4 *General community concerns*

The effect of mining on the wider community was an issue raised in may submissions. It was suggested that mining would have a detrimental effect on small business and tourism in the area. However, little evidence was given to substantiate these claims and unfortunately no-one directly involved in tourism or small business made a specific submission to the committee.

Considerable emotion was displayed concerning the potential loss of local heritage due to families forced to sell their land and move to alternative districts. Some of the families affected have farmed the area for up to six generations. It was evident that the impact of such an upheaval was significant on the families themselves, the small towns and the general community. Erosion of community spirit was also evident due to the surrounding uncertainty.

In its submission, the Toolondo and District Survival Committee suggested that families leaving the area could result in the closure of the State Primary Schools at Noradjuha and Clear Lake. It also suggested that survival of sporting clubs and fire services in the district may also be placed in jeopardy with consequent effects on the maintenance of facilities such as halls and recreation reserves. The submission reflected the general feeling that the mining community would centre its activities around Horsham rather than the surrounding towns. It failed to acknowledge that mining could introduce new members into the area possibly boosting the support of these groups and facilities.

There is considerable uncertainty as to whether the communities surrounding Horsham will benefit from mining in the area. The contribution WIM is willing to make to allay these areas of broader community concern and the willingness of the local community to embrace such contribution will be crucial in this issue.

5.5 *Radiation [nuclear activities (prohibitions) Act 1983] and Health*

A number of submissions raised concerns over the possible release of radon gas and increase in the level of radioactivity resulting from the mining process.

Radioactive thorium and uranium are contained in the rear earth minerals monazite and xenotime which are present in the ore body in extremely low levels. According to the WIM submission, the respective levels by weight of thorium and uranium I the ore body are approximately 0.003 per cent and 0.0003 per cent.

WIM have confirmed that they are not mining for thorium or uranium and the neither of these substances will be produced at the mine.

Dr Michael Axtens representing Doctors Opposing the Nuclear Threat and David Mudie both suggested that in processing the sands into their individual minerals, the radioactive substances would become more concentrated. Dr Axtens further suggested that this radioactivity may be released into the water used in the process, becoming a potential contaminant if released or contained on site. In arguing that no level of radioactivity was safe, Dr Axtens noted that radiation limits set by governments have been progressively revised downwards over the years. He also argued, as did David Mudie, that importers were increasingly turning to countries *with clean nuclear records and that Australia's reputation could be tarnished if sand mining was allowed to proceed. Dr Axtens generally disagreed with the position adopted by governments who allow radiation levels which do not impose an unacceptable burden on society due to health effects. While arguing that sand mining should not proceed for these reasons, Dr Axtens suggested that the most pessimistic calculation of radiation risk should be adopted.*

WIM's submission noted that such an approach has been adopted in tests performed to date and that recorded levels were still well below recommended maximum levels. WIM's submission also noted that its proposed mining activities comply with the Nuclear Activities (Prohibitions) Act 1983. The Minister for Industry and Economic Development Hon David White was quoted by the Company as acknowledging this with respect to WIM 150. It was also noted that the Victorian Solicitor - General has advised the Victorian Government that the WIM 150 proposal is entirely legitimate.

On the issue of health, WIM acknowledge that radiation will be elevated to levels above those the community is exposed to on a daily basis from the sun and natural conditions. But this, it submitted, is still at extremely low levels and confined to close proximity to the mining and processing areas. The submission states the surrounding districts will not experience any measurable effect in regard to additional radiation, and radiation levels will be below the levels existing in may residences due to radon gas.

So far as the exposure of workers in the WIM plant and operations are concerned, WIM stated the expected slightly elevated radiation levels will be well below the maximum exposure limits set by statute. Further, the Company has established a Radiation Management Plan to protect against workers at the pilot plant being subjected to dangerous levels of exposure. It is assume as similar Plan will be adopted for subsequent mining activities.

The issue of radon gas was also raised Dr Axtens noted the impact of the gas in poorly ventilated areas, particularly in the United States where it is reported to be the second largest cause of lung cancer after smoking. Nevertheless, no firm evidence was adduced to establish a link to this with mining activities.

WIM acknowledged that the levels of radon gas were slightly elevated during and shortly after construction of a costean but that these levels barely exceeded those typically found in an Australian home. It was further submitted by WIM "to keep things in perspective", that ploughing a field similarly increases the level of radon in the atmosphere.

Dr Sutherland noted that radioactivity is an emotive word, often not understood, and that it is easy to over-react. These matters will be further considered in the Environmental Effects Statement which will form part of the process of public scrutiny called for by David Mudie and Dr Axtens.

*5.6 **Compensation***

Farmers faced with the prospect of having their land mined generally have two alternatives. They can sell to the mining company provided the company is interested in buying, or they can retain ownership of the land and receive compensation. Farmers were generally unhappy about these alternatives.

It was submitted that if they sell, the price paid for the land may be depressed cause only the miners are interested in the land. It was argued that a lack of "agricultural" buyers exist because of the uncertainty created by proposed mining. Suggestions were made that land values in the area were already depressed for this reason. The Committee accepts this as a possible factor but also notes that ..... economic circumstances and depressed prices for wool and wheat may also have an impact on existing land values at this time.

The Toolongo and District Survival Committee argued that the miners should be forced to buy for at least twice market value to adequately compensate the land owner for costs incurred, such as:

- *relocation of family*
- *relocation of plant and equipment*
- *worry and trauma*
- *lost income as a result of relocation*
- *lost local markets for produce*
- *lost development on farm*
- *goodwill in agricultural circles*
- *goodwill in community and service centres*
- *stamp duty*
- *legal costs*
- *capital gains tax*

The Committee acknowledges that many of these costs are valid but notes that under existing legislation there is no requirement that the miner purchase the land. Amendments to the Mineral Resources Development Bill would be required to achieve this objective.

Incorporating some of these costs into the compensation provisions for farmers intending to retain ownership may be more feasible, particularly as it was submitted that even if the farmer decided to retain ownership, or the mining company was no longer willing to buy, compensation payable would still be insufficient. Again, amendments to legislation may need to be considered. It may be necessary to increase solarium in Clause 85 of the Bill from 10 per cent to 20 per cent.

The VCM on the other hand noted that industry experience reveals that in a great majority of cases compensation agreements are amicably arrived at.

The VCM submission also noted that where purchase of land was justified, the mining companies would take into account non economic factors in negotiating a fair purchase price. These included the strong attachment to the family farm that exceeds that felt for a purely economic asset and the difficulties of uprooting ones family from a community and making a fresh start elsewhere.

Shire of Dunmunkle Concerns

The Shire of Dunmunkle, in their submission to the National Party Parliamentary Committee, outlined their concerns as:

- *The Victorian Government intended making the Department of Industry and Economic Planning the "Planning Authority" and "Responsible Authority" under the Planning and Environment Act for dealing with Planning Scheme Amendments and Permits related to mining issues. This decision was made without consultations with Local Government. See "Authorisation of Minister for Industry and Economic Planning to Prepare Amendments to Planning Schemes" sent by David Rae, Department of Planning and Urban Growth and the response from the Municipal Association of Victoria "Planning Scheme Amendments Relating to Mining".*
- *the loss of rates. If land use went from predominantly farming (which is ratable) to mining (non-ratable) Council could lose a large proportion of it's ratable income. In addition, mining would lead to additional costs for local government due to heavy traffic on local roads in the mining area.*
- *landholders may not be sufficiently compensated*

Community Action to Date

In response to community concern over the possibility of mining, public meetings were held on 6th and 7th June 1990 in the WIM 200 (Rupanyup) and WIM 250 (Banyena) areas, to discuss the possibility of forming a group, and what action should be taken. A group formed, called the Dunmunkle Land Protection Group (DLPG). 120 property owners each contributed $250 for the establishment of a trust fund.

One of the first activities of the group was to hire the legal services of Peter Bobeff of Corrs Australian Solicitors, who had in the past represented mining companies in the acquisition of land. Peter Bobeff met with CRA to discuss their plans, and advised their group to lobby politicians and prepare their own environmental Impact Study.

The main activities of the group can be summarised as follows:

- met with National Party Politicians on the Parliamentary Mining Committee to discuss concerns
- liaised with VFF, Australian Conservation Council, Department of Agriculture, Department of Manufacturing and Industry Development
- investigated the possible side effects on the water table and salinity and the effect of radiation due to mining
- visited other mines to assess the quality of rehabilitation
- pushed for trial work to be done to assess the soils prior to and after mining, and productivity of agriculture in the Shire of Dunmunkle
- lobbied WIM to put in a trial costean in the Shire of Dunmunkle to show the quality of rehabilitation

Council action

The Shire of Dunmunkle, prepared a funding submission in consultation with the DLPG (dated 17th September 1991), seeking funding from the Department of Manufacturing and Industry Development. Council expressed concern about:

- the restoration of farm productivity should mining take place
- effects on groundwater level changes during and after mining
- effect of increases in the ground level after soil is replaced

Concern was expressed that the Stage 1 Report on Rehabilitation at WIM 150 by Coffey M.P.W. had not adequately addressed these issues. It recommended that a joint technical committee be formed, consisting of farmers, mining company representatives and technical staff in the area , to address the rehabilitation issue. Council requested financial assistance to carry out research on the following areas

Farm Productivity

Review and analysis of comparative data from other rehabilitation projects.
Preliminary classification of soil types in the regions affected.
Preparation of past production figures to form the basis for any later study.
Review and modification of current WIM 150 rehabilitation project.

Groundwater and Ground Level Changes

Review of any technical information from WIM on these problems.
Discussion in detail of any likely effects on specific properties.

Council intended hiring services of Robert van de Graaf, a soil scientist and Len Walker, a geotechnical engineer. They requested $40 000 to carry out this work over a 12 m period. Following discussion between the Shire of Dunmunkle, the DLPG, WIM, DMID and Dept. of Food and Agriculture, The Department of Manufacturing and Industry Development approved the following package to assist the Shire and DLPG:

1. Improved access to WIM 150 EES process for review, advice and assistance to Shire of Dunmunkle and DLPG on project issues

2. DFA to report on past and current farm productivity issues and land management systems for WIM 200 and WIM 250 areas in Shire of Dunmunkle. DMID to fund the study at a cost of $10 800.

3. DFA to supply "Farm Biz" and "Farm Record Book" farm management system and training package to landowners to enable the collection of reliable farm productivity and related information. DMID buys "Farm Biz" package at a cost of $5 625.

4. Provision of a $10 000 grant to the Shire of Dunmunkle to allow the Shire to employ suitable person(s) to provide advice on mining and rehabilitation matters.

The estimated total cost of the package was $26 425.

(From letter written by Keith Bowen, General Manager, Project Facilitation Division, DMID to Minister David White, dated 3rd March 1992).

Visits to Other Mining Areas

Various members of the DLPG and Dunmunkle community have visited other areas affected by mining in Australia and overseas - in an effort to understand the processes and risks and possibilities from land rehabilitation.

See Appendix 6 for a report prepared by Ian Morgan on visits made to mine sites by Ian Morgan and Jim Starbuck in 1990. Also, see photographs of sand mining and rehabilitation on page 28.

AGRICULTURE AND THE LAND RESOURCE

Production Levels Around Rupanyup

"The Yarriambiack Shire had a GVP for agriculture of $215 069 168 in 1995-96, the highest in the region and comprising 3.9% of the Victorian total. This is almost exclusively (89%) the product of cropping activity, particularly wheat, barley and chickpeas. Wool ($9 891 891) and livestock production for meat ($11 970 575) together contributed less than 10% of the total GVP, although these contributions were not insignificant". See **Appendix 5** on Shire of Yarriambiack.

A summary of crop yields and other information from the MEYCHECK program in 1994 is included as **Appendix 7**.

Data on crop yields are available from Australian Bureau of Statistics. Raw data and summaries from this source are appended to this report as **Appendix 8**. Graphs summarising the statistics for 1992-94 on area sown by crop in (former) Shire of Dunmunkle are shown in Figs. 10 and 11.

Soils in the Rupanyup Area

The soil associations of the former Shire of Dunmunkle are shown in Fig 12. The proportions of each soil type are shown in Table 1.

Table 2 Soil associations in the former Shire of Dunmunkle and approximate % area

SOIL ASSOCIATION	DESCRIPTION	Percent
Callawada	Water course clays	10
Wal Wal	Cracking clays with bleached subsurface layers	14
Donald	Hard alkaline duplex soils	2
Kalkee 1	Cracking grey clays	29
Kalkee 2	Cracking grey, brown and red clays	9
Murra Warra	Cracking brown & red clays, & some grey clays	36

Derived from Badawy 1984. Soils of the Eastern Wimmera.

A study of profiles of main soil types in the WIM 200 and 250 areas (see Fig 1) Dunmunkle area was commissioned by the DLPG . The Report by Alan Bedggood is presented as **Appendix 9**.

Figure 10 Area Sown by Crop, 1961 – 1994, Dunmunkle

(Source ABS)

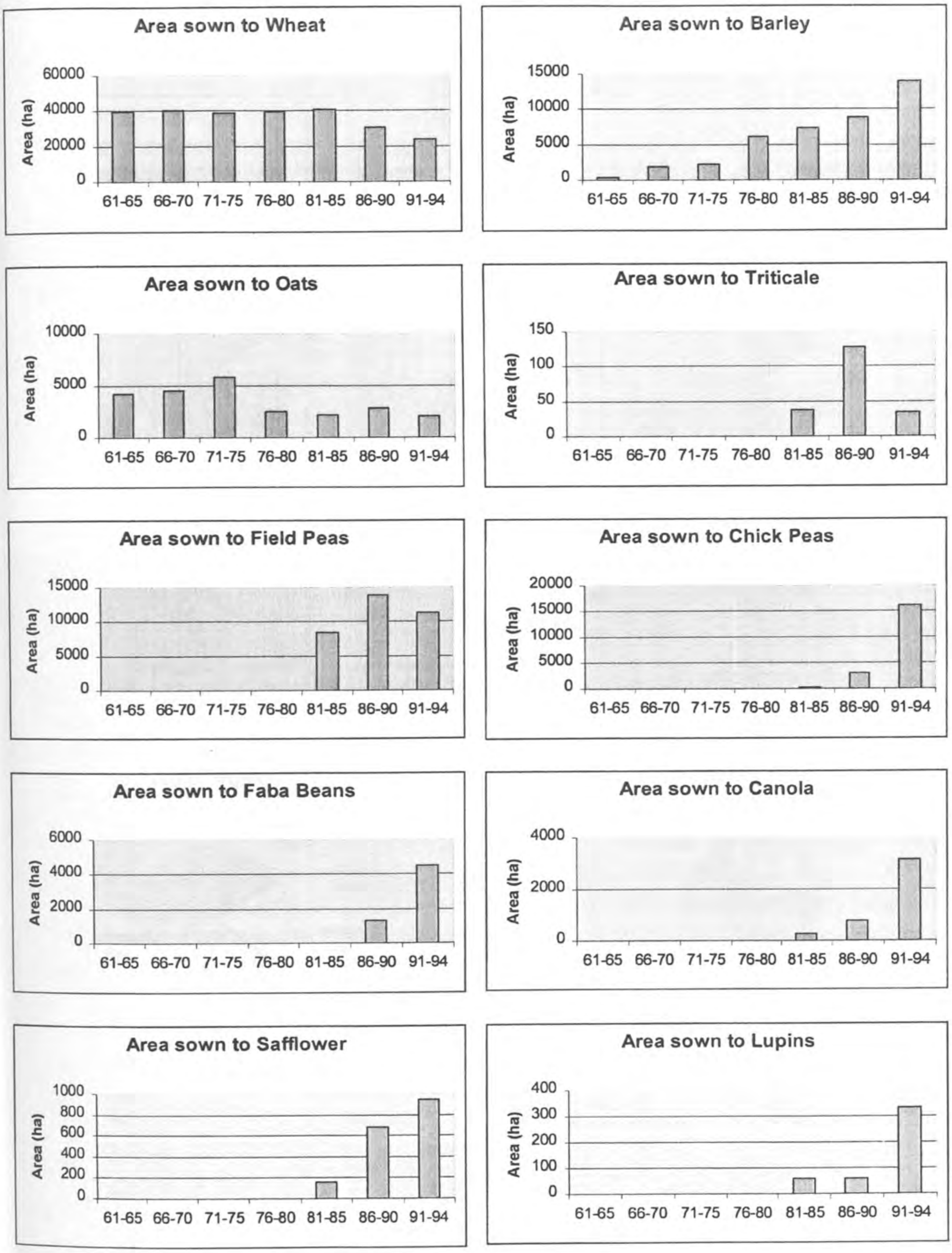


Figure 11 Area Sown by Crop (Ha), Five Year Average, 1961 – 1994, Dunmunkle, as a percentage of total cropped area
(Source ABS)

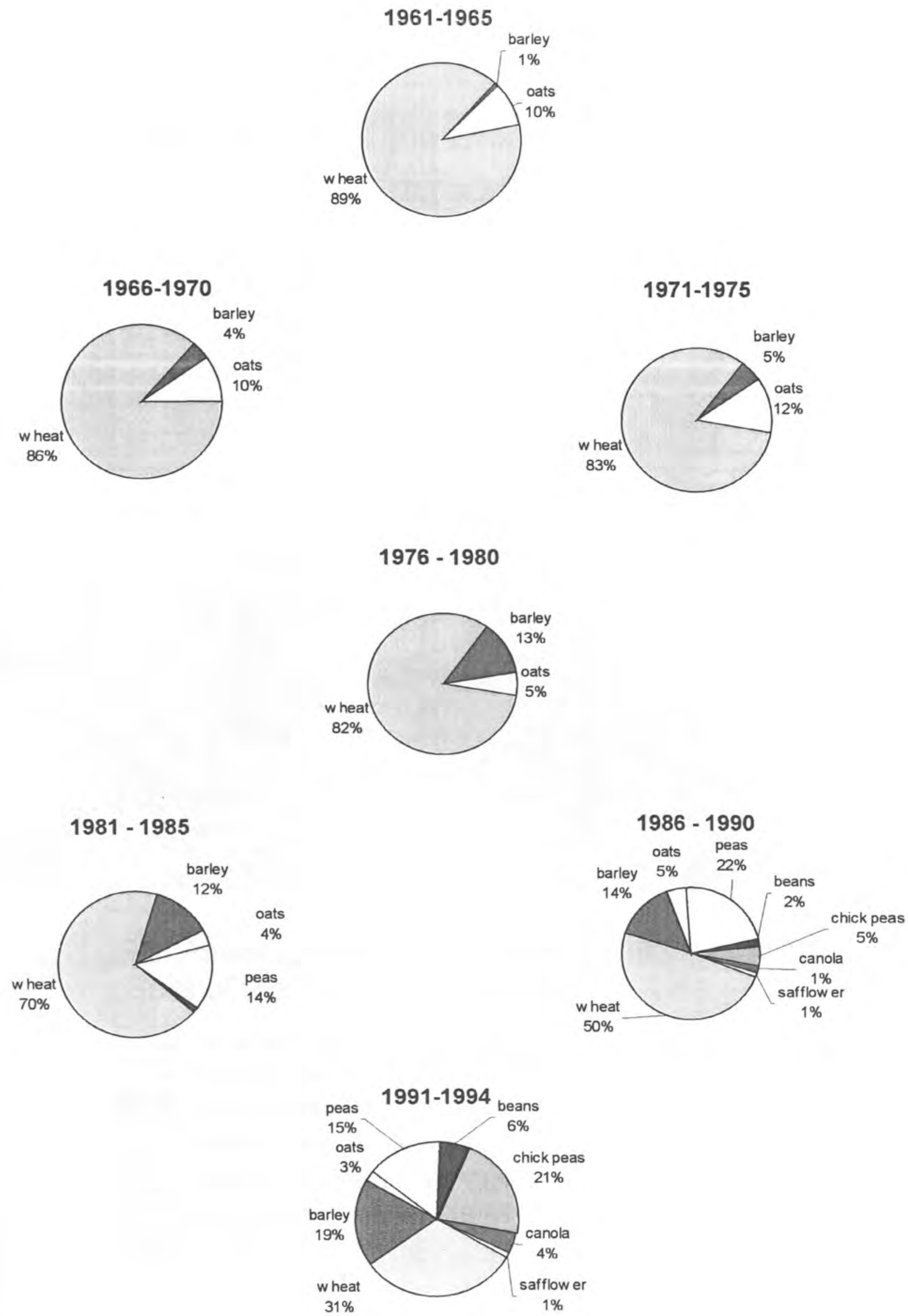
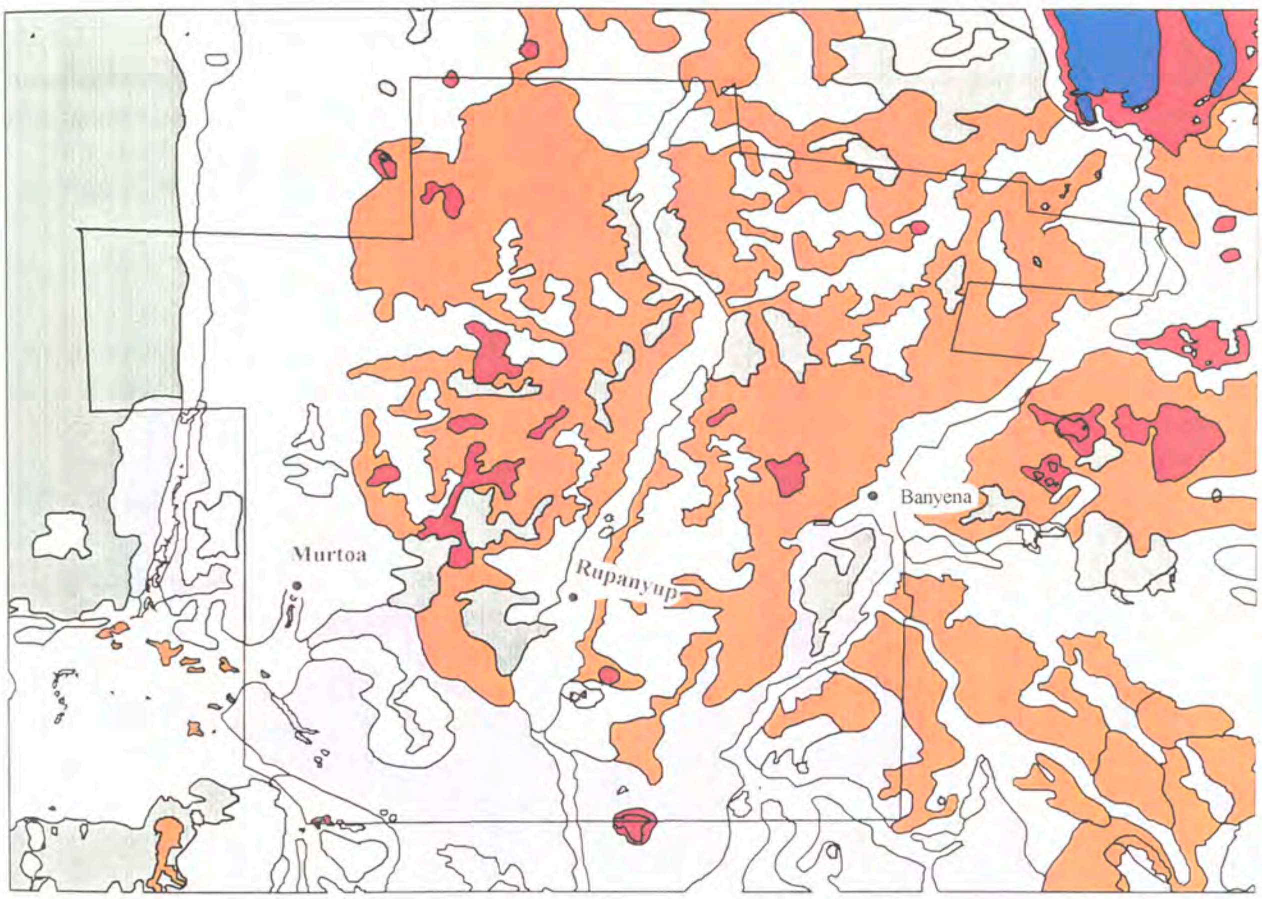


Figure 12 Soil Associations of the Shire of Dunmunkle

See Fugure 1 in Appendix 1 for locations of main rural centres on this map.



Soil Assoiciations, after Badawy 1983
(Soils of the Eastern Wimmera)

- Callawada - water course clays
- Wal Wal - cracking clays with bleached subsurface layers
- Donald - hard alkaline duplex soils
- Kalkee 1 - cracking grey clays
- Kalkee 2 - cracking grey, brown and red clays
- Murra Warra - cracking brown and red clays, with some grey clays
- Lake Buloke

Land Management Units

The Rupanyup area is in the *Wimmera Plains* resource management unit (see map – **Appendix 10**). The area consists of irregular, slightly undulating plains, with pronounced ridges and occasional dunes. The soils are mainly uniform grey self mulching and brown cracking clays, and some red duplex. Predominant native vegetation was open woodland forest with Black Box, Buloke and Yellow Gum and Grey Box. Rare and threatened flora are located on some sites (CNR 1993: Wimmera Regional Landcare Plan, Landcare Victoria; and also Wimmera Regional Catchment and Land Protection Board 1997).

Land Use

The land is used predominantly for broadacre dryland agriculture, with minimal grazing. Annual rainfall is 350-400mm.

Native Vegetation and Wildlife

"Originally the Wimmera Plains were covered by open forests and woodlands of Yellow Gum (*Eucalyptus leucoxylon*), Buloke (*Allocasuarina leuhmanii*), Black Box (*Eucalyptus largiflorens*) and Grey Box (*Eucalyptus microcarpa*) with large areas of natural grassland occurring between these woodlands. It is estimated that between one and two per cent of this original vegetation remains on the Wimmera and Mallee Plains.

Over 80% of the entire Wimmera Catchment has been cleared for agriculture. Most of the extensive areas of remaining native vegetation are on public land, and only about 1% of private land supports remnant vegetation. Remaining areas of native vegetation are home to a diverse range of flora and fauna and a large number of rare and threatened species" (DNRE 1998: Yarriambiack Creek Management Plan).

The main areas of native vegetation in the area are:

- Brinterion Reserve
- Mutton Swamp
- patches of buloke and black box on crown and private land
- properties which front onto the Dunmunkle Creek

The Banyena area has more timber areas, especially waterways along the Richardson River.

Although these areas are small, they are significant on a State level,
because the areas are diminishing in size and number, particularly the buloke stands.

Some Critical Issues in Land Rehabilitation After Mining

From the study of soils associated with the proposed mining sites in the Rupanyup area (**Appendix 9**) and information gleaned about possible mining by dredging, there appear to be many areas that need to be considered in land rehabilitation for use in cropping after mining. Three of these are outlined below:

1. Topography/landscaping

If mining were to go ahead, during the rehabilitation phase the surface drainage pattern could be reshaped - and this could be to the advantage or disadvantage of the community. For example, slopes could be made more gentle, or steeper in places. The whole topography could be altered, within limits. Material could be replaced so that drainage lines were similar to before, or so that water could be controlled, to concentrate more water, or to create wetlands or other characteristics desired by the owners or community. Water flow could be sped up, or slowed down, so that there was more recharge. It is important that the community be aware of this possibility and retain control of their future landscapes. This aspect could be very important in relation to the effects on future salinity in the region, and may also offer possibilities for creation of a desirable living environment after mining, if it was to proceed.

2. Soil could be misplaced, if not very carefully controlled

Depending on the mining process adopted, there could be a danger that during mining and rehabilitation, the most valuable top 1-2m is mis-located during the backfilling process (although the Act may prohibit this). Thus soil may end up many metres away from its origin. Consequently, paddocks (or farms?) could lose some of their topsoil, and inherit topsoil from other paddocks (farms?). Potentially, a farmer who has good soil structure, organic matter, a high population of soil microflora, few weeds and soil borne diseases may inherit topsoil which is inferior, and vice versa.

A most important aspect of rehabilitation would be the precision with which materials (particularly topsoil) are replaced at the correct level in the profile. Mistakes in this process could have disastrous effects on productivity of rehabilitated land for cropping. Landowners need would to ensure that they have control over how soil is handled and replaced in the profile on their farms.

3. Potential for sodic, saline or soil of high pH to be brought near the surface

A major issue is that of bringing the poorer subsoil to the surface. Great care would need to be taken to ensure that the subsoil, which may not be conducive to plant growth, is not brought to the surface. For example, the self-mulching grey clay at Lingham's property at Rupanyup South displays increasing pH at depth. The topsoil pH is 8.1, but the pH of the subsoil at a depth of 50-70cm is 8.8. At Jim Starbuck's, the " sodicity of the soil increases with depth, as does the dispersion, which restricts water penetration." At David Matthews property at Burrum, "the salinity level rises at depth to levels which begin to inhibit plant growth and would be a limiting factor for rooting depth" and availability of nutrients.

Another issue would be that the different soil types on a farm would inevitably be mixed or changed, and farmers would have to re-learn the land capability of their land in each part of the farm.

One positive result could be that in the more saline areas around Banyena, the non-saline soil in the rises could be used to make the topsoil thicker in the flat saline areas, effectively making the topsoil less saline by burying the saline soil under non-saline soil.

REHABILITATION WORK AT WIM 150

At their WIM 150 site near Drung, WIM excavated three costeans, a borrow pit and two sets of tailings dams, covering an area of almost seven hectares. These areas have been filled in and rehabilitated, mainly as cropping and grazing land. This is the first time in Australia that rehabilitation after exploratory mining activity has been attempted on cropping land. WIM claims that the results indicate that crop yields on the previously mined land are at least as high on surrounding unmined areas (unpublished). Further, trials over the years since 1991/2 have allowed the development considerable knowledge and practical rehabilitation methods for the Drung area.

The DLPG feels that the rehabilitation studies on the rather poorly drained soils at Drung have little relevance to the Dunmunkle area, and would like to have trials conducted in their area (see Appendix 4. National Party Parliamentary Mining Committee 1990, p.2) before mining proposals are approved.

The results of the rehabilitation work at Drung (WIM 150) are not currently available to the public, but some are to be published later in 1999 at a conference on mineral sands.

REFERENCES

Badawy, N (1983) Soils of the Eastern Wimmera, Department of Agriculture, Victoria.

CNR (1993) Wimmera Regional Landcare Plan, Landcare Victoria, (Dept of Conservation and Natural Resources).

DNRE (1998) Yariamibiack Management Plan, Prepared for Dept of Natural Resources and Environment (DNRE), by University of Ballarat.

Energy Australia (1998) Murray Darling Basin Heavy Mineral Deposits. [Map in Figure 2]

Huntley I (1998) Murray Basin Mineral Sands Review, Consultants Report, Ian Huntley Pty Ltd.

National Party (1990) Investigation and Report on a Proposal to Mine Heavy Mineral Sands in the Wimmera, National Party Parliamentary Mining Committee, Canberra, October 1990 [Appendix 4]

Smart J (1989) The Hydrogeology of the WIM 150 Study Area and the Effects of Mining, Wimmera Industrial Minerals Pty Limited, Paper presented at the conference on the Wimmera River Catchment of the River Basin Management Society, Horsham, October 1989.

WIM (1989) Environmental Effects Statement: WIM 150 Demonstration Project, Wimmera Industrial Minerals Pty Limited, January 1989 [Appendix 2]

WIM (1991a) WIM 150 Project, Drung South, Shire of Wimmera near Horsham, Victoria: Brief Project Description", Wimmera Industrial Minerals Pty Limited, 28 June 1991 [Appendix 3].

WIM (1991b) Wimmera Industrial Minerals, Groundwater Modelling Study of Mineral Sands Mine, Coffey Partners International Pty Ltd, August 1991.

Wimmera Catchment Authority (1998) Wimmera Catchment Region, Demographic and Socio-Economic Profile: A strategic review of the social and economic character of the Wimmera Catchment Region, TBA Planners Pty Ltd with SGS Consulting, McGuinness and Associates and Neil Clark and Associates, November 1998 [Appendix 5]

Wimmera Development Association (undated) The Wimmera: A Socio Economic Profile, Wimmera Development Association, Horsham.

Wimmera Regional Catchment and Land Protection Board (1997) Wimmera Regional Catchment Strategy, Horsham, Victoria.

APPENDIX

TO

MINERAL SANDS IN THE WIMMERA AND POSSIBLE IMPACT OF MINING IN THE RUPANYUP AREA

A Report Commissioned by the Dunmunkle Land Protection Group

January 1999

Appendix 1	Press release and article on mineral sands exploration in the Wimmera 1998 a) Deputy Premier opens up Wimmera's sand mining exploration area fro competition and hastened development. 11 September 1998 b) Sands decision sets stage for scramble (the Age, 14 September 1998)
Appendix 2	Environmental Effects Statement : WIM 150 Demonstration Project. Wimmera Industrial Minerals Pty Limited, January 1989
Appendix 3	WIM 150 Project, Drung South, Shire of Wimmera near Horsham, Victoria: Brief Project Description", Wimmera Industrial Minerals Pty Limited, 28 June 1991.
Appendix 4	National Party Parliamentary Mining Committee, "Investigation and Report on a Proposal to Mine Heavy Mineral Sands in the Wimmera", National Party, October 1990.
Appendix 5	Wimmera Catchment Authority (1998) Wimmera Catchment Region, Demographic and Socio-Economic Profile: A strategic review of the social and economic character of the Wimmera Catchment Region, TBA Planners Pty Ltd with SGS Consulting, McGuinness and Associates and Neil Clark and Associates, November 1998.
Appendix 6	Reports by DLPG members on Visits to Other Mines
Appendix 7	Meycheck Paddock Report, 1994, Rupanyup, Department of Agriculture.
Appendix 8	Raw data from Australian Bureau of Statistics, on Area by Commodity, 1992 – 1994. Rupanyup Shire (former boundary). Summary of Statistical Data, Area by Commodity, 1961 - 1994.
Appendix 9	Preliminary Study of Soils Associated with the WIM 200 and WIM 250 Mining Sites in The Yarriambiack Shire (1999), Prepared for the Dunmulkle land Protection Group, by Alan Bedggood, Victorian Institute of Dryland Agriculture, DNRE, Horsham.
Appendix 10	Map of Resource Management Units. Wimmera Regional Catchment & land Protection Board (1997) Wimmera Regional Catchment Strategy, DNRE, Horsham, Victoria.

APPENDIX 1

Press release and article about mineral sands in the Wimmera (1998)

a) **Deputy Premier opens up Wimmera's sand mining exploration area for competition and hastened development. 11 September 1998**

b) **Sands decision sets stage for scramble (The Age, 14 September 1998)**

NEWS RELEASE

From the Office of the Deputy Premier
and Minister for Agriculture and Resources

Friday, 11 September 1998

DEPUTY PREMIER OPENS UP WIMMERA'S SAND MINING EXPLORATION AREA FOR COMPETITION AND HASTENED DEVELOPMENT

Deputy Premier and Minister for Agriculture and Resources, Mr. Patrick McNamara today announced that as a result of a major restructuring of Rio Tinto PLC's Wimmera exploration acreage, fine grained mineral sand and coarse grained sand strandline deposit exploration acreage will soon be opened up to other mining companies.

Mr McNamara said that in the interest of all Victorians he could not allow such a large area of land to remain undeveloped.

"Unfortunately, while Rio Tinto has identified substantial deposits of fine grained mineral sands with the potential to underpin a major new export industry for Victoria, as yet unresolved economic and market entry problems have delayed development", Mr McNamara said.

"Rio Tinto understood my view and has cooperated in the process of restructuring".

The Deputy Premier said a number of companies have been actively exploring for strandline deposits of coarse grained mineral sands in the Mallee and Wimmera.

"Based in part upon geological information from the Government's $25 million Victorian Initiative for Minerals and Petroleum (VIMP), several rich deposits have been discovered in the Mallee. Plans to develop these deposits are progressing well and final approval of the first of these projects is anticipated later this year", Mr McNamara said.

"I am confident that there will be a great deal of interest in the land area we are putting up for exploration and that the extra competition I am introducing will maximise the probability of developments which will in turn bring new industries and jobs to the region".

Rio Tinto, through the former CRA Ltd subsidiary, Wimmera Industrial Minerals Pty Ltd, has held approximately 3000 square kilometres in the Wimmera region under Exploration Licences since 1979.

The Rio Tinto Exploration Licence area has now been reduced to 316^2 kilometres with the balance of the area placed under temporary exemption from exploration and mining licence applications.

"This exemption will be lifted, and the area released for exploration bids, after the acreage has been marketed to the national and international industry", Mr McNamara said.

"The area retained by Rio Tinto is however, sufficient for them to develop a world scale minerals sands production operation lasting many decades".

"My Department will ensure that the interests of farmers are protected throughout these activities".

"Modern minerals sands mining and rehabilitation processes, undertaken by responsible companies can co-exist with, and bring great benefits to Victorian rural communities", Mr McNamara said.

Media enquiries:
John Richards press secretary; ph: (03) 9651 5799
Barbara Ryan DNRE media liaison officer; ph: (03) 9637 8036

RJP2/MEDIAREL

Sands decision sets stage for scramble

GARIMPEIRO

BARRY FitzGERALD

The Victorian Government has set the stage for something of a pegging rush in the Wimmera after convincing Rio Tinto that it should loosen its grip on mineral sands exploration ground in the region.

Rio Tinto has held about 3000 square kilometres of prime mineral sands ground in the Wimmera under exploration licences since 1979, hoping to get up a world-class project.

It found the WIM deposits near Horsham, which were big but did not make it to the development stage because the fine-grained nature of the sand was always going to make it difficult to produce an acceptable product.

What's more, responsibility for the WIM project shifted to Canada in the international carve-up of responsibilities that followed the "merger" between CRA (now Rio Tinto) and its British parent, RTZ.

The long and the short of it is that the WIM project has been in the deep freeze for several years and looks like staying that way. One for the grandchildren, if you like.

So did Rio Tinto really need to be locking everyone else out, particularly now that vacant exploration ground is at a premium in the great Murray Basin mineral sands boom to the north-west?

No it didn't. And with a bit of encouragement from the Government, it has contracted its licence area to 316 square kilometres, which is more than enough to protect its interests at the WIM deposits.

The Minister for Agriculture and Resources, Pat McNamara, said on Friday that in the interests of all Victorians, he could not allow such a large area of land to remain undeveloped.

The Murray Basin boom is based on exploration for coarse-grained deposits, which are easier to bring to market. According to the experts, they are known to exist on the old Rio Tinto ground but have never been chased up.

That is all about to change, with a mix of both senior and junior mineral sands groups expected to scramble for slabs of the ground vacated by Rio Tinto, now in temporary exemption.

The Government plans an international marketing campaign, hoping to attract big-spending work program bids. First acreage grants are expected within six months.

THE AGE MONDAY 14 SEPTEMBER 1998

APPENDIX 2

Environmental Effects Statement : WIM 150 Demonstration Project.
Wimmera Industrial Minerals Pty Limited, January 1989

PREFACE

Wimmera Industrial Minerals Pty Limited (the Company) holds a Development Lease over 1365 hectares at Drung South, about 18 kilometres south-east of Horsham and fronting the southern side of the Western Highway. Application is now being made to the Minister for Industry, Technology and Resources for a Mining Lease to cover 120 hectares of land wholly within the Development Lease area. This Lease, also under the *Mines Act* 1958, will permit the mining and processing of mineral sand deposits held by the Company.

This Environment Effects Statement (EES) has been prepared at the request of the Minister for Planning and Environment under the *Environment Effects Act* 1978. It covers a Demonstration Project (the Project) and describes the potential effects on the environment.

The Project is for a comparatively small mine and processing plant which are needed to determine whether full-scale commercial mining of the resource would be viable. An existing Pilot Plant is being used to develop novel methods of mineral separation.

A site-specific Amendment for the Project is proposed to the Shire of Wimmera Planning Scheme in an area that is currently zoned "Rural A". A draft copy of the Amendment is included at Appendix A however, at the time of writing, it has not been considered by the Shire of Wimmera. This EES also serves as the supporting document for the Amendment.

Formal public comment on this EES may be made by 31 March, 1989 to :-

The Shire Secretary
Shire of Wimmera
Roberts Avenue
Horsham, Vic. 3400

Such comments will be forwarded by the Shire Secretary to the Chief Assessment Officer, Ministry for Planning and Environment, Melbourne and to the Company.

Following consideration by the Shire of Wimmera of a final draft of the Planning Scheme Amendment it will be advertised and placed on exhibition under provisions of the *Planning and Environment Act*, 1988 Formal comment on the Planning Scheme Amendment should also be made to the Shire Secretary within the time stated in Council's advertisement.

If the statutory period for exhibition of the Amendment extends beyond the "due date" by which comments on the EES may be made to the Shire of Wimmera (31 March,1989, as stated above) then the due date will be extended accordingly to allow joint consideration of the two documents.

Copies of this EES may be obtained for $15, and enquiries in this and other regards should be made by contacting :-

The Secretary
Wimmera Industrial Minerals Pty Limited
Post Office Box 7292
St Kilda Road,
Melbourne, 3004
Telephone : 03 695 3017

SUMMARY

Background

Wimmera Industrial Minerals Pty Limited (the Company), a member of the CRA group of companies, proposes to establish a small scale Demonstration Project on Company-owned land which is currently held under a Development Lease.

This EES describes the Project and its potential environmental effects, and is the supporting document for an Amendment to the Shire of Wimmera Planning Scheme 1977.

The Project involves mining and processing of ore from a large mineral sand deposit (known as WIM 150) which was discovered in 1983. The operation builds on the results of laboratory and pilot scale studies and will produce sufficient quantities of concentrates for process evaluation by potential customers around the world.

The prime reason for the Project is to assess the performance of WIM 150 concentrates in the manufacture of titanium dioxide pigment. Concentrates containing the titanium mineral ilmenite and also the high titanium group (rutile, anatase, leucoxene) will be produced, as well as zircon and the rare earth minerals, monazite and xenotime.

Australia is currently a major world producer of these minerals from mines operating in Queensland, New South Wales and Western Australia. The WIM 150 deposit has the potential to contribute substantially to Australia's production should commercial viability be demonstrated.

Mining and processing

The overburden will be stripped and the ore will be mined from a pit using conventional earth-moving equipment, including bulldozers, scrapers and graders. About one million tonnes of ore and an equal quantity of overburden (clay and barren sand) will be mined over two years. Initially, overburden will be stockpiled, and later it will be placed on tailings in the mined-out areas.

Processing will involve mixing the ore with water to create a slurry, removal of oversize and undersize particles, and feeding of the slurry through a circuit which will utilize flotation, magnetic separation and other processes to separate the minerals. Reject material and tailings will initially be deposited in a clay dam, but for most of the mine life they will be deposited in the mined-out part of the pit.

Products

The individual mineral concentrates will be trucked to port from where they will be shipped to overseas customers.

CONTENTS

TABLES

FIGURES

PLATES

1 INTRODUCTION

1.1 THE COMPANY

Wimmera Industrial Minerals Pty Limited (the Company) is a wholly-owned subsidiary of CRA Limited. It was established to develop the mineral sands discovered by CRA Exploration Pty Limited (CRAE, another wholly-owned CRA subsidiary) into a long term, world scale, commercial mining operation.

CRA is a major Australian resource company whose origins go back to 1905. It has wide and varied interests in most metals and minerals of economic importance. These include copper, iron ore, lead/zinc, aluminium, coal, gold, silver, diamonds, tin and salt.

In October 1986, CRA became a majority publicly owned corporation with Australianised status as a result of The RTZ Corporation PLC reducing its shareholding in CRA from 52.3 per cent to 49 per cent.

CRA operates mining, processing and fabricating ventures, in addition to distributing and marketing metal and mineral products. These activities extend internationally to Japan, New Zealand, Papua New Guinea, the United Kingdom, the United States of America, Europe and South East Asia. A range of exploration and research programmes are also international in scope and direction.

CRA Ltd has a market capitalization of about $4.5 billion. It has assets of $8.5 billion with a capital base provided by 34 000 shareholders. Total sales revenue in 1987 exceeded $5 billion.

In 1987 CRA Group earnings were $740 million of which $409 million was paid directly in state and federal taxes.

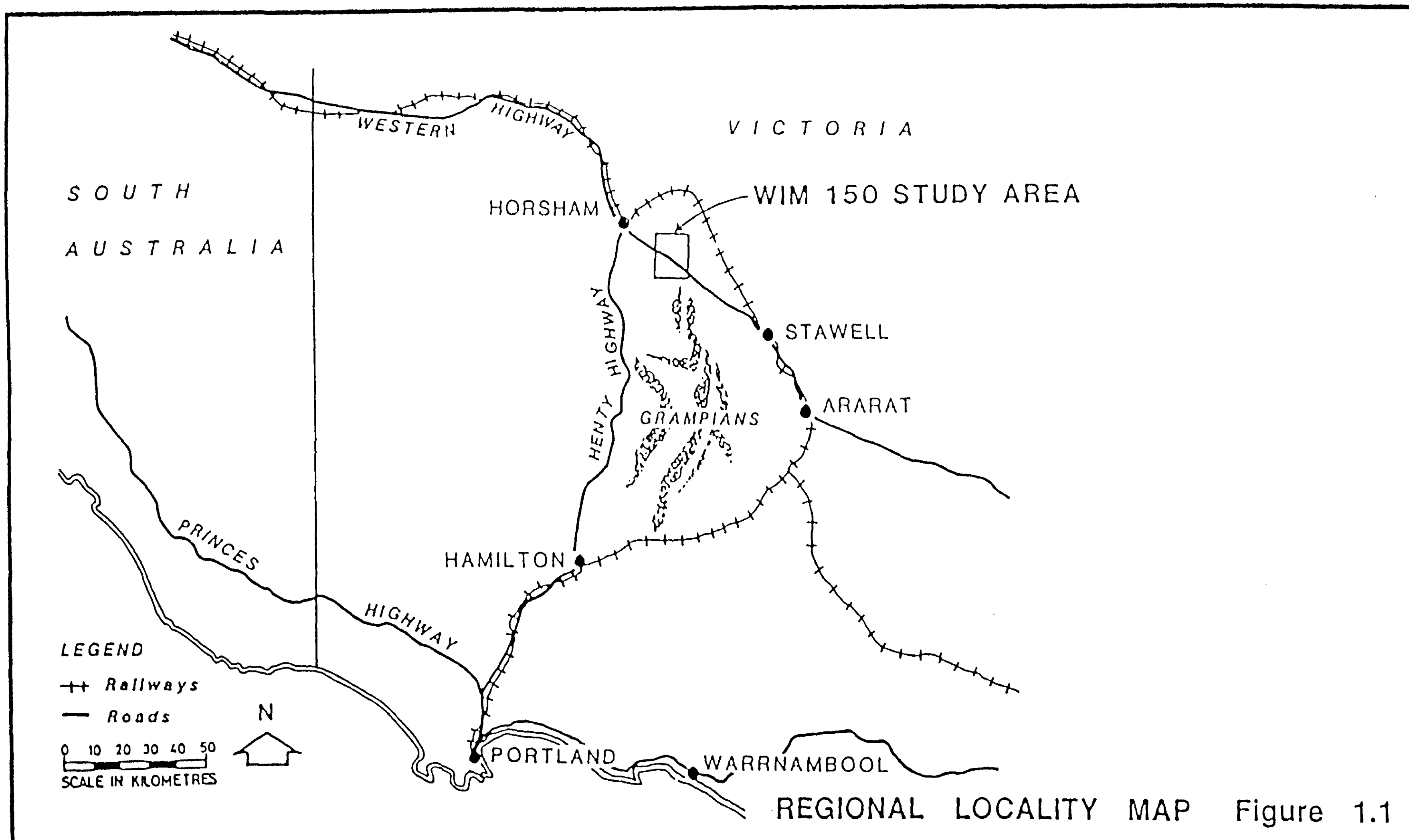
More than 20 000 people work with CRA and its Business Units in Australia and overseas, with another 15 000 employed in associated Companies.

1.2 BACKGROUND TO THE PROPOSAL

In December 1985, CRAE and the Victorian government jointly announced the discovery of 'WIM 150', a substantial mineral sand deposit at Drung South, near Horsham (Figure1.1). The discovery resulted from extensive exploration programmes by CRAE throughout Victoria for a range of minerals. Since 1980 about $35 million has been spent on these programmes.

In December 1987 the Company announced that following favourable indications from exploration a decision had been made to commence evaluation of commercial mining. Currently a "Pilot Project" is under way which involves obtaining ore samples from costeans (large trenches), for processing through a small scale Pilot Plant, and evaluating the market potential of the extracted minerals. Formerly it was planned to proceed from a Pilot to a Commercial Project, but the Company now proposes an intermediate scale Demonstration Project, referred to as "the Project". This Environment Effects Statement (EES) has been prepared at the request of the Minister for Planning and Environment, under the *Environment Effects Act* 1978.

This EES does not cover possible commercial mining operations but these are mentioned where appropriate. A further EES would be prepared to accompany an application for a commercial stage.



REGIONAL LOCALITY MAP Figure 1.1

1.3 STAGES IN DEVELOPMENT

Given that the Company now proposes a Demonstration Phase between the Pilot and Commercial Phases, development of the WIM 150 deposit is following this sequence of events :-

- exploration - discovery of the deposit and delineation of reserves;
- laboratory testwork - investigation of the methods for separation of the minerals on a very small scale;
- pilot phase - proving the technical feasibility of selected methods and developing a process to allow continuous extraction of minerals;
- demonstration phase - continuous production of minerals in quantities suitable for shipping to potential customers for process evaluation;
- commercial phase - full scale mining, production, upgrading and marketing of mineral concentrates.

The transition from laboratory testwork to commercial mining involves higher tonnages of ore at each stage. For WIM 150, the amount of ore required for laboratory testwork was about 100 tonnes, the amount to be processed in the Pilot Plant will be up to 20 000 tonnes and the amount to be mined and processed during the Demonstration Project life will be about one million tonnes. A possible commercial mine would rely on economies of scale, and therefore would entail a much higher mining and processing rate than the Demonstration Project.

1.4 AIMS OF THE PROJECT

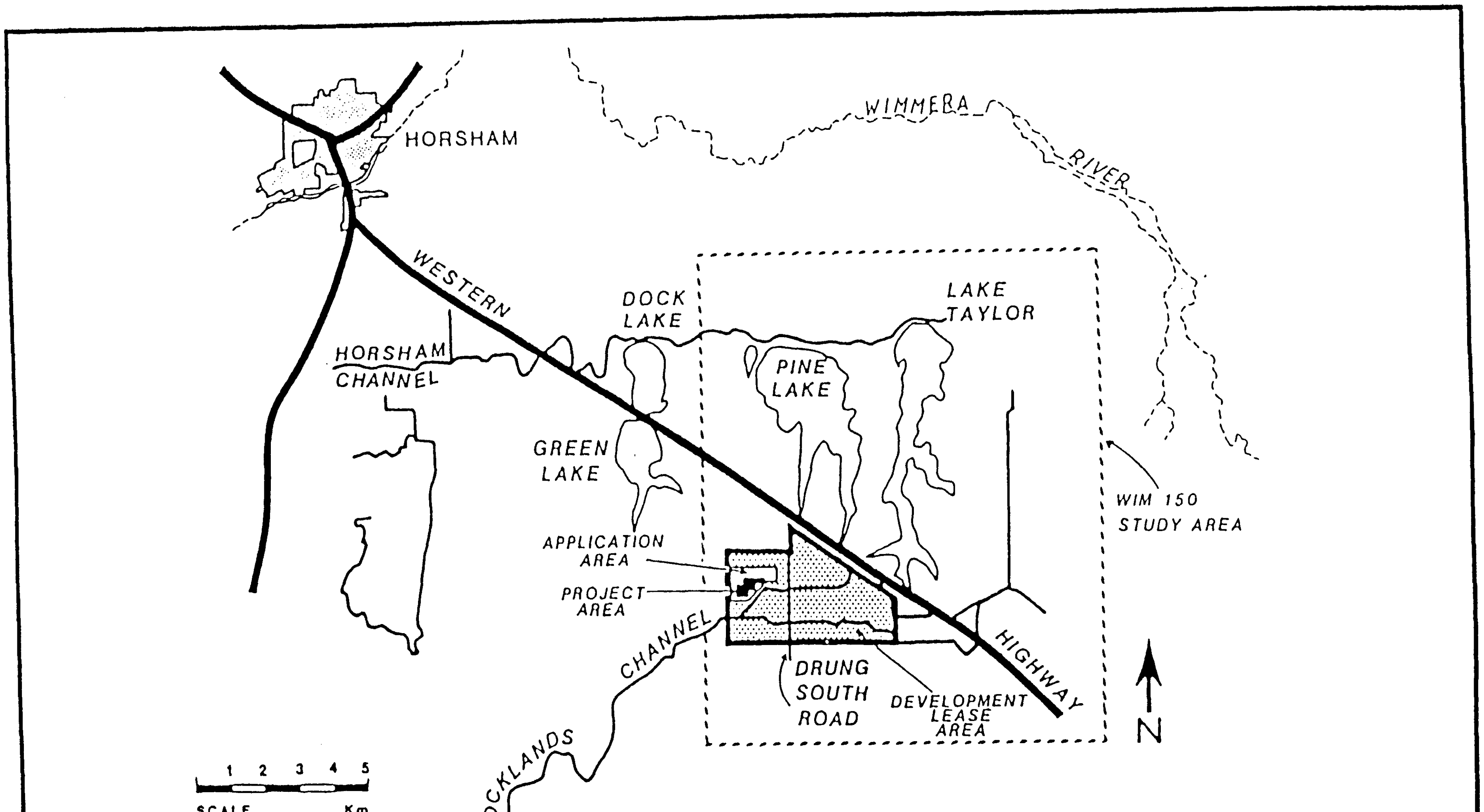
The primary aim is to :-

- establish the suitability and competitive potential of WIM 150 mineral concentrates in world markets.

The secondary aims include to :-

- scale-up and optimise the flotation technology developed by the Company for mineral recovery;
- obtain further data on WIM 150 geology, hydrogeology, and a range of related issues;
- assist in planning for commercial mining operations;
- continue studies over a range of environmental issues to enable preparation of an EES to accompany applications for commercial mining;
- upgrade certain WIM 150 minerals to enhance market value.

The Project will provide a range of data for subsequent use in an EES to cover possible commercial mining.



LOCALITY MAP Figure 1.2

1.5 MINING APPROVALS AND THE LEASE AREA

The principal legislation for the mining industry in Victoria is the *Mines Act*, 1958, which is administered by the Department of Industry, Technology and Resources. The principal mineral titles are the Exploration Licence (EL), Development Lease (DL) and Mining Lease (ML). The requirements for each are specified in the Act. One of the prior requirements to the grant of a Lease is appropriate authorization under the *Planning and Environment Act*, 1988.

The transition from an EL to an ML entails a concentration of activity on a particular area which is proven or likely to have economically recoverable grades of the target mineral(s).

Exploration in the WIM 150 Study Area (Figure 1.2) is conducted under the terms of an Exploration Licence (EL 1257). Among the many conditions of this licence are - expenditure commitments; the lodging of a $20,000 bond to cover rehabilitation; and the requirement to enter into compensation agreements with landholders before work commences on their land.

The current Pilot Project is covered by a Development Lease (DL 301), which was issued on 6 December, 1988. This DL covers an area of about 1365 hectares (Figure 1.2 and 1.3), of which the Company owns 1100 hectares. It is referred to as the "Lease Area". All the activities of the Pilot Project and the proposed Demonstration Project are on Company-owned land.

An application is now being made for a Mining Lease (ML) to cover an area of approximately 120 hectares within DL 301 to allow the Demonstration Project. The boundaries of the ML will be the same as those for a proposed Planning Scheme Amendment (Shire of Wimmera Planning Scheme 1988). For clarity in this EES, the proposed ML and Amendment area is referred to as the "Application Area" (Figure 1.2 and 1.3). The Application Area encloses the smaller "Project Area" of 30 hectares.

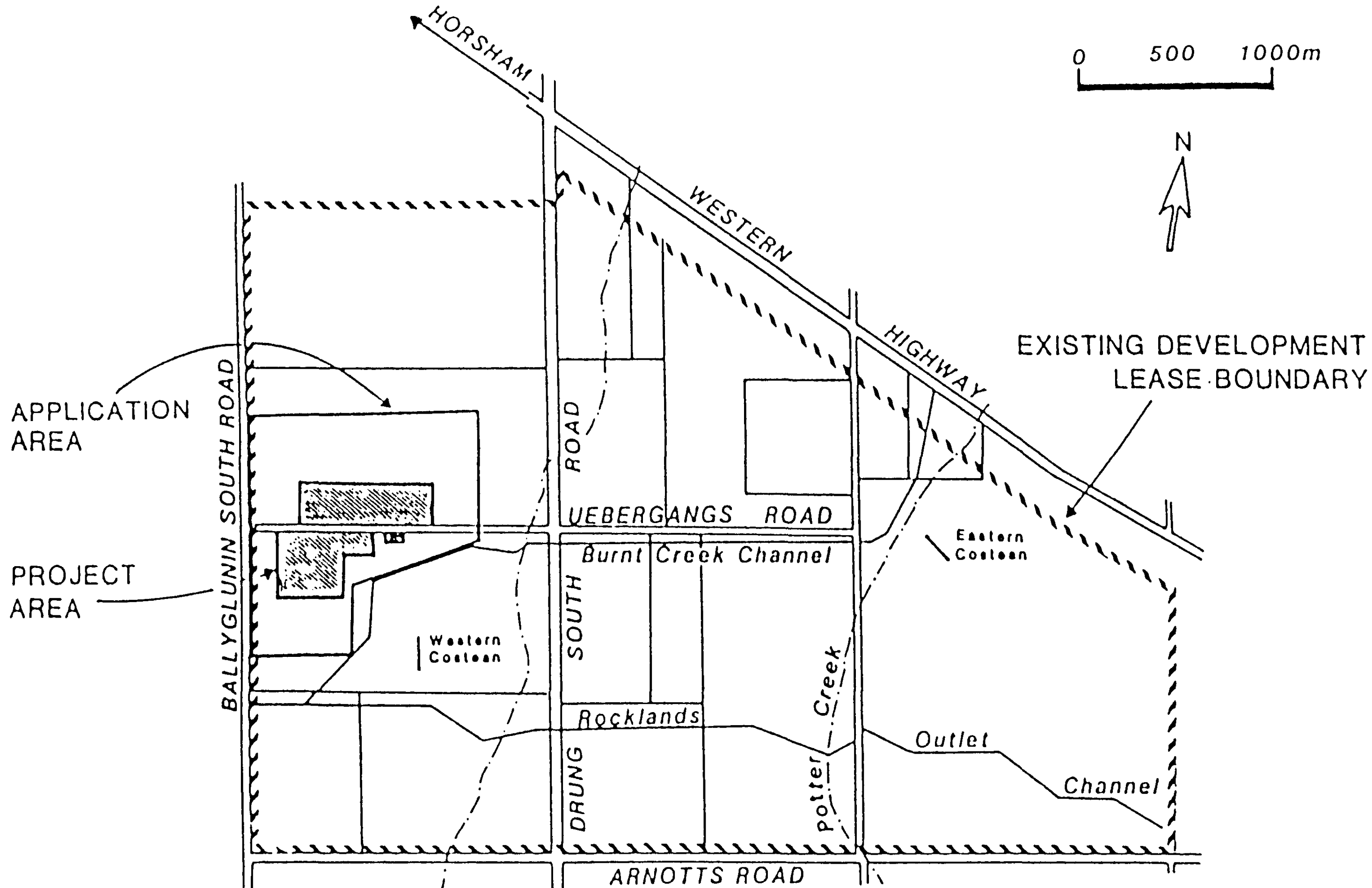
1.6 PLANNING APPROVALS

Land within the Lease Area is zoned Rural A under the Wimmera Planning Scheme which came into effect on 16 February 1988. The Local Section of the Scheme contains two chapters. The Lease Area is covered by Chapter 2 - Balance of Shire. Within the Rural A zone a planning permit is required from the Shire of Wimmera for mining as defined in the State Section of the scheme:-

Mineral prospecting/exploration means the search for any mineral, as defined in the *Mines Act 1958*, by:

- exploratory drilling;
- excavation by hand-held equipment;
- eductor dredges operating in streams;
- geological surveys;
- geophysical surveys;
- geochemical surveys;
- loaming or panning;
- similar means.

The search must not involve substantial or permanent alteration to the natural condition or topography of the land, the construction of any permanent buildings or works or the removal of any established trees or shrubs.



APPLICATION AREA Figure 1.3

Mineral evaluation/development means the search for any mineral, as defined in the *Mines Act 1958*, or the evaluation of the extent or quality of any deposit of minerals by:-

- drilling;
- re-entering of mines;
- trial mining;
- similar means.

The search or evaluation may involve substantial or permanent alteration of the natural condition or topography of the land, noise or nuisance, the construction of permanent buildings or works or the removal of established trees or shrubs.

Mineral production means production on any premises to obtain any mineral, as defined in the *Mines Act 1958*. It includes stockpiling or storage of earth or any other materials from which minerals may be obtained; and the treatment of earth or other materials to recover minerals, but not mineral prospecting/exploration or mineral evaluation/development.

Prior approvals obtained include:-

- The construction of two existing costeans (as indicated on Figure 1.3) carried out in accordance with Planning Permit No. 244, issued 14 August 1987, for "Mineral Working" involving outline exploration, research sampling and environmental studies.

  "Mineral Working" was defined under the then Shire of Wimmera (Balance of Shire) Interim Development Order 1977 as :-

  > "The use or development of land for the purpose of obtaining by any mode or method gold or any mineral as defined in the *Mines Act* 1958 and includes the stacking or otherwise storing of any earth from which } gold or minerals may be obtained."

- The Pilot Project in accordance with Planning Permit (No. 299) issued 8 November 1988. This permit allows Mineral Evaluation/Development as previously defined. As further discussed in Section 1.9 this permit was issued following disallowance by the Administrative Appeals Tribunal of an appeal by the Conservation Council of Victoria against The Shire of Wimmera's Notice of Determination to Grant a Planning Permit.

The Stage 2 Pilot Project was the subject of a Preliminary Environment Report (PER) which was requested by the Minister for Planning and Environment under the *Environment Effects Act* 1978. The Minister's assessment report on the PER concluded (in part) :-

"The Stage 2 research and evaluation program is unlikely to cause environmental degradation providing measures are taken to minimize effects and monitor potential problems as detailed in Section 4 of the assessment."

The proposed Demonstration Project could be covered by a further Planning Permit. However, the Minister for Planning and Environment has advised the Company and the Shire of Wimmera that a site specific Amendment to the Planning Scheme is the appropriate approval route. Other advantages of an Amendment rather than a Planning Permit are that the procedures for exhibition, public comment and assessment of an Amendment are readily co-ordinated with those for an EES. In particular, following public comment, both documents can be jointly assessed by an independent panel which may be appointed by the Minister for Planning and Environment.

The Planning Scheme Amendment is designed to allow use of the land within the Application Area for mineral prospecting/exploration, mineral evaluation/development and mineral production subject to compliance with a series of prescribed conditions.

The Amendment would allow the Project as described in this EES to proceed without the need for consequential Planning Permits from Council by :-

- authorizing the development of the site on a conceptual site development plan basis with any further development or amendment to require the lodging of an amended plan to the satisfaction of Council;

- specifying that development and use comply with a balanced framework of planning provisions and development controls. These controls would preserve the amenity of the existing environment and ensure that appropriate environmental management techniques are implemented. The planning controls have been framed to complement other regulations and approvals required by other authorities. Where specific aspects of the proposal are adequately covered by the other approvals (for example, the *Mines Act 1958*), the Amendment seeks to avoid unnecessary duplication of detailed controls and conditions;

- balancing the need to provide certainty and security as to the manner in which land may be developed against the need to retain sufficient flexibility in the planning controls to allow for minor alterations in design and layout which may be required from time to time. The Amendment will be designed to ensure that flexibility has not been introduced at the expense of general environmental objectives, nor at the diminution of amenity.

On 9 December 1988, the Shire of Wimmera resolved to proceed with a Site Specific Amendment to its Planning Scheme to allow for the Demonstration Project. The Amendment will be prepared by the Shire of Wimmera based on a draft prepared by a consultant. The Company will meet the Shire's consultant planning costs associated with the Amendment, given that the Shire will not receive the normal planning fee. A copy of a draft Amendment, which at the time of writing has not been considered by Council, is incorporated in Appendix A. **(Council will however be advertising exhibition of its considered Amendment in due course and this EES will be on exhibition until the statutory time for the Amendment's exhibition has elapsed).**

Separate planning approval would be sought and an EES would be issued when the project proceeds to the commercial mining phase.

1.7 OTHER APPROVALS

A number of other approvals will be required at various stages of the Project. These include building permits, water-use permits, approval of a Radiation Management Plan by the Victorian Health Department (Section 4.5) and other operating approvals under the *Mines Act* 1958. A Notification of Works to the Environment Protection Authority (EPA) may be required for noise and a Works Approval will be required for emissions to air from the agglomeration plant. Export approvals will be obtained prior to shipment of the mineral concentrate.

1.8 CONSULTATION WITH AUTHORITIES

Extensive Government agency consultation has taken place during the preliminary investigations of the WIM 150 deposit, during the preparation of the Preliminary Environment Report, and during preparation of this EES.

The Company has provided briefings and held discussions with a range of local and state government departments. These include :-

- Shire of Wimmera;
- City of Horsham;
- Department of Premier and Cabinet;
- Ministry for Planning and Environment;
- Department of Industry Technology and Resources;
- Department of Agriculture and Rural Affairs;
- Department of Conservation, Forests and Lands;
- Health Department Inspection Services Branch (Radiation);
- Department of Water Resources;
- Rural Water Commission;
- Environment Protection Authority;
- Victorian Archaeological Survey;
- Country Fire Authority.

1.9 PUBLIC RESPONSES, COMMENTS AND OBJECTIONS

In early 1988 public responses were invited on the PER and the Planning Permit Application (which both dealt with the Pilot Plant Project). In all, 11 submissions were received on the PER. Of these, 9 were from government agencies, one was from an individual and one was from a conservation group. The environmental issues raised by the respondents included :-

- soil salinity;
- radioactivity;
- impact on groundwater;
- visual effects, including siting of excavations, pipelines and other features;
- transport issues;
- impact on Wyperfield National Park and Albacutya State Park;
- rehabilitation.

A submission and an objection were received on the Planning Permit application. The National Trust of Victoria lodged a submission and expressed concerns about the Pilot Project and possible future expansion of mining. However, the Trust did not object to the granting of the Permit. An objection was lodged by the Conservation Council of Victoria (CCV) on the following grounds :-

- implications of the *Nuclear Activities (Prohibitions) Act* 1983;
- non-inclusion on the permit of all the MPE assessment recommendations;
- general environmental concerns;
- inappropriate use of the PER mechanism.

After considering the Minister's assessment report of the PER, and the CCV's objections, the Shire of Wimmera issued a Notice of Determination to Grant a Planning Permit. The CCV appealed against the determination to grant a permit. Appeal No: P88/1745 was heard on 4 October 1988 by the Administrative Appeals Tribunal (AAT). The CCV, DITR and the Company were represented at the appeal and called expert witnesses. The Shire Engineer and the Chairman of the Council Planning Committee addressed the tribunal. The Minister for Planning and Environment lodged a written submission to the Tribunal. After considering the information in the PER and the evidence provided at the hearing, the AAT disallowed the CCV's appeal and determined that Planning Permit No 299 should issue (see Appendix B). This Permit was received on 8 November 1988.

Both the CCV and the National Trust have been invited to a briefing and to visit the WIM 150 site. These invitations will be extended again for the Demonstration Project.

The conditions attached to the Planning Permit for the Pilot Project Phase included :-

. formation of a Review Committee comprising representatives of the Shire and various government agencies;

. costeans to be sited at least 100 metres from roads, houses, RWC channels and watercourses, and 200 metres from the Western Highway;

. procedures for reporting of chemicals used and stored on site;

. procedures for design and monitoring of dams;

. conditions for road usage;

. no discharge of waste from the Lease Area;

. no works to affect surface watercourses without RWC and Shire approval.

From the above it is evident that the issues relating to the development of the WIM 150 deposit have already received considerable public debate and there has been a good deal of government agency involvement.

The issues discussed in this EES substantially cover those previously raised in public comments on the PER. Public comment was requested on the proposed contents of this EES through advertisements placed in newspapers on December 2 and 5, 1988, and the proposed contents were circulated to the 28 parties who had expressed interest in the PER. The matters raised in responses to the draft contents have been addressed in this EES.

1.10 STATE GOVERNMENT POLICY AND THE PROJECT

1.10.1 The State Economic Strategy

The Victorian government commented on the WIM 150 Project in its 1985 publication "Victoria - The Next Decade" which outlined its Economic Strategy for Victoria, in the following terms :-

"The government supports this project, subject to satisfactory resolution of all planning, environmental and mining issues."

1.10.2 The State Conservation Strategy

Victoria's State Conservation Strategy includes a provision for the "wise use of non-renewable resources" with a "recognition that the community should be able to sustain a high level of material well-being". The Demonstration Project, as part of the overall development of the WIM 150 deposit, entails a wise use of the resource with the potential to add to the community's material well being with negligible adverse, and in some cases positive, environmental effects (Section 4.11).

2 MINERAL SANDS AND THEIR USES

2.1 MINERAL SANDS

The term "mineral sands" refers to sand deposits which contain significant levels of the commercially important titanium minerals (rutile, anatase, leucoxene and ilmenite), the zirconium mineral (zircon), and the rare earth minerals (monazite and xenotime). Such minerals are among a group of minerals known in the industry as "heavy minerals" because they have densities greater than 2.9 t/m^3 and are thus "heavier" than the common rock-forming minerals whose densities are typically around 2.7 t/m^3. The term "heavy minerals" should not be confused with "heavy metals" which covers such metals as lead, cadmium, zinc and mercury.

Heavy minerals are widespread in nature and occur at low concentrations in most rock types. While they are generally formed in igneous or metamorphic rocks, such primary sources are seldom economically recoverable. In most economic ore bodies, the minerals have been freed from the parent rock by weathering and erosion, and subsequently concentrated by wind or water. Thus they are typically found in both present day and ancient beaches and sand dunes. In the case of WIM 150 they were laid down between 5 and 2 million years ago when the area was part of the Murray Basin marine environment. The sea subsequently retreated and the deposit is now about 200 kilometres from the present coastline.

2.1.1 Titanium minerals

WIM 150 contains ilmenite (about 54 per cent TiO_2) and three other titanium minerals, which are collectively referred to as high titanium or "high-Ti" minerals. They are rutile and anatase (about 97 per cent TiO_2) and leucoxene, which is an alteration product of ilmenite containing 60-90 per cent TiO_2.

The titanium minerals are predominantly used for the manufacture of titanium dioxide pigment for paint, plastics and paper. A small amount is used for titanium metal production and for welding fluxes.

2.1.2 Zircon

Zircon is zirconium silicate. It commonly contains low levels of thorium and uranium, and commercial zircon concentrates are all weakly radioactive. It is mainly used in the refractory, foundry and ceramics industries.

2.1.3 Monazite and Xenotime

Monazite is a phosphate of cerium and other lanthanide (rare earth) elements, while xenotime is a phosphate of yttrium, with small amounts of lanthanide elements.

The individual rare earth elements have a wide range of specialised applications in several high technology fields. These include electronics, high-strength magnets, automotive emission-reduction catalysts, steel alloys, high strength ceramics and phosphors. Yttrium has potential use in superconductors.

All known occurrences of monazite and xenotime also contain low levels of the radioactive elements uranium and thorium which do not confer any additional value on the minerals and are regarded as impurities that add to the final cost of processing. The uranium and thorium remain locked in the crystal structure of the monazite and xenotime when mined and concentrated, and are separated overseas during the refining process overseas.

2.2 MONAZITE, XENOTIME AND *THE NUCLEAR ACTIVITIES (PROHIBITIONS) ACT* 1983.

2.2.1 Provisions

Section 5.(1) of this Victorian Act states :-

"Subject to section 6, but notwithstanding anything else to the contrary in any Act, and notwithstanding the terms of any mining title, a person shall not explore, mine or quarry for uranium or thorium."

Mining the WIM 150 resource does not entail mining *for* uranium or thorium. In the course of mining (for various minerals other than uranium and thorium) there will be small quantities of uranium and thorium removed in two of the minerals (monazite and xenotime).

Section 6.(1) of the Act states :-

"Notwithstanding Section 5, a person who is the holder of a mining title and who mines or quarries uranium or thorium in the course of mining or quarrying pursuant to his mining title for some mineral other than uranium or thorium shall not be guilty of an offence under this Act provided that:-

(a) uranium of an amount greater than .02 per centum by weight or thorium of an amount greater than .05 per centum by weight is not removed from the land covered by the mining title;

(b) mined or quarried material containing uranium or thorium is treated in the prescribed manner; and

(c) he complies with such conditions (if any) as the Governor in Council may from time to time impose in respect of the mining or quarrying in which he is, or is to be, engaged."

The prohibition imposed by Section 6.(1)(a) relates to uranium of an amount greater than 0.02 per centum by weight or thorium of an amount greater than 0.05 per centum by weight of the total weight of ore mined to that point of time pursuant to the mining title. If the amounts are in excess of those specified the uranium or thorium is not to be removed from the land covered by the mining title. If it is removed the Section ceases to apply and the blanket prohibition contained in Section 5 of the Act remains.

Section 9 of the *Nuclear Activities (Prohibitions) Act* 1983 requires a person to comply with the provisions of Section 511.(2) of the *Mines Act* 1958. By letter dated 29 September, 1988, the Minister for Industry, Technology and Resources has provided the Company with the necessary authorization to ensure compliance.

2.2.2 Discussion

Thorium and uranium are relatively common elements, occurring in the earth's crust at 10ppm and 3ppm respectively, comparable with lead (12ppm) and tin (2ppm). They may be present as specific thorium or uranium minerals, but they are most commonly found at low levels in a wide range of other minerals. In mineral sand deposits, thorium and uranium occur in monazite, xenotime and, to a much lesser extent, in zircon. They may also be present in other minerals.

Because of these different modes of occurrence, the most reliable estimate of the thorium and uranium content of a mineral sand ore is by assaying for total thorium and uranium. Calculations based on determination of the amount of, say, monazite in the ore and the amount of thorium and uranium in the monazite are less accurate. Analysis of a bulk composite sample from richer areas of the WIM 150 ore body shows an average of 0.012 per cent thorium and 0.0024 per cent uranium. The maximum levels found in selected samples were 0.017 per cent thorium and 0.0029 per cent uranium which are still many times below the limits set in the Act.

To summarize the position, small amounts of contained uranium and thorium will be recovered incidentally and unavoidably while mining for other minerals and will remain in those minerals. They do not confer any additional value on the minerals.

2.2.3 Administrative Appeals Tribunal Determination (see Appendix B)

The Determination of the Planning Division of the Administrative Appeals Tribunal of Victoria which heard Appeal No: P88/1745 lodged by the Conservation Council of Victoria on the Pilot Plant proposal stated (in part) that :-

"It seems to us that the Act is precisely designed to cover such a case as the present. This is not a uranium mine. It is exploration for various minerals other than uranium or thorium but in the course of such exploration there may be produced uranium or thorium in quantities prima facie less than those specified under the Act. If, of course, the quantities produced exceed those specified under the Act then the uranium or thorium may not be taken from the land covered by the mining title."

"We accordingly reject the contention of the Appellant that no permit should be granted on the ground that any such permit would be for an illegal use."

The percentages of uranium and thorium indicated in the WIM 150 orebody are not at levels that would compromise the Company's ability to comply with the provisions of this Act.

2.3 WIM 150 AND AUSTRALIAN RESERVES

Proven in-situ reserves in the core area of the WIM 150 deposit exceed one thousand million tonnes of ore at over three percent heavy minerals. The reserves of individual minerals, compared to current Australian reserves are as follows :-

Mineral	WIM 150	OTHER AUSTRALIAN
high-Ti	8.0 Mt	16.0 Mt
ilmenite	12.5 Mt	53.9 Mt
zircon	5.1 Mt	16.6 Mt
monazite	0.58 Mt	0.9 Mt
xenotime	0.17 Mt	n.a.

These figures show clearly that the WIM 150 deposit has the potential to contribute significantly to the production of these minerals.

Mineral sands have been mined in Australia since 1934. Between 1934 and 1980 there have been 56 producers active on the east coast alone. Currently, there are mines in Western Australia, Queensland and New South Wales. Australian production (in 1987) and its value was :-

Mineral	'000 tonnes	Value ($A million)
high-Ti	722	273
ilmenite	1051	78
zircon	600	135
monazite	24	16
xenotime	1	7
Total	2398	509

Australia is already a major world producer, supplying about 47 per cent of the world's rutile, 23 per cent of the ilmenite, 59 per cent of the zircon and 66 per cent of the monazite. Development of the WIM 150 resource would contribute to maintaining Australia as a major world supplier of heavy minerals.

2.4 MINING AND PROCESSING OF MINERAL SANDS

2.4.1 Introduction

Mineral sand deposits are mined using either conventional earth-moving equipment (dry mining) or by dredging (wet mining). Dry mining is employed where the water table is low and ore grades are high. Dredging is generally carried out where the water table is within the ore zone or can be made so artificially and is almost mandatory for low grade deposits where the higher costs of dry mining cannot be sustained.

The minerals of commercial value occur as discrete grains in a gangue of quartz sand and 'trash' heavy minerals. Trash minerals in the WIM 150 deposit are mainly goethite (a form of iron oxide) and tourmaline, a complex aluminium boro-silicate.

2.4.2 Processing

Conventional processing utilizes differences in the density, electrical and magnetic properties of each mineral to achieve separation. The mineral particles in the WIM 150 deposit are finer than in other deposits currently mined in Australia and have led to the need to utilize novel flotation technology for concentration and separation (see Section 3.4.2).

2.4.3 Industrial processing

In Australia at present the minerals are generally exported as concentrates for further processing :-

- ilmenite is digested in sulphuric acid to make titanium dioxide pigment by the sulphate route;

- high titanium minerals and synthetic rutile prepared (in Australia) from ilmenite are chlorinated to make pigment (and metal) by the chloride route;

- zircon is used partly in its natural form, but most is ground and classified into the desired size ranges;

- monazite and xenotime are digested in acid to separate the desired elements from the waste (phosphates and radioactives). Individual elements are later separated and refined to a very high level of purity.

2.4.4 Process evaluation

The mineral concentrates produced from the Project will be tested in processing plants overseas to determine their suitability and cost competitiveness as feed stock for the existing industrial processes. The Project will also enable assessment of several "value added" options the Company has been researching.

The size of the Demonstration Project has been chosen for the timely production of sufficient tonnages of concentrates to enable trials through commercial scale plants.

The trials are important to accurately assess the potential for the successful transition of WIM 150 to a long term, world scale commercial mining operation.

3 DESCRIPTION OF THE PROJECT

3.1 OVERVIEW

3.1.1 Introduction

The Demonstration Project entails the following activities:-

- stripping of topsoil and overburden to expose ore;
- mining up to 1 million tonnes of ore and transport to an adjacent processing plant;
- construction of a water dam and a tailings dam;
- processing of the ore to separate the commercial minerals from the waste (or tailings);
- agglomeration of high titanium minerals;
- disposal of tailings to a dam initially, and later to mined-out areas of the pit;
- rehabilitation and revegetation of the tailings and most of the pit area.

3.1.2 Project areas

The Project will be developed on Company-owned, cleared farmland to the north and south of Uebergang's Road. The area is gently sloping and has light tree cover (Plate 3.1).

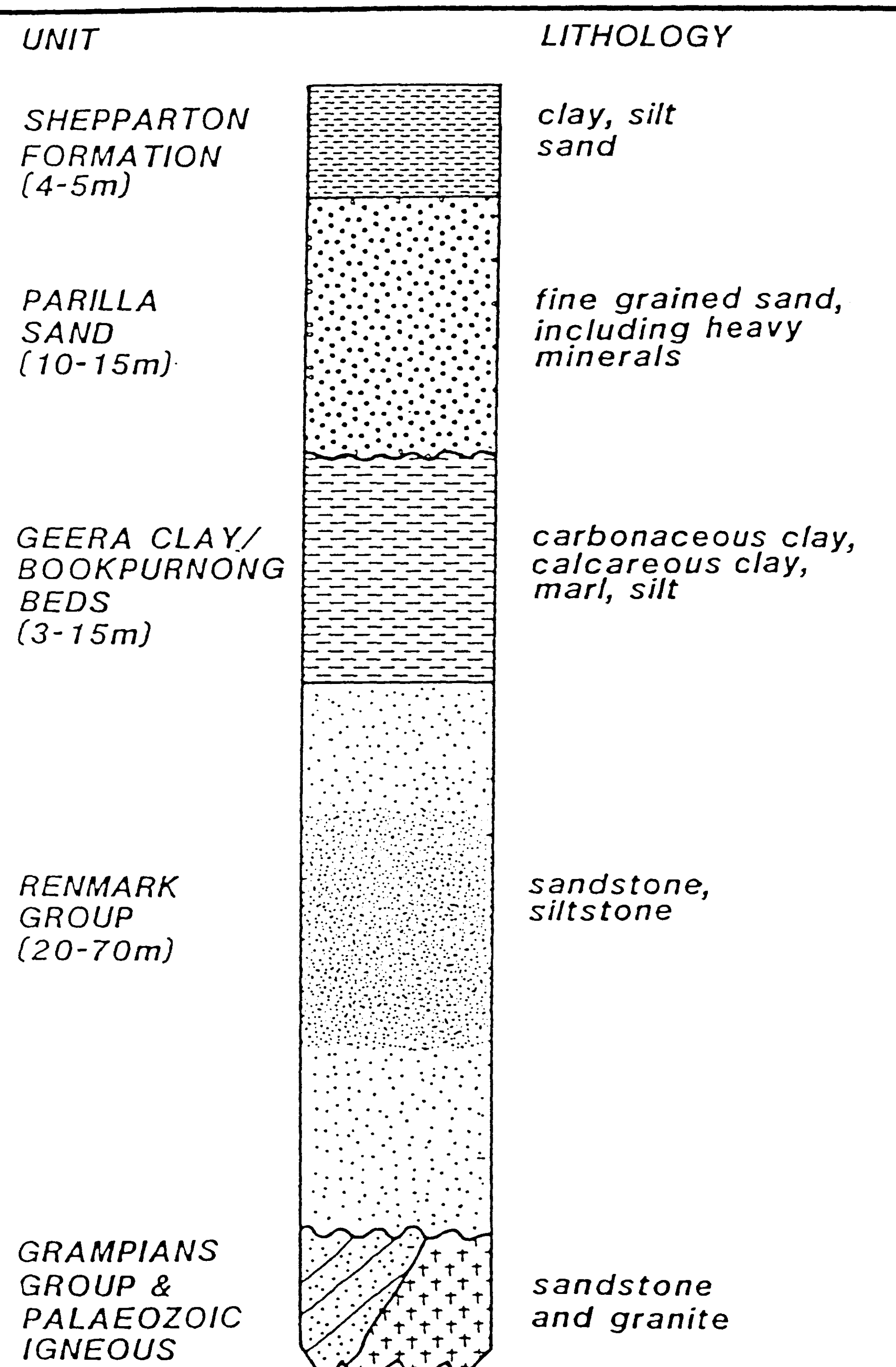
The main components of the Project, and the anticipated areas they would occupy are :-

. mine pit	15 hectares
. stockpiles	5 hectares
. plant area	2 hectares
. water and tailings dams	10 hectares
. roads	1 hectare
Total	33 hectares

The actual areas will be known when detailed site and mining plans are drawn up together with details of the processing plant. Such plans will take into account the results of current Pilot Plant operations and further drilling of the proposed mine pit area in early 1989.

3.1.3 Project schedule and expenditure

The Project entails establishing a mine and processing plant with the capacity to handle up to one million tonnes of ore over a two year period. It will be accompanied by the continuation and expansion of various environmental monitoring programmes, some of which have been in place for several years. The activities of design, procurement, construction, operation, rehabilitation and revegetation suggest a Project life of about three years (Table 3.1) and an expenditure of at least $10 million.



WIM-150 STRATIGRAPHY Figure 3.1

Table 3.1 **Indicative project schedule**

ACTIVITY	1989	1990	1991	1992
Detailed Project design, procurement	-----------			
Construction of Processing Plant		----------		
Stripping of overburden		---- ------	----	
Dam construction		----		
Mining		-------------------------------------		
Operation of plant		-------------------------------------		
Tailings to dam		-------		
Tailings to pit		-------------------------------		
Overburden to pit		---	-----	-----
Topsoil spread and seeded		---	----	---

3.2 GEOLOGY

3.2.1 Regional Geology

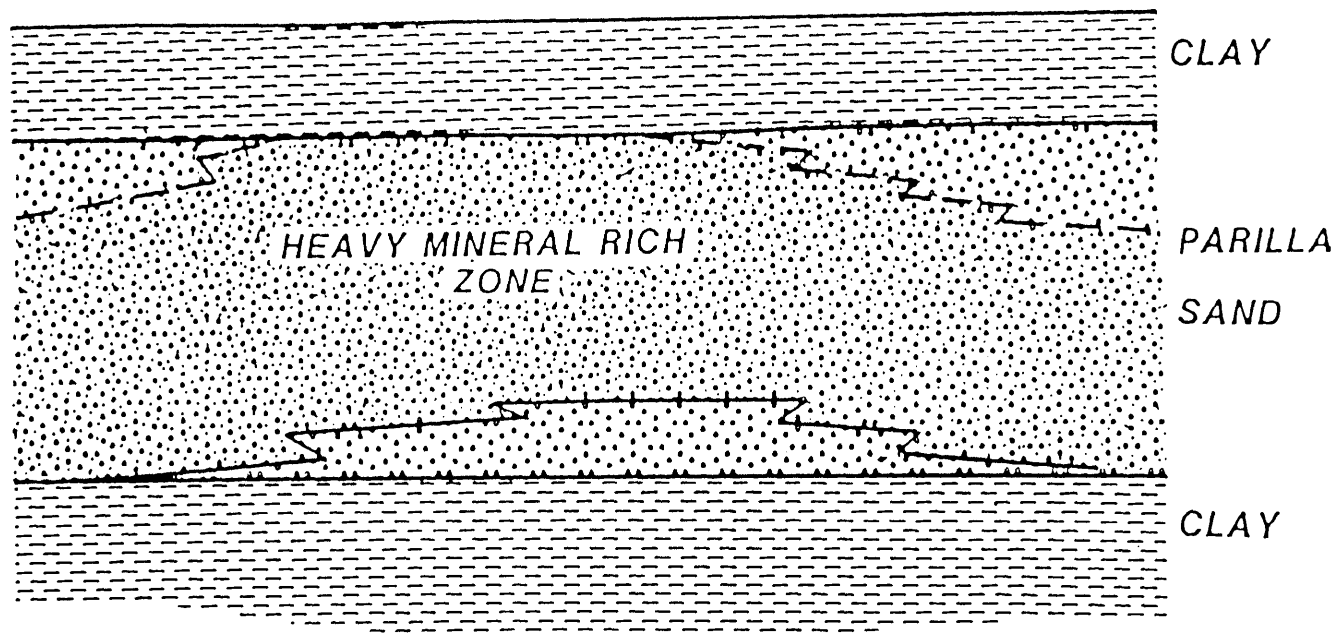
To understand the proposed mining operation, it is helpful to understand the main features of regional geology.

The WIM 150 mineral sand deposit lies on the southern margin of the Murray Basin, just north of the Grampians. The Murray Basin is a Cainozoic sedimentary basin which contains a relatively thin sequence of marine and continental sediments. The stratigraphy in the WIM 150 Study Area is shown schematically in Figure 3.1.

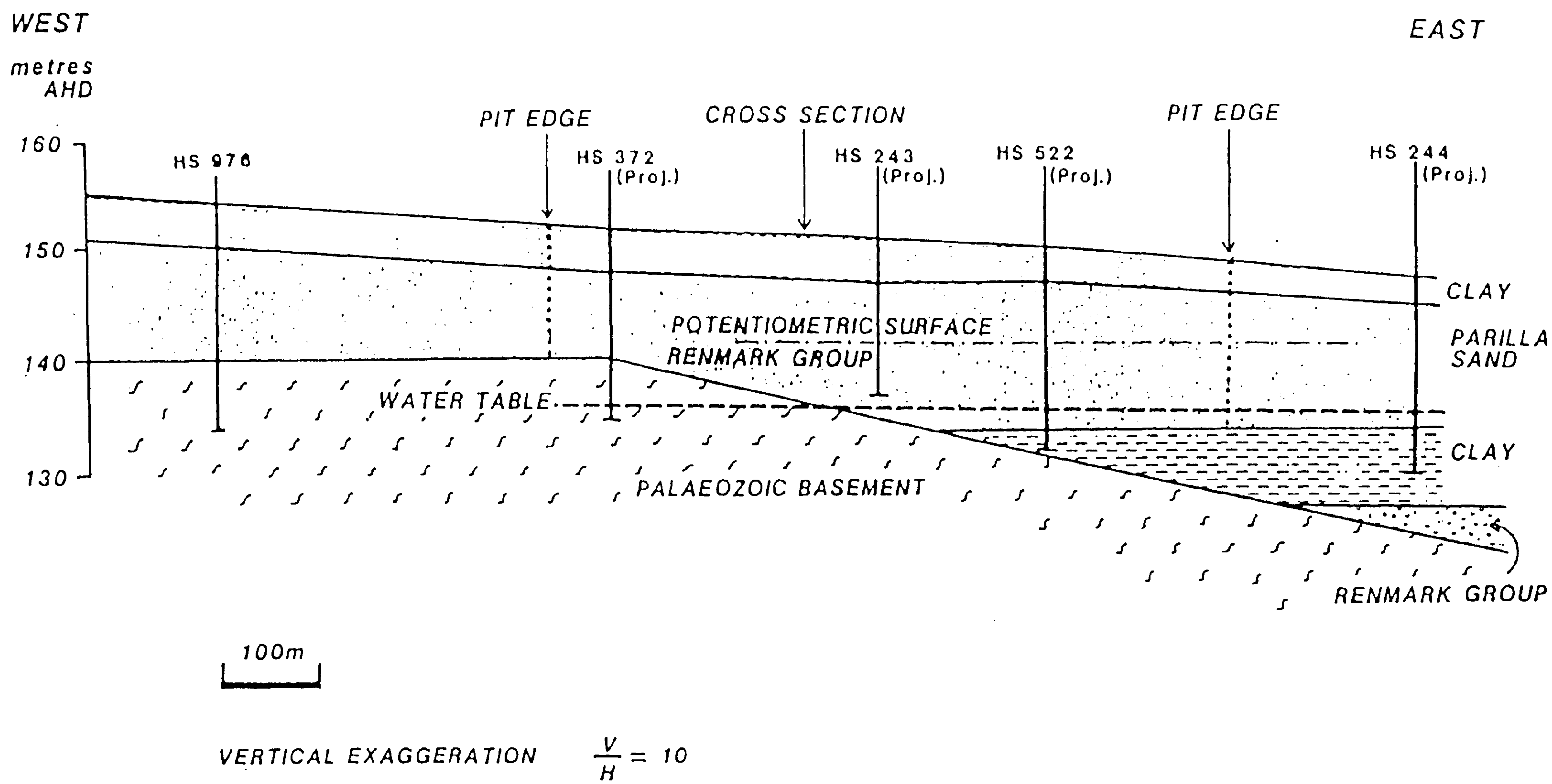
3.2.2 Orebody

The WIM 150 orebody is contained within the Parilla Sand, which is a marine sand formation of Miocene to Pliocene age (5 to 2 million years ago) present over much of the western Murray Basin.

The orebody is the zone which is rich in heavy minerals. It may start at the top of the Parilla Sand formation or a few metres below (Figure 3.2).



DIAGRAMATIC SECTION OF OREBODY Figure 3.2



WEST-EAST SECTION OF DEMONSTRATION MINE AREA Figure 3.3

At the top of the Parilla Sand an iron pan about one metre thick has developed due to lateritic weathering. Beneath this indurated horizon, the Parilla Sand is very compact but generally uncemented. The grain size distribution is much finer than in most other mineral sand deposits, with the bulk of the particles being between 0.04 and 0.06 millimetres in diameter. The economically valuable heavy minerals occur within a gangue of quartz sand, accompanied by trash heavy minerals (predominantly tourmaline and goethite).

3.2.3 Overburden

The Parilla Sand is overlain by a heavy, sandy clay in which the dominant clay mineral belongs to the montmorillonite group. Clays of this type exhibit two important properties.

Firstly, they have a high shrinkage rate on drying, but when re-wetted they take up water rapidly and lumps disaggregate. Hence the term 'self-mulching' is used for soils of this type. It means they are of very low permeability and form a virtually self-sealing material for dam construction. Clays of similar type, in a more pure form (bentonite) are commonly used to reduce permeability in earthen constructions.

Secondly, these clays have a particular response to cation exchange. When sodium is the dominant cation, the clay is in a dispersed state, that is, the clay particles are separate. In this state there is considerable swelling on wetting and a correspondingly high shrinkage when water is lost. Dry clay is hard and difficult to cultivate.

The replacement of sodium with calcium causes the clay to flocculate and form much larger aggregates. This is the principle behind the application of gypsum to soils of this type in the Wimmera and elsewhere. It reduces the swelling properties and reduces shrinkage on drying. The addition of calcium to clays of this type is a common engineering practice to improve workability and wetting characteristics during earthworks.

The clay in its natural state has sodium as the dominant cation and will be used in that state. As the process water will also have sodium as its dominant cation, there will be no change in the clay. Experience in the district shows that the clay is an excellent material for dam construction.

3.2.4 Hydrogeology

Two distinct aquifer systems are present in the Study Area. They are the deep (confined) aquifer of the Renmark Group which contains relatively fresh water (1 100 mg/L TDS) and the shallow saline aquifer of the Parilla Sand in which the orebody occurs (Figure 3.1).

The Renmark Group aquifer

The Renmark Group is present at a bore site about one kilometre south-east of the mine pit (HS616). At this location it is separated from the Parilla Sand aquifer by clayey sediments which are about 15 metres thick. To the west, the Renmark Group cuts out against a basement ridge and the Parilla Sand rests on Grampians Group sandstone (Fig 3.3). The basement lithology in the nearest bores (e.g. HS 976) is a hard, well-cemented sandstone, although bore HS 616 encountered granite (Fig 3.1). Both lithologies are of very low permeability.

In the western part of the proposed pit area the Parilla Sand rests on basement (Fig 3.3). Further east within the pit, the Parilla Sand rests on clay but the presence of the Renmark Group has not been established. A drilling programme planned for early 1989 will include at least one deep hole in the Project Area. It will determine whether the Renmark Group exists there and, if so, the nature and thickness of the overlying material.

If the Renmark aquifer is present beneath the eastern part of the pit area, it must be separated from the Parilla aquifer by a significant thickness of clayey sediments. The reason for this confidence is that the potentiometric surface (standing water level in a bore) of the Renmark aquifer at this location is about 5 metres above the water table in the Parilla aquifer. Clearly, if the clay aquitard was thin or absent, water would pass upwards into the Parilla aquifer and would be expected to cause a local rise in the Parilla water table, which has not been observed. Several hundred drill holes in the WIM 150 Study Area have all encountered clay or basement immediately below the Parilla Sand.

The potentiometric surface in the Renmark Group in bore HS616 is about 141.5 metres AHD (Australian Height Datum), which is about 5 metres above the anticipated level of the pit floor. This is similar to the likely level of water resulting from the planned return of tailings to the pit. Consequently, there is no possibility of downward movement of saline Parilla water into the relatively fresh Renmark aquifer.

To summarize, there is no evidence of upward water movement at present and given the method proposed there should be none during mining. The only possible effect of the potentiometric surface of the Renmark aquifer being above the pit floor would be slight floor heave if the clay aquitard is very thin. This could easily be avoided if circumstances required by limiting the depth to which mining is carried out. Again, the pre-mine drilling programme will clarify these aspects.

The Parilla Sand aquifer

The Parilla Sand is a widespread aquifer in the western part of the Murray Basin. However it is of relatively low hydraulic conductivity (low permeability) and the water is generally saline. In the WIM 150 Study Area, total dissolved solids (TDS) range from 1 g/L to 22 g/L, averaging 5 g/L, and the main salt is sodium chloride (as in seawater which has a TDS content of about 36 g/L). Most crops cannot tolerate water of over 1.5 g/L TDS. The formation was deposited in the sea and it is likely that the present ground water salinity results from partial flushing of the original contained water. The flushing process is incomplete because of the low hydraulic conductivity, clay cover and dry climate.

There has been little use of the Parilla Sand aquifer in the Study Area because of its high salinity, low hydraulic conductivity, and the availability of good quality water at low cost from the Rural Water Commission (RWC) channel reticulation system.

Groundwater in this aquifer also contains elevated levels of radionuclides which originate from radioactive decay of the uranium and thorium in the monazite and xenotime (Table 3.2). Although these minerals contain extremely insoluble forms of uranium and thorium, some of the progeny resulting from decay of their radioactive isotopes are potentially soluble in water, depending on pH and the nature of anions present. The concentrations of radionuclides appear to show a positive correlation with the salinity of the groundwater.

The TDS in borehole HS976 are higher than upper limits recommended for potable and irrigation water, and the radionuclide concentrations exceed National Health and Medical Research Council (NHMRC) guidelines for potable water. The TDS in the water from HS522 is the lowest of any bore in the Study Area and is below the upper limit for potable water. The level of radionuclides in HS522 is also lower than average for the Study Area. Further information on radionuclides is contained in Section 4.5.4.

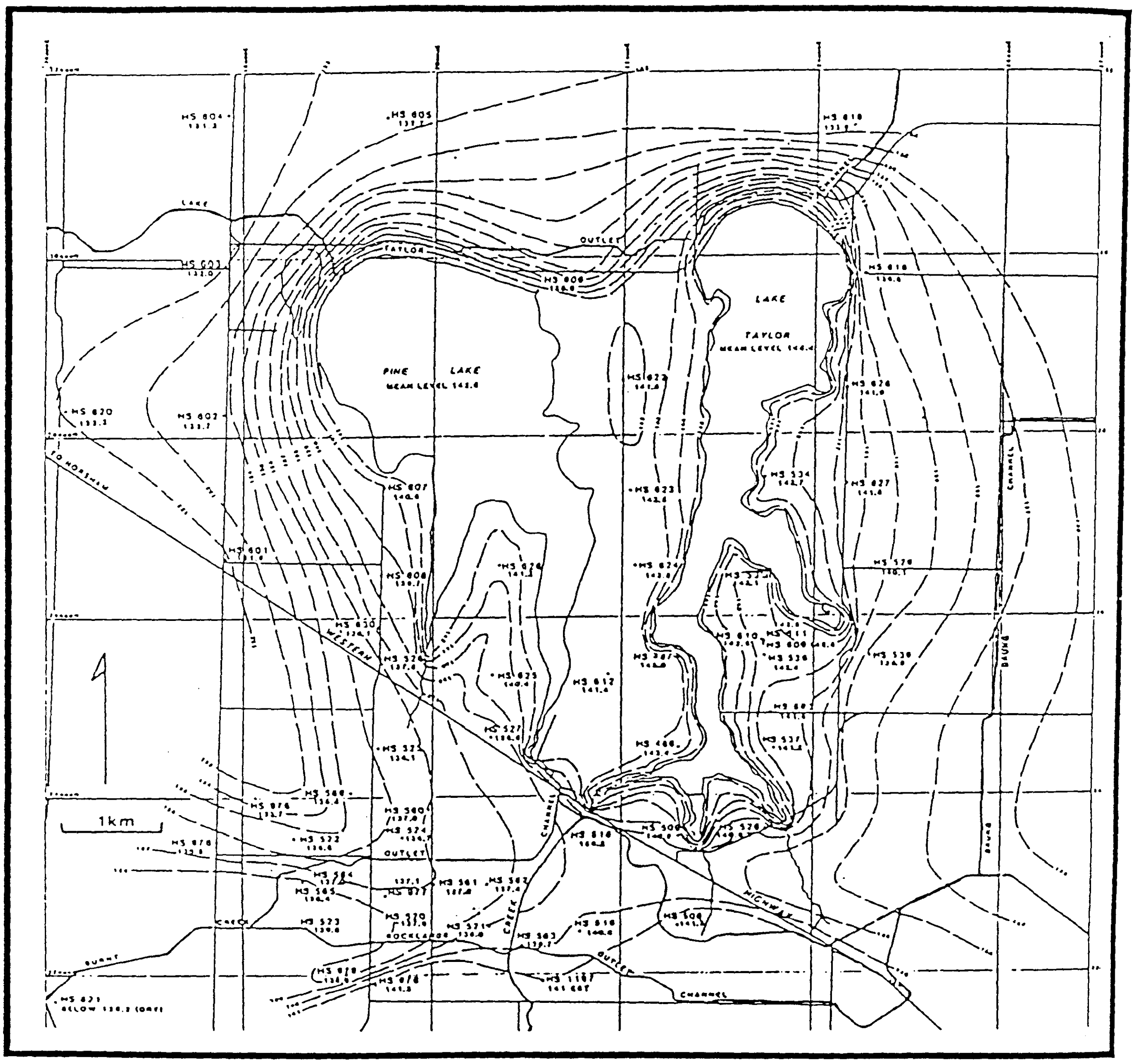


Figure 3.4 Parilla Sand water table contours, metres AHD, June 1988. AMG shown.

Table 3.2 **Results of water quality analyses of two bores in the Parilla Sand aquifer in the Application Area**

	Borehole HS976 (400 metres west of pit)	Borehole HS522 (northern edge of pit)
pH	6.7	6.2
Total dissolved salts (mg/L)	12 000*	790
Ra226 (mBq/L)	220	40
Ra228 (mBq/L)	1450	590

* NaCl equivalent from conductivity measurement.

In this part of the Murray Basin, the water table in the Parilla Sand generally slopes to the north west and so groundwater movement is in that direction. The groundwater flow rate is very slow because both the hydraulic gradient and the hydraulic conductivity of the Parilla Sand are low. In the WIM 150 Study Area K = 1-2 m/day, with the highest recorded being 5 m/day. Aquifers in which water flows freely generally have hydraulic conductivities of about 20 m/day. Detailed groundwater data obtained during studies carried out by the Company (Figure 3.4) show that the simple pattern of a water table gradient to the north is disturbed by two effects :-

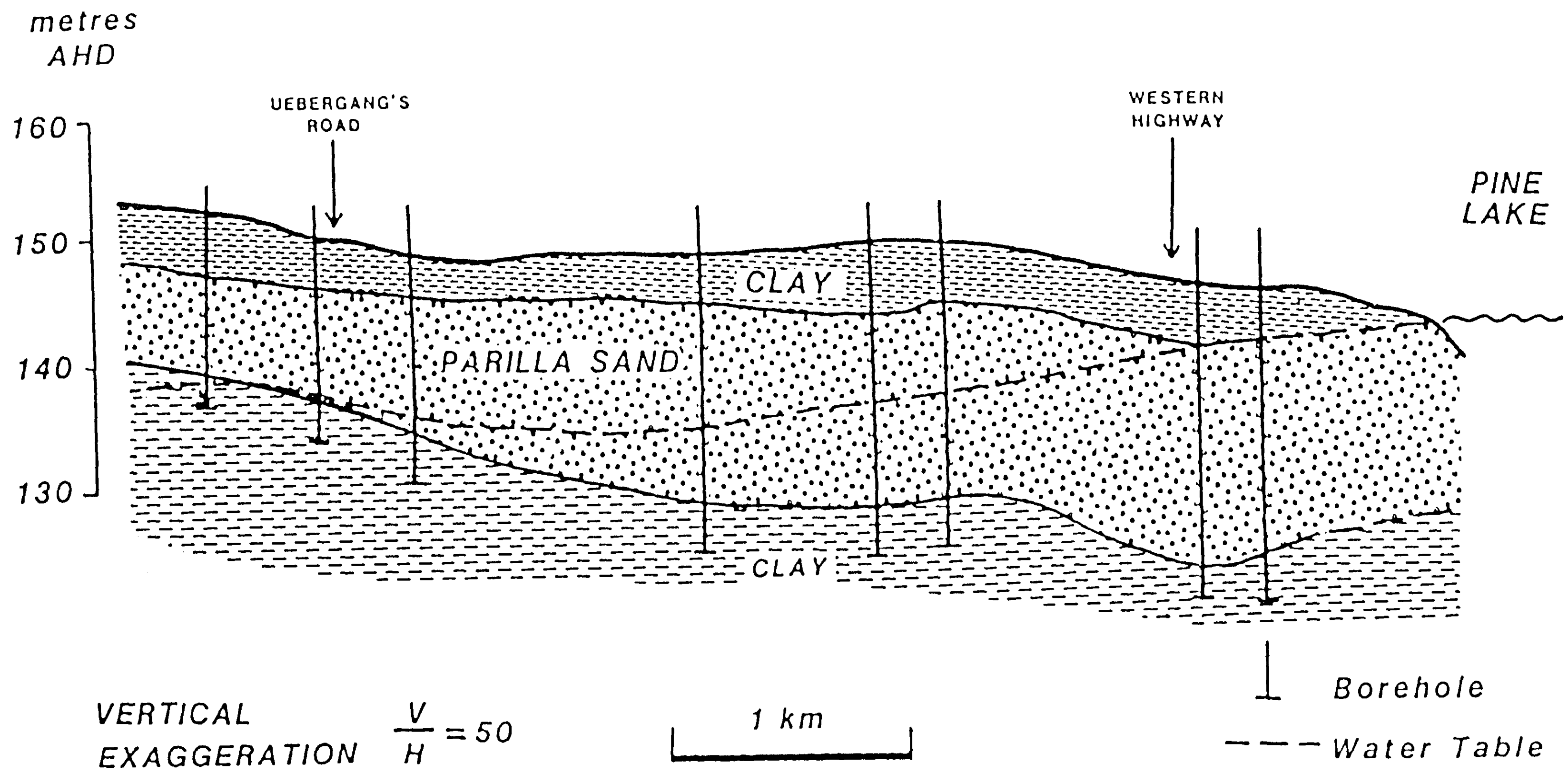
- the water table in the south west is low, which probably reflects relatively higher hydraulic conductivity in the Parilla Sand. This conclusion is supported by lower salinities in this area, which are probably caused by higher rates of flushing;

- the water table around Pine and Taylors Lakes is higher than expected. Around the lake edges, the water is in hydraulic continuity with the Parilla Sand and so water moves laterally into that formation (Figure 3.5). This effect has been artificially induced by the impoundment of water in Pine and Taylors Lakes at levels well above the natural water table.

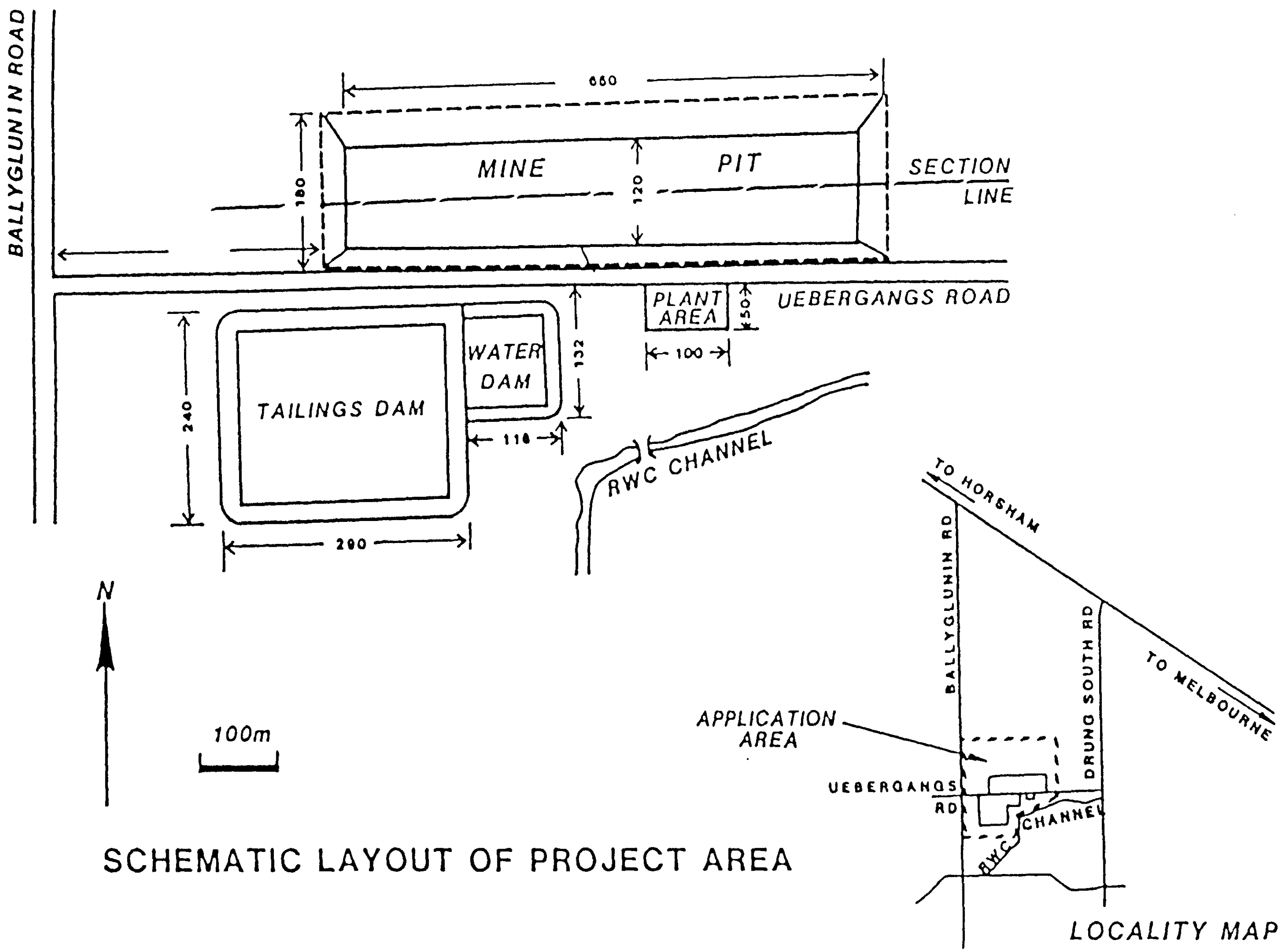
Apart from immediately around the lakes, the gentle hydraulic gradient and low hydraulic conductivity allow only a relatively slow movement of groundwater.

In the WIM 150 Study Area the Company already has about sixty observation bores, whose levels are monitored at approximately monthly intervals. Some have been monitored for three years and most for two years. Except in bores very close to the lakes, no significant change in water level seasonally or yearly has been observed. Bores close to the lake show a subdued and delayed response to the raising and lowering of lake levels. The irregularity of the water table contours near the lakes is due to intrinsic differences in the grain size and sorting of the Parilla, local cementing effects (lateritic weathering), and local sealing of the sand by alluvial clay on the lake edges.

The Company has prepared a technical paper on the hydrogeology of the Study Area which will be provided to relevant government authorities and will be made available to interested parties on request, which should be made to the Company.



SECTION SSW FROM PINE LAKE Figure 3.5



SCHEMATIC LAYOUT OF PROJECT AREA

Figure 3.6

3.3 MINING

3.3.1 Introduction

The Mine is required to supply about one million tonnes of ore to the Plant at the desired grade over a two year period. To allow this approximately one million tonnes of topsoil, overburden and barren sand will be moved. The grade of the ore is such that only a small proportion (up to about 5 per cent) will actually be removed from the site as mineral concentrates.

Other considerations in designing the proposed mine operation include the need to return tailings to the pit as early as possible but with maximum water recovery for re-use, and without compromising options for future commercial mining.

For a large-scale commercial operation at WIM 150, dredging would be the most economic and practicable method because the water table is above the base of the orebody for almost the entire deposit. However, for the amount of ore required for the Demonstration Project (which in mining terms is very modest) the cost of establishing a dredging operation would be prohibitive. Consequently the most appropriate method is excavation with tractor-scrapers at a location where the water table is at, or near, the base of the ore body. In industry terminology this is known as "dry mining".

The Project Area (Figure 3.6) meets the required criteria. The water table is very close to the base of the ore body, the site is close to a source of water (the RWC system), tailings dams, water dams, and overburden stockpiles can be located on adjacent areas of low grade ore, and following a decision to proceed with commercial mining the last bay of the mine pit would be a suitable site for erection of a dredge.

The boundaries of the Application Area were chosen to provide adequate space for the operation and to form a regular, easily defined shape.

3.3.2 Method

The mining involves two processes. The first is stripping, to remove the topsoil and overburden, and then actual mining of the ore for delivery to the plant.

Stripping will be done on three occasions (Table 3.1) and will be confined to the summer. Mining will start in mid 1990, and will continue for the remaining Project life.

The mining operation will utilize tractor-scrapers (open bowl and/or elevating) for excavation, graders for batter shaping and road works, and bulldozers for minor earthworks and ripping. Plate 3.2 shows a view of costean excavation which, although smaller in scale, is similar to the method that would be employed in the Demonstration Project.

During the initial phase, the object will be to strip overburden and construct the dams, plant, roads and other services. Topsoil (150 mm) will be stripped from the sites of the dams and from about 5 hectares of the pit and stockpiled for use in rehabilitation. The bulk of the overburden clay will be used to build dams while the remainder will be stockpiled. Ironstone at the top of the Parilla Sand will be broken up by ripping and used for access roads and hard standing areas. To the extent that barren sand is encountered it will be stockpiled separately for later return to the pit.

During subsequent stripping phases (i.e. in the second and third summer) most of the barren sand, clay and topsoil will be directly spread, in sequence, on the drained tailings to rehabilitate most of the pit. Nevertheless some stockpiling will be required in the second year.

Tailings will be pumped to the tailings dam for the first few months but subsequent tailings will be placed in bunded-off, mined-out areas of the pit (Section 3.5.2).

In practice, the sequential laying of barren sand and clay overburden on the tailings cannot commence until they are sufficiently drained. The final stage is to spread the topsoil and revegetate the surface (Section 4.1).

Due to the swelling of the sand and clay when excavated the final ground level of the pit area will be higher than at present. The actual level will depend on the degree to which compaction is achieved when tailings and overburden clay are returned to mined-out bays of the pit. The clay and barren sand will be placed by scrapers and hence will undergo some compaction by the equipment.

The initial "swell factor" is expected to be about 30 per cent for clay and 20 per cent for the sand. Final net swell is likely to be in the order of 20 and 10 per cent respectively, equivalent to a nett rise in elevation will be approximately 3 metres. The pit is located on an area of locally higher ground, so any increase in elevation will not interfere with drainage patterns. Low bunds will be provided against the ingress of surface water.

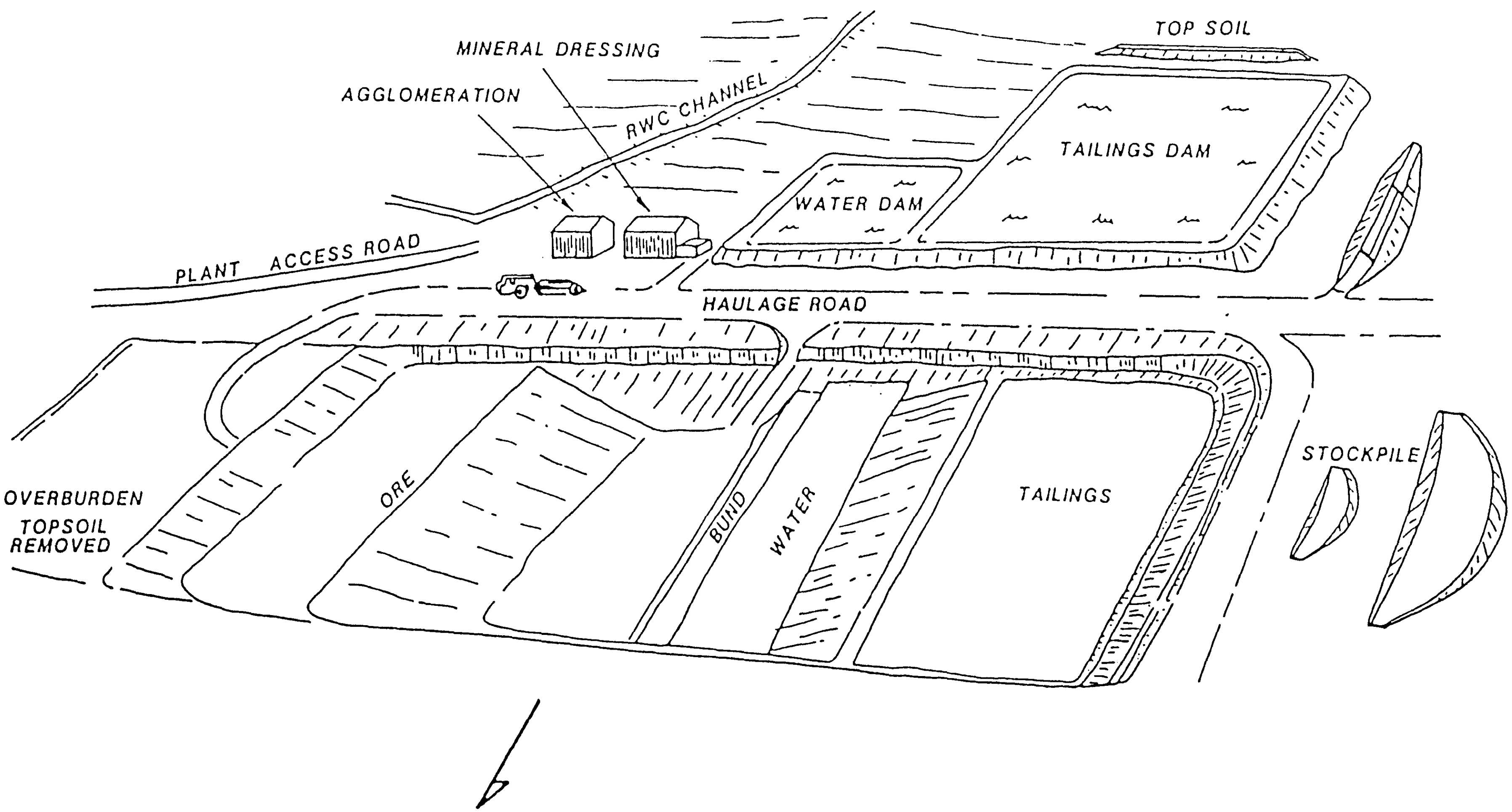
As the base of the ore zone in the pit is at or near the water table, there will be no dewatering as commonly understood. Based on experience during costean excavation it is possible to excavate with scrapers down to (and some distance below) the water table. In practice the intrusion of ground water into the pit will be very slow due to the low hydraulic conductivity. However, once tailings are being placed in the mined-out areas of the pit the lateral seepage will produce a mound of groundwater in the immediate area (Section 3.5.4). This raised water table will cause water to seep into the mining area immediately east of the bund. Although difficult to quantify in advance, this effect will help to reduce water consumption, because the water seeping into the pit will be recycled to the plant. Apart from this, water pumped from the pit will be from rainfall or minor seepage resulting from excavation below the water table.

Pit Design

A schematic layout is shown in Figure 3.6. and Figure 3.7 is an artist's impression of the scene. A long narrow pit has been selected to enable convenient management of the tailings, despite the cost penalty of extra perimeter batters. Gentle batters are nominated for the northern side in order that overburden stripping at a later commercial stage can be started easily and safely. The southern edge will be as steep as stability and safety considerations permit. Final details of pit design will be based on the results of pre-mine drilling early in 1989 and will accommodate the actual equipment to be used and safety requirements.

Dams

The dams will be similar in construction to the tailings dam at the Pilot Plant, although higher. Topsoil to a depth of about 150 mm will be removed from the whole area of the dams and stockpiled. The dam walls will then be built from overburden clay stripped from the minepit. The tailings dam will probably be about 5 m high and the water dam about 4m, with wall batters 1 : 2.



ARTIST'S IMPRESSION OF PROJECT LAYOUT Figure 3.7

Stockpiles

Overburden will be stockpiled adjacent to the pit and tailings dam. To minimise the placement of overburden on ore of recoverable grade it may be necessary for stockpiles to be up to 15 metres above ground level. Topsoil, clay and barren sand will be stockpiled separately.

Schedule

As previously stated, the plant is scheduled to start operations during the winter (June) of 1990. Consequently it is planned to commence pre-stripping and preliminary site works during the preceding summer. This stripping will expose sufficient ore for about 6 months mining.

3.3.3. Rehabilitation

As noted in 3.3.2, the material overlying the ore zone will initially be stockpiled. Sometime during the second summer (1990-91) it should be possible to start placing the freshly stripped overburden directly on to drained tailings and this will continue to the end of mining. Such material will be relaid in its original sequence and covered with topsoil prior to revegetation (Section 4.1).

An important aspect of the mine planning is to avoid imposing constraints on the orderly commencement of future commercial mining. For this reason it is not proposed to rehabilitate the entire pit area in the first instance. The northern edge will be left exposed so that overburden stripping can be safely and conveniently resumed when appropriate. Also, the eastern part of the pit will be left unfilled so it can be developed into the initial dredge pond for a possible commercial mine. If commercial mining does not eventuate, the northern edge of the pit will be rehabilitated, and the eastern part will be either rehabilitated or partially filled and sealed with clay for use as a water storage.

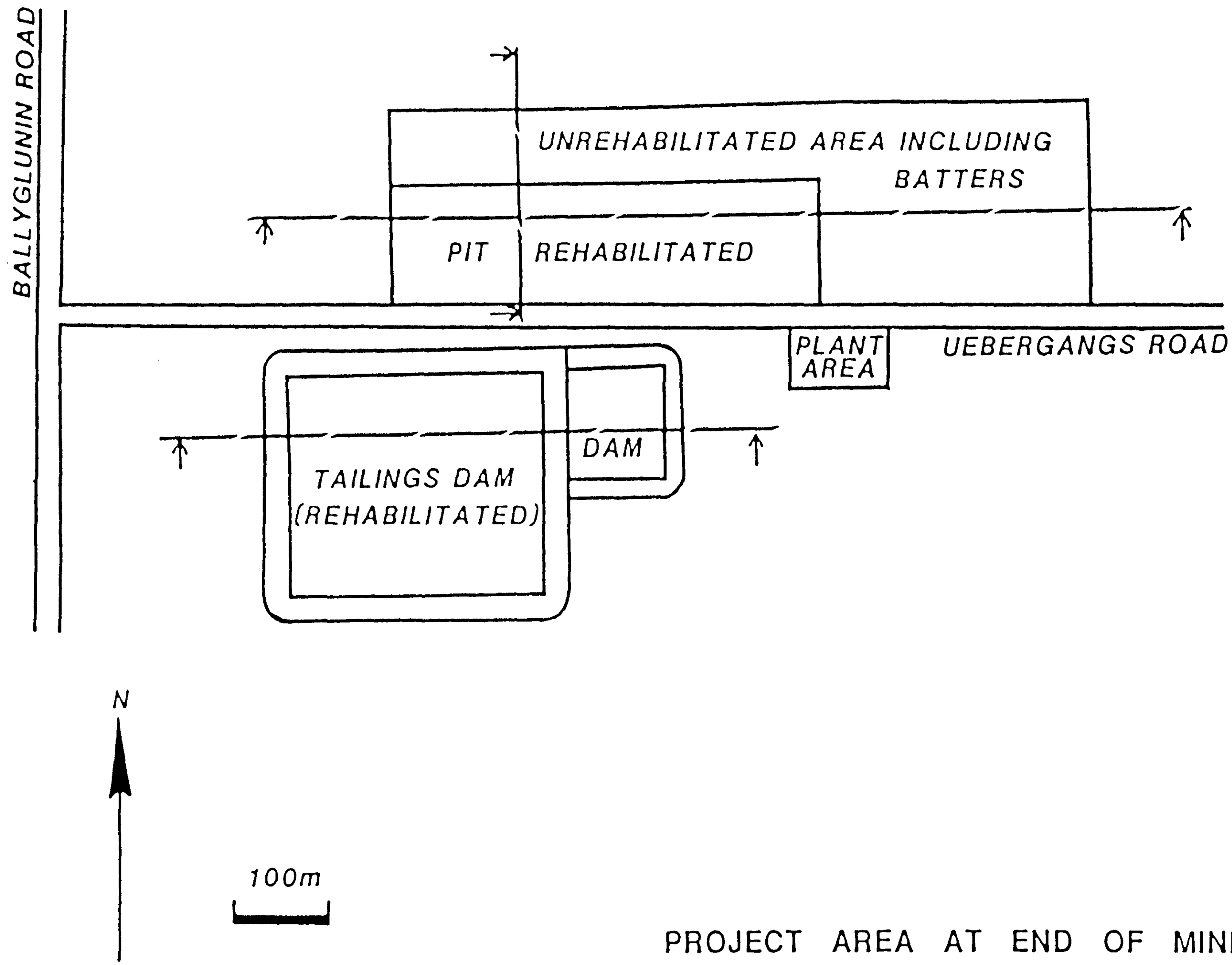
The surface of tailings in the pit and dam will be rehabilitated by shaping it into a concave surface then covering it with clay, and finally topsoil. Figure 3.8 shows the general layout and Figure 3.9 shows cross sections. The batter angles will about 1:3 for the edges of the relaid clay.

3.4 PROCESSING

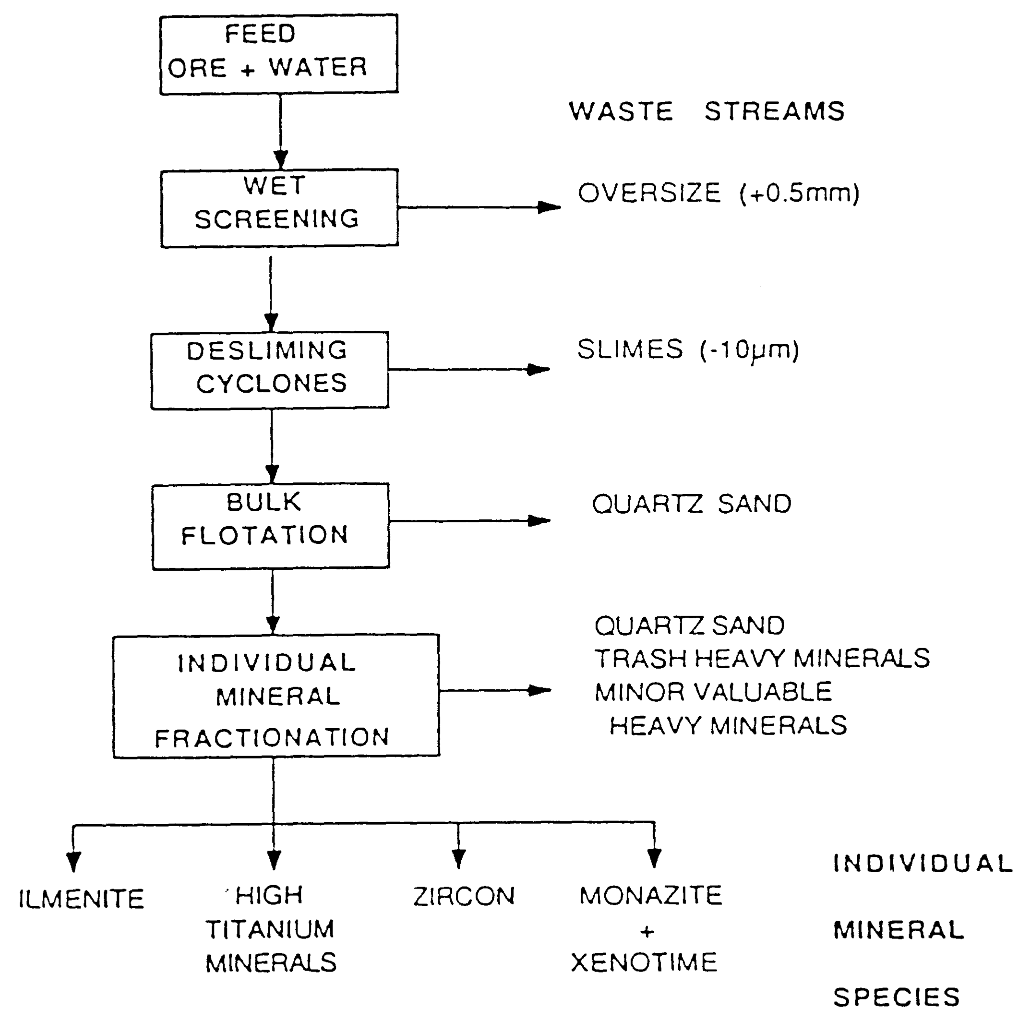
3.4.1 Components of the plant area

Final design of the Demonstration Plant will necessarily be dependent on the outcome of the current Pilot Plant operations. However it will have the following components :-

- a feed receiving and preparation area, where the ore is stockpiled;
- a process area, where the minerals are extracted from the ore;
- an agglomeration plant area;
- storage areas for mineral concentrates;
- pumping systems and pipelines to bring water to the plant and take tailings away;
- offices and amenities;
- car-parks;
- workshops, fuel and general stores;
- sewage and waste disposal facilities.



PROJECT AREA AT END OF MINING Figure 3.8



DEMONSTRATION PLANT FLOWSHEET
(SCHEMATIC)

Figure 3.10

It is currently envisaged that the process area, storage areas (except those for monazite and xenotime) and office areas will be enclosed in a large industrial-type building. It will have walls and sides of galvanized iron and be set on a securely drained concrete slab. Its approximate dimensions will be 50 metres x 30 metres x 10 metres in height. A smaller but similar shed would accommodate the agglomeration plant.

Monazite and xenotime concentrates will be separately stored in sealed drums in accordance with industry practice and held in a designated brick building, as specified in the Radiation Management Plan (Section 4.5.4). The design of other storage areas will follow the appropriate regulations.

Most of the plant area of about one hectare will be surfaced with gravel over a crushed stone base.

Construction of all components is scheduled for the first six months of 1990.

3.4.2 Mineral processing

Introduction

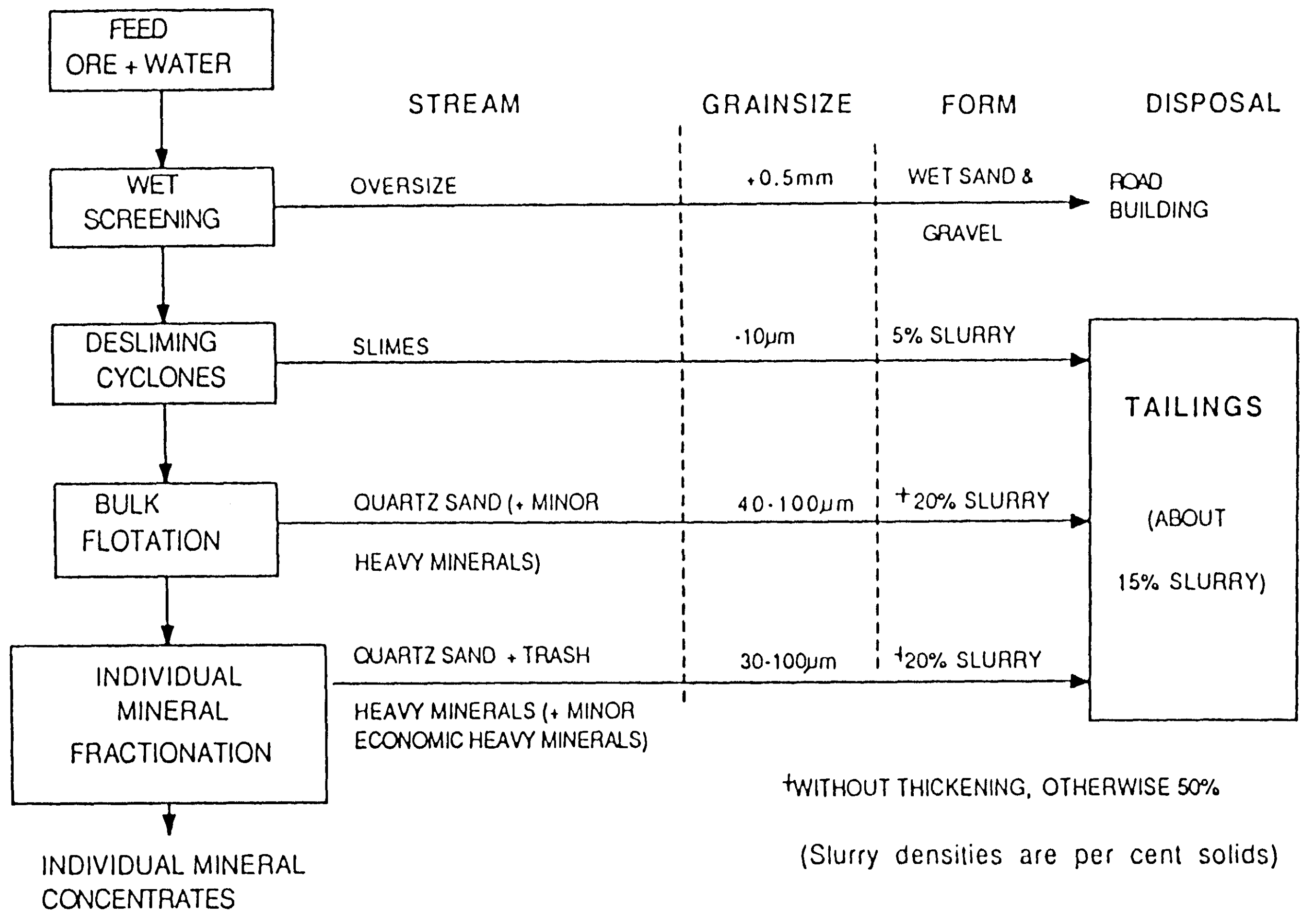
The processing of ore in the Demonstration Plant will follow essentially the same steps as are being developed in the Pilot Plant. The main difference between the two operations will be in flexibility to reconfigure equipment to accommodate development requirements. In the Pilot Plant, equipment is small and free-standing and may be rearranged with ease as the experimental programme demands. In contrast, flexibility in the operation of the Demonstration Plant will be mainly through modification of internal pipework, feeds, circuits and systems. The equipment will be much larger and fixed in position. Major configurational changes are unlikely, since an objective of the Pilot Plant programme is to reduce uncertainties in the Demonstration Plant design.

Processing of the ore can be divided into three stages - feed preparation, bulk concentration, and then individual mineral fractionation (Figure 3.10).

A fourth stage, agglomeration, will apply to the high-Ti concentrates and possibly the ilmenite. This is one of the areas where the Company has a substantial research effort in progress at the time of writing.

Feed preparation

Ore will be dumped into a hopper adjacent to the Plant. From the hopper it will pass to a feed mixing device where the "dry" ore will be disaggregated and mixed with water to create a slurry of about 25 per cent solids (by weight). The slurry will be then be fed to screening devices which produce a reject stream of oversize material (> 0.5 mm). The remaining slurry will be then fed to hydrocyclones which produce a reject stream of very fine clayey material (< .010 mm). The prepared feed will then be pumped to the bulk concentration area.



DEMONSTRATION PLANT FLOWSHEET AND WASTE DISPOSAL (SCHEMATIC)

Figure 3.11

Bulk concentration

- *Principle*

The prepared feed will be treated by froth flotation to produce a bulk mineral concentrate.

The conventional concentration and separation methods used in the mineral sands industry are gravity, magnetic and electrostatic techniques. However, Company research has shown that froth flotation (which is widely used in the mineral industry for the treatment of finely ground ores) is the preferred technology for the fine-grained sands of the WIM 150 deposit.

A principal feature that follows from the use of flotation is that all processing is carried out "wet". In conventional mineral sand processing, some separation stages are carried out in which the minerals are necessarily dry. This practice raises a dust hazard of considerable environmental significance since monazite and xenotime (with their radioactive content) are conventionally involved in these latter dry stages. By contrast, the dust hazard should be essentially eliminated in a flotation circuit. Further, the Company's research programme has shown it is possible to extract most of the radioactive minerals at an early stage in the flotation circuit, giving maximum flexibility in the choice of separation and cleaning techniques used in the later circuits. A principal aim of the Pilot Plant and Demonstration Plant programmes is to optimise this early separation of radioactive minerals in a manner that minimizes the hazard to operating personnel.

The process of flotation depends on the relative affinity of the surface of mineral particles for air or water. When bubbles of air are passed through a slurry containing mineral particles some of which have an affinity for water (hydrophilic), and the others which have an affinity for air (hydrophobic), the bubbles will tend to adhere to the hydrophobic grains. The particle-bubble aggregates are buoyant and float to the surface, collecting in a froth layer for recovery.

Most minerals are naturally hydrophilic, particularly the oxide, silicate and phosphate minerals which are present in the WIM 150 deposit . Consequently, to effect a separation by flotation, they must be rendered hydrophobic by adsorbing a chemical onto their surfaces. Selectivity is then achieved by choosing reagents which have a preferential affinity for specific minerals. This is controlled by variations in acidity, or by promoting or depressing the properties of the surface coating by other reagents.

The flotation circuit which evolved from laboratory research, and which is being further developed in the Pilot Plant, involves a preconcentration or "bulk" flotation of *all* the commercial minerals, while rejecting gangue materials into a tailing for disposal to a dam or eventually to mine fill. The much reduced volume of bulk concentrate compared with that of the original ore facilitates the separation of the individual mineral concentrates of commercial value.

The Company's research has advanced bulk flotation technology through the laboratory. Initial pilot trials were conducted in Adelaide and the process is at present in a Pilot Plant Phase at Drung South to refine and optimize the range of flotation procedures.

Present indications are that the reagents chosen in laboratory testing will continue to be used at the Pilot and Demonstration scales. However, the optimum addition rate of these reagents may vary due to differences between the batch processing methods used in the laboratory and the larger scale continuous processing methods. Consequently it is not possible to define the preferred reagents at this stage but they are described in Section 3.4.3.

. *The process*

The prepared feed will be mixed with reagents in a series of conditioning tanks from which it will pass into a bank of "rougher cells" where it is mixed with air. The tailings from the rougher cells are rejected to tailings areas while the bulk mineral-rich concentrate is delivered to a second set of "cleaner cells", where a purer bulk concentrate is produced. Tailings from the cleaner cells, having a concentration of heavy minerals which is similar to the prepared feed, may be recycled to increase recovery.

In the event that the rougher cells produce a concentrate pure enough for individual mineral separation, the bulk cleaner stage may not be required.

. *Waste*

The tailings material rejected from the bulk concentration stage will contain about 75 per cent water (i.e. 25 per cent solids) with traces of residual process chemicals. For the first 3-6 months of the operation this material will be pumped to the tailings dam, then subsequently to a bunded-off area of the pit.

Individual mineral fractionation

. *The process*

The bulk mineral concentrate will be separated in stages to produce four separate concentrate streams. The processes will include :-

- flotation, to separate the monazite/xenotime;
- magnetic separation, by WHIMS (wet high-intensity magnetic separation) to separate the ilmenite;
- flotation, to separate the zircon;
- flotation, to separate the high-Ti minerals and reject remaining gangue and "trash" minerals;
- gravity separation using devices (such as shaking table which separate materials of different specific gravities) may be used for final purification of the individual mineral concentrates.

Reject streams from any of these stages may either be combined with the bulk concentrate tailings or recycled to the ore feed.

. *Quantities*

The average daily quantities of the individual concentrates produced will depend on the grade of the ore. Based on average orebody grades, the Plant would be expected to yield :-

high-Ti	25 tonnes per day
ilmenite	35 tonnes per day
monazite/xenotime	1.5 tonnes per day
zircon	15 tonnes per day
Total	75 tonnes per day

The grades in the pit area may vary somewhat from the average over the deposit, leading to variations in output.

Agglomeration

The grain size of the WIM 150 high-Ti minerals appears to be too fine for conventional processing into titania pigments. In a novel agglomeration process developed jointly by CSIRO and the Company, the fine grains of concentrate are fused into a product which is similar in size to the mineral sands conventionally used in pigment production. It is proposed that initial demonstration trials into agglomeration of the WIM 150 high-Ti concentrates will be carried out in existing facilities in Melbourne, with later transfer to the Demonstration Plant.

The main steps in the process are :-

- drying;
- agglomeration, through the addition of essentially mineral binders;
- further drying;
- sintering.

Emissions from the agglomeration plant will be combustion gases after removal of particulate matter to comply with EPA requirements.

Construction of the agglomeration plant will not commence until an EPA Works Approval has been obtained.

3.4.3 Reagents

The flotation reagents to be used in the Demonstration Plant are not expected to pose any significant risk to the workforce, public health or the environment. The classes of reagents with examples of each are :-

- pH control - the pH of the process is controlled with alkalis such as sodium carbonate and acids such as sulphuric acid;
- frothers - these are used to assist bubble formation and typically involve surfactants such as polypropyleneglycol and nonyl phenol polyethoxylates;
- depressants - these are used to keep specific minerals hydrophilic and include sodium metasilicate (water glass) and starch derivatives;
- collectors - these attach preferentially to specific chemicals, making them hydrophobic so that they can be separated from the aqueous phase and collected in the foam (possible types to be used include certain soaps and detergents).

The total consumption of flotation reagents is anticipated to be in the order of 0.5 kg per tonne of ore and they are all of low toxicity. Most of this amount will be collectors which are adsorbed onto the surface of the mineral particles and are largely removed from the process with them. The bulk of the pH control reagents, frothers and depressants will be recycled from the tailings with the reclaimed process water although about 30 per cent is expected to remain with the interstitial water in the tailings sand.

Prior to use the name and quantity of all reagents will be advised to the Shire of Wimmera, Country Fire Authority, Environment Protection Authority and Rural Water Commission.

3.4.4 Energy usage

Most of the plant will be electrically powered, with the major usage being in the agitator systems. It is estimated that total Project electricity consumption will be of the order of two megawatts, which will be supplied from the existing grid.

Agglomeration is an energy-intensive process, and it is envisaged that the Demonstration Project life this process will require about 800 tonnes of gas or about 1350 tonnes of diesel fuel.

3.4.5 Water supply

It is proposed to purchase water for the process from the Rural Water Commission system which services much of the Wimmera Mallee with stock and domestic water. It will be obtained from the RWC's Burnt Creek channel at a regulator structure adjacent to the plant. The maximum total consumption for the Project is estimated at 850 megalitres over the two year period, but would probably be considerably less. The water demand will not be constant - it will decrease in the later stages (see also Section 4.3).

3.4.6 Occupational health

The Project workforce will be exposed to no greater risk of injury associated than in mining and similar industrial applications. Such risk will be minimized by good industrial and engineering practice, to comply with the appropriate regulations pertaining to noise, dust and injury hazards. An additional factor associated with the Project is the exposure to low levels of radiation, an aspect given detailed discussion in Section 4.5.

3.5 WASTE DISPOSAL

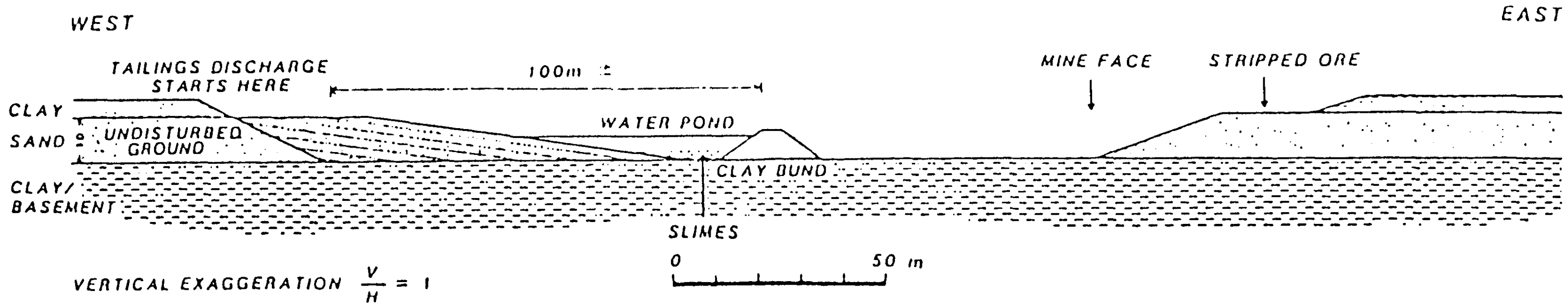
3.5.1 Introduction

The proposed plant flow sheet is shown in Figure 3.11. Four waste streams are present. Each stream is distinct, comes from a different part of the plant and is in a different physical form.

The proportion of ore ending up in the various waste streams will depend on the grade and grain size distribution of the ore being fed to the plant but, typically, the total waste will exceed 95 per cent of the feed and will be predominantly quartz sand.

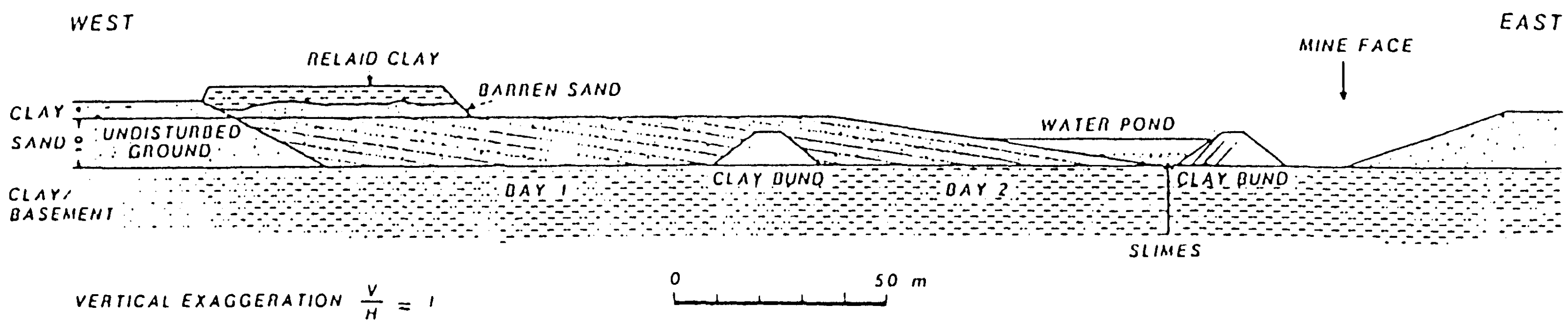
Apart from the oversize material (which, if of value, will be trucked from the plant), all other waste streams will be combined and pumped to the mined-out areas of the pit (or tailings dam in the early stages).

The slimes fraction is a cyclone overflow. It is, of necessity, of low solids content and difficult to thicken. When mixed with the sand-sized tailings, the resulting slurry will be 15 to 20 per cent solids. However, if required, the sand fraction can be thickened easily and cheaply (by cycloning) to around 50 per cent solids. In this case when the various streams are combined, the resultant solids level will be 35 per cent or greater. Thickening of tailings may have advantages in management of the tailings.



WEST-EAST SECTION OF OPERATIONS IN EARLY STAGES
TAILINGS BEING DEPOSITED IN INITIAL BAY

FIGURE 3.12



WEST-EAST SECTION SHOWING THE PROGRESSION EASTWARDS
OF MINING & TAILINGS DEPOSITION

FIGURE 3.13

3.5.2 Tailings management

For the initial few months of production, tailings will be pumped to the tailings dam. The dam will be designed to have a capacity of about 6 months tailings, which will provide some latitude in the event of any delay in starting with disposal into the mined-out area, and to allow for any contingencies during subsequent operations. When mining has advanced eastward about 100 metres a clay bund will be constructed across the mine pit to form the first "bay" for re-filling. Tailings will then be pumped directly from the plant to the western end of the bay (Figure 3.12). The deposition of tailings will form a small water pond to allow maximum re-use of process water and reagent. This water will be recycled to the plant via the water dam, which will act as an additional settling pond.

As mining advances and the first bay is filled, further bunds will be constructed and the process repeated (Figure 3.13). It is likely that over the mine life about six to eight such bunds would be required.

The actual behaviour of tailings is difficult to predict in advance, though the principles are well understood. It will be affected not only by the grain size distribution, but also by the influence of pH and salinity on the clay particles. However, the management system discussed here is indicative of what one might reasonably expect. It should also be noted that operating experience with the Pilot Plant tailings will be of assistance in the final design of the tailings management system for the Project.

3.5.3 Water balance

The calculated water balance of the operation is shown in Figure 3.14 Using the highest hydraulic conductivity measured in the WIM 150 Study Area (as a pessimistic assumption) the annual water consumption will be about 425 megalitres. In practice one would expect much lower consumption - perhaps as little as one quarter of this figure.

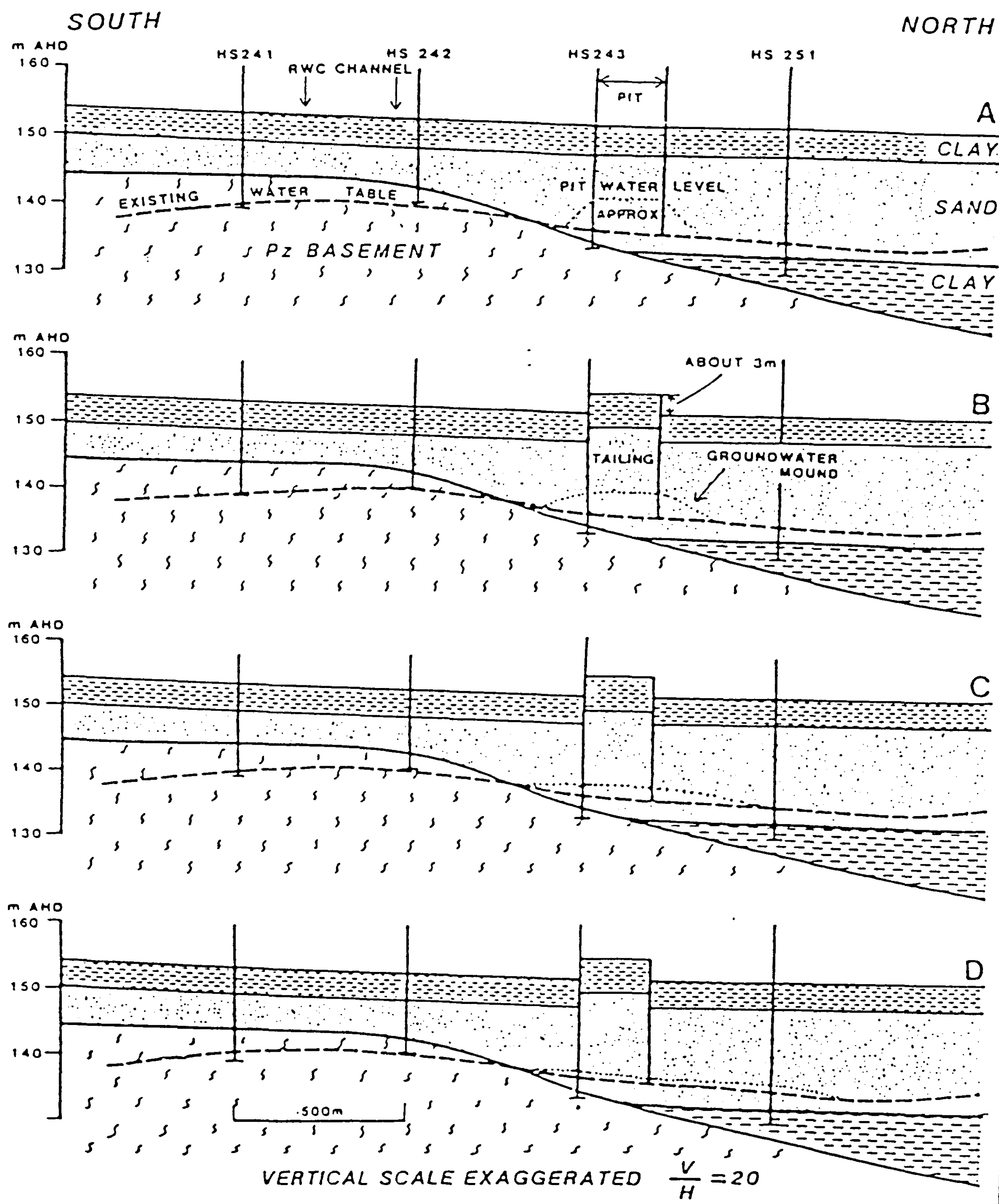
When tailings are placed in the pit, water losses occur predominantly in two ways. Firstly, by retention in the pore spaces of the tailings and secondly through seepage into the undisturbed ground adjacent to the pit. Accuracy in estimation of these amounts is constrained by two factors - the degree of compaction which will be achieved in the tailings and the hydraulic conductivity of the adjacent Parilla Sand. These aspects are discussed further in section 3.5.4.

Water loss from tailings stored in the dam will be confined to pore water entrained in the tailings, and evaporation. Given the low permeability of the clay used for construction of the dam walls and the construction method proposed, seepage losses through the dam floor and walls will be negligible.

3.5.4 Groundwater effects

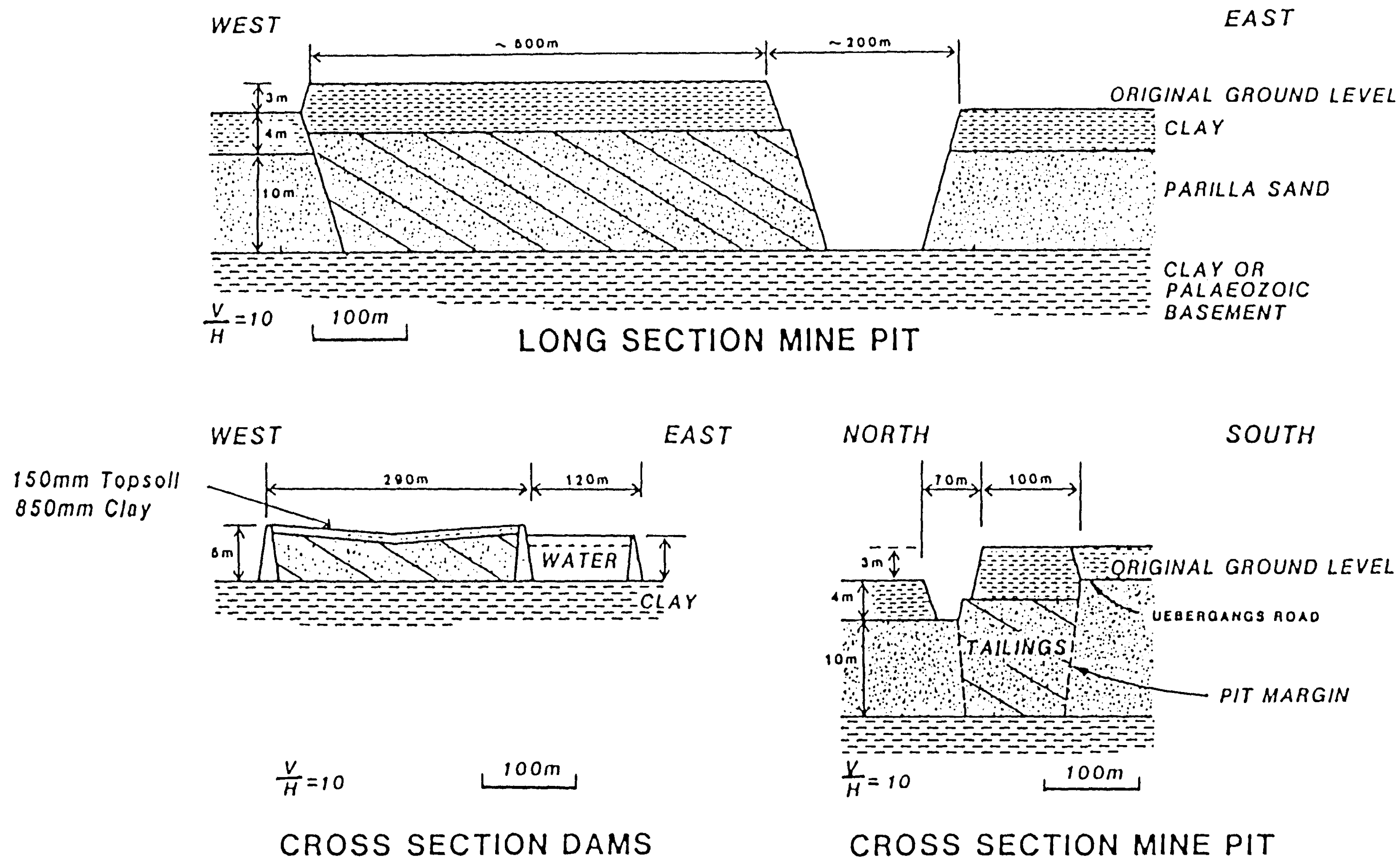
In practice the contents of the tailings dam will only be saturated (and thus capable of exerting a hydrostatic head) during the actual filling period. Subsequently the dam will contain only damp sand from which the water will slowly evaporate. The water storage dam will contain 3 to 4 metres of water throughout the life of the Project. However, once again, the clay quality and construction method will ensure that seepage into the Parilla aquifer from this dam will be negligible (the clay base being about 5 metres thick).

Consequently, the only measurable effect the Project will have on groundwater will be from seepage once tailings are being placed in mined-out areas of the pit.



NORTH-SOUTH SECTION OF PIT SHOWING
THE MOVEMENT OF WATER FROM THE TAILINGS

Figure 3.17



VERTICAL SCALE EXAGGERATED

PROJECT AREA AT END OF MINING - SECTIONS Figure 3.9

It is possible to predict in a general way what will happen to the seepage of process water from pit tailings and from the accompanying water-recovery pond. These predictions enable one to establish a mass balance (Figure 3.14) and also to develop suitable measures to monitor the actual effects. Such monitoring will identify any significant deviations from the predicted behaviour and allow prompt remedial action. One of the important side-benefits of the Project will be a better understanding of hydrogeology in the area.

The discussion which follows uses "conservative over-estimates" of the mass balance. It is appropriate to do so to assess the effects of a "worst case" situation on the existing environment.

Firstly we can consider the existing groundwater regime. The regional water table declines to the north-west. The elevation of the Parilla Sand water table in the WIM 150 Study Area is shown in Figure 3.4. In the Project Area it is apparent that the water table slope is to the north-north-east. Figure 3.15 shows the inferred water table on a larger scale, together with existing observation bores. Some of the additional exploration holes drilled during early 1989 will be used for extra monitoring. Observation bores may also be installed in the tailings areas after filling.

When tailings are placed in the first mined-out bay of the pit, there will be seepage into the adjacent undisturbed ground on three sides. After about six months when all tailings are going into the second bay, seepage will be on the north and south sides only; the bund of the previous bay will prevent any direct movement west from the new bay. Figure 3.16 shows diagrammatically the progressive movement of seepage into the adjacent undisturbed ground.

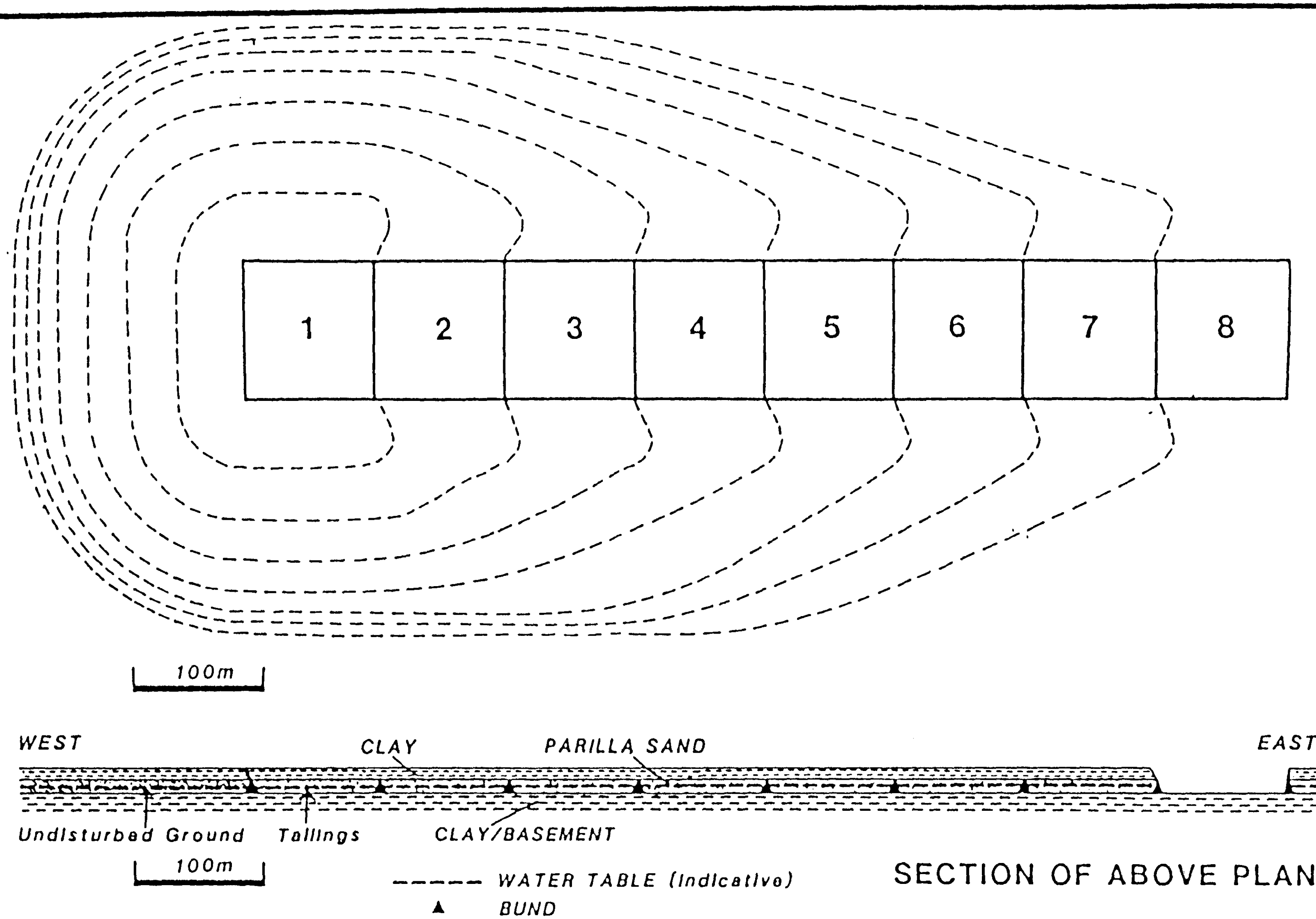
As the water table in the pit is virtually at the base of the ore body, the hydraulic gradient (and therefore the movement of water in the immediate vicinity) will predominantly be affected by the level in the water recovery pond and the wet tailings (Figure 3.17A). However, once the water moves away from the pit some tens of metres, its movement will begin to be influenced by the existing, natural water table (Figure 3.17B). Movement to the south will be limited to a few hundred metres because the natural water table rises in that direction (Figure 3.17C). Conversely, there will be greater movement to the north because the natural groundwater slope is in that direction (Figure 3.17D). To the east and west, there is very little natural hydraulic gradient and water movement will be only in response to the gradient developed by the mound of water around the pit.

Computer modelling by Coffey and Partners Limited suggests that after one year of tailings being placed in the pit the influence of the seepage water will extend to about 300 metres from the pit. When equilibrium is achieved (i.e. there is no hydraulic head to provide further movement) the water will have traveled a total of about one kilometre. Equilibrium will occur about a year after the last tailings are placed in the pit.

The modelling used K = 2 m/day, a reasonable estimate for the Study Area. Should the actual value be higher, then the rate of water movement will be greater, a larger volume of undisturbed ground will be occupied, and equilibrium will be reached sooner.

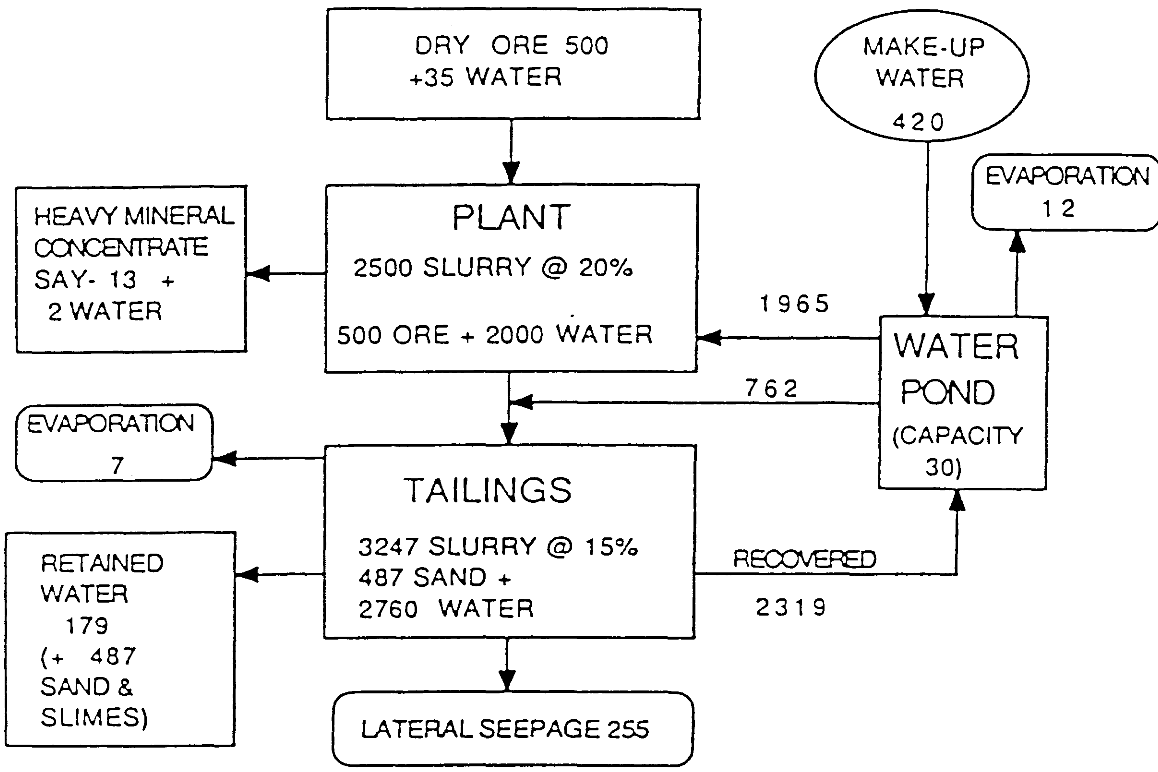
The actual flow rates will of course depend on the hydraulic gradient and the hydraulic conductivity of the undisturbed ground. The hydraulic conductivity can only be estimated at present, but will be established from bores which are monitored while tailings are being deposited.

To put this discussion in perspective, the mass of water and the volume of sand that could be affected warrant consideration.



SECTION OF ABOVE PLAN

DIAGRAMATIC REPRESENTATION OF THE LATERAL EXTENT OF SEEPAGE Figure 3.16

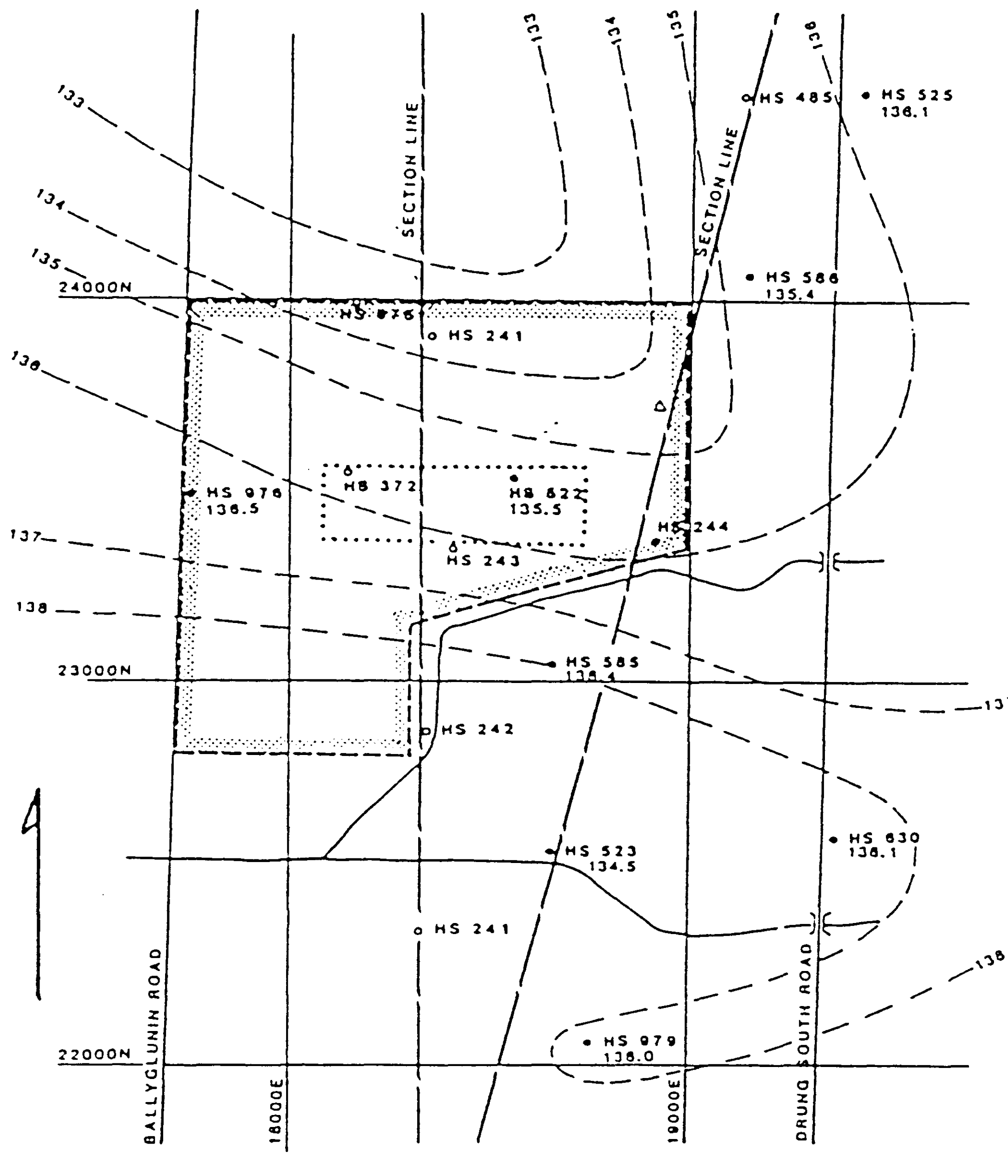


DEMONSTRATION PLANT MASS BALANCE

MASSES IN KILOTONNES

0.85 t WATER/ t FEED.
1 megalitre water = 1 kilotonne

Figure 3.14



LEGEND

APPLICATION AREA BOUNDARY

PIT OUTLINE APPROX

• HS 522 135.5 OBSERVATION BORE WITH CRAE REF No & ELEVATION OF WATER TABLE

DATUM - AHD

o HS 243 EXPLORATION DRILLHOLE USED ON SECTIONS WITH CRAE REF No

INFERRED WATERTABLE AND EXISTING OBSERVATION BORES Figure 3.15

The estimated total mass of water required for the two year life of the Project is 850 kt (thousand tonnes). Losses by evaporation are estimated at 19 kt, leaving 831 kt. After the tailings are fully compacted and drained, they will still hold about 12 per cent water, which is 120 kt Therefore the maximum mass of water which could move out into undisturbed ground is 711 kt. In practice, the tailings are unlikely to compact fully and will retain rather more water.

Parilla Sand above the water table contains an average of about 7 per cent water, while that below the water table (which is saturated) contains about 20 per cent water. Thus the Parilla Sand above the water table is capable of holding a further 13 per cent of water, equivalent to an additional 0.22 tonnes of water per cubic metre of sand.. The effect of water seeping out of the pit into undisturbed ground will be to create a localized groundwater mound. If the sand is saturated the mound will be about 3.2 Mm^3, (i.e. 711 kt divided by 0.22 m^3). This volume would be occupied by a body of sand covering an area of one square kilometre, 3.2 metres thick, or a more extensive but thinner body occupying the same volume.

This groundwater mound will gradually flatten to form a body of damp sand (about 12 per cent water content) which has less water than the saturated sand below the water table (about 20 per cent), but more than the undisturbed ground above the water table (about 7 per cent). The volume of sand then affected will about 14.2 Mm^3. For comparison, the Parilla Sand in the WIM 150 Study Area occupies about 900 Mm^3, most of which is saturated with water. The water added to the Parilla Sand therefore will represent about one half of one per cent of the existing volume of Parilla Sand water in the Study Area alone; moreover, the added water will be of better quality than existing ground water, in terms of its salt and radionuclide content.

It must be emphasized that the northward movement of water poses no risk to the RWC water storages. The maximum possible northward movement is well short of Pine Lake and, more importantly its elevation is much lower than the lake.

4 THE EXISTING ENVIRONMENT AND EFFECTS OF THE PROPOSAL

4.1 TOPOGRAPHY AND LAND USE

The Application Area is on a gently undulating plain north-west of the Grampians with a gentle slope to the north of about one in a hundred.

The main impact of the Demonstration Project on the topography will be the construction of the mine pit and stockpiling of overburden to a height of up to 15 metres. In addition, when the pit is re-filled and rehabilitated, the final surface will be slightly higher than the original surface (Section 3.3.3).

The Application Area is farmed in a manner typical for the region. The main activities are sheep grazing for wool and meat production, and cropping (mainly of wheat). Most of the Area has been cultivated and sown with introduced pasture grasses or crops many times since the area was opened to European settlement about 100 years ago. The Demonstration Project will only occupy about 30 hectares and therefore will have little impact on the current farming operations on the 1100 hectares of farm land owned by the Company, and will have no direct effects on the activities of neighbouring farmers.

Revegetation

After the tailings deposited in the dam and mine pit have drained and consolidated, they will be covered by barren sand, overburden clay and topsoil in sequence (Section 3.3.3)

The topsoil layer in the Lease Area is only about 10-15 centimetres thick. Because it is so thin it is inevitable that the stockpiled "topsoil" will actually contain quantities of the underlying clay. Further mixing with the clay will occur when the "topsoil" is re-spread. Mixing of clay with topsoil will have several effects on soil structure :-

- the particles of soil will be on average smaller and more prone to waterlogging and compaction. This problem will be overcome by the application of gypsum to improve the soil structure. Gypsum is routinely used in the Wimmera to improve clayey soils (Section 3.2.3);

- the soil will probably require applications of fertilizers to redress any imbalances or deficiencies of plant nutrients;

- the organic content of the soil will be lower than in surrounding areas, and will be built-up in the conventional way through growing and working-in legume species which will also aid in increasing the nitrogen content of the soil.

After taking measures to improve the re-spread soil, the mined area will be returned to farming.

There are unlikely to be any major difficulties in revegetating the mined areas. Even without the remedial measures mentioned above, the topsoil mined from the costeans during 1987 has been colonized by a number of pasture species, and some growth is also evident on overburden clay (Plate 4.1).

4.2 CLIMATE

Horsham has cold winters and hot summers. Mean daily maxima range from 13.5°C in July to 30.8°C in January. Mean daily minima range from 3.9°C in July to 14.2°C in January and February.

In the Grampians, the average rainfall is over 750 mm, while at Horsham it is 449 mm. About 20 kilometres north of the Application Area (at Longerenong College) the average annual evaporation exceeds precipitation by 1146 mm (Table 4.1), and even in the wettest year on record (1973) evaporation (of 1424 mm) exceeded precipitation (of 810 mm) by 614 mm.

Table 4.1 Average rainfall and evaporation at Longerenong College. Period of record: Precipitation 1967-1987, Evaporation 1969-1987.

MONTH	RAINFALL (mm)	EVAPORATION (mm)	DIFFERENCE (mm)
January	31	257	-226
February	25	221	-196
March	26	171	-145
April	34	102	- 68
May	47	56	- 9
June	32	36	- 4
July	49	40	+ 9
August	49	59	- 10
September	39	84	- 45
October	48	133	- 85
November	34	180	-146
December	25	239	-214
TOTAL	439	1 585	-1146

These evaporation and rainfall figures have been used in considering the water balance (Section 3.5.3) and surface runoff (Section 4.3).

Wind monitoring carried out at Drung South from September 1986 to September 1987 (NSR 1987) showed that winds are fastest during the summer and slowest during the winter with an median (average) wind speed of seven knots.

4.3 SURFACE WATER

Natural drainage

Rainfall in the Application Area is largely absorbed and held in the surface layer of the soil, or forms surface pools which evaporate. During periods of high rainfall some runoff occurs from the Project Area to roadside ditches along Uebergang's Road, and to a low-lying area of a paddock to the east. A drainage ditch has been cut through this paddock along what was probably an intermittent natural watercourse and the limited surface runoff finds its way to this ditch which ultimately enters Pine Lake to the North.

The Project will entail surface disturbance on a scale far less than that which occurs during the cultivation activities which are a normal feature of farming in the district. Guidelines for Minimizing Soil Erosion and Salination for Construction Sites in Victoria will be followed.

A programme of monitoring the quality of surface water has commenced. Included in this programme is a site on the drainage line near the Project Area which will be regularly monitored during the Demonstration phase. The parameters being monitored are pH, conductivity, dissolved oxygen, colour, turbidity, suspended solids, major cations and anions, metals and nutrients.

Rural Water Commission Channel System.

The Lease Area is traversed by Burnt Creek Channel and Rocklands Channel, which are integral parts of the RWC system which distributes water to the Wimmera and Mallee through a system of channels. The water is used for irrigation, replenishment of farm dams, domestic purposes and town supplies.

The Project Area is located about 200 metres to the north of the Burnt Creek Channel. It is proposed that water will be purchased from this channel to supply process water for the Project.

The Company recognises the importance of maintaining the integrity of water quality in the RWC system. A working group comprising senior RWC officers has been formed by the RWC Regional Manager, Horsham. The group liaises with the Company on technical aspects of the WIM 150 Project to ensure that RWC interests are taken into account at all stages.

Currently, the RWC system releases about 150 000 megalitres of water annually, which is derived from catchments in the Grampians and from the Wimmera, Avon, Glenelg, Richardson and Avoca Rivers. Of this total about 70 per cent either evaporates or leaks from channels and storages. Current efficiencies vary from about 65 per cent water delivery in the Wimmera area, to 33 per cent in the Mallee and 10 per cent in the North Mallee.

The quantity to be purchased over the two year life of the Project will be about 850 megalitres (Section 3.5.3). At this rate the Demonstration Project will use about 0.25 per cent of the typical RWC annual release of water (for each of two years). This is equivalent to the annual water entitlement for an irrigation holding of approximately 40 hectares.

Completion of the Demonstration Project will improve estimates of the water requirement for commercial mining. Currently it is thought that 10 000 megalitres would be required for a mining operation at the rate of 20 million tonnes per year

It is unlikely that this amount of water can be supplied from the RWC system in its present form. Three options are being discussed between the Company and the RWC whereby this water could be supplied without adversely effecting current users, or the Wimmera River catchment :-

- several times the WIM commercial mining water requirement could be saved by system improvements to the open channels in areas of the highest water losses (which would have the added advantage of reducing salination in those areas);
- mined out areas could be retained as additional fresh water storages to boost the RWC reserves;
- the underlying Renmark aquifer could be a partial source of process water.

The Company believes development of the WIM 150 resource offers the potential for useful improvements in the efficiency of the RWC's Wimmera Mallee system, with consequential benefits to current water users and the Wimmera River catchment.

4.4 REGIONAL GROUNDWATER

A full consideration of the effects on groundwater is included in Section 3.2.4. The effects on regional groundwater systems will be undetectable, because of the relatively small quantities of additional water introduced to the Parilla Sand aquifer. This additional water will be fresh and will therefore tend to reduce the salt and radionuclide concentrations.

Dams

The tailings dams will be constructed of overburden clay from the mine pit. The contents of the dam will be saturated (and thus capable of exerting a hydrostatic head) only during the times it is in use. For the rest of the time it will contain only damp sand which will slowly lose water through evaporation. By the time the dam is covered and revegetated, the tailings will be virtually dry.

4.5 RADIATION AND OCCUPATIONAL HEALTH

4.5.1. Radiation in the environment

Radiation includes visible, infra-red and ultra-violet light and radio waves, as well as "ionizing radiation". The latter is radiation which causes atoms to become electrically charged or "ionized". The presence of such ions in living tissues may affect biological processes and thus represents a health hazard. At very high levels ionizing radiation causes burns or acute sickness, but at lesser levels long-term effects include an increased probability of cancer or genetic damage.

Isotopes of the uranium and thorium in the monazite and xenotime undergo spontaneous radioactive decay, through a series of progeny isotopes, to stable isotopes of lead. During this decay, three types of ionizing radiation are emitted :-

- alpha radiation - particles which have low energy and low penetrating power;
- beta radiation - particles which have moderate energy and moderate penetrating power;
- gamma radiation - electromagnetic radiation which has high energy and high penetrating power.

Assessment of alpha and beta radiation is based on measuring individually the activity of the individual isotopes in the decay series, or by measuring the levels of alpha or beta radiation. Measurements of the activities of isotopes are expressed in becquerels (or disintegrations). Concentrations in air are quoted in becquerels per cubic metre (Bq/m^3) and concentrations in water are expressed in becquerels per litre (Bq/L).

Measurement of gamma radiation is in terms of the amount of energy absorbed per unit mass of material. The System Internationale (S.I.) unit is the "gray", where one gray is the amount of radiation which deposits one joule of energy in one kilogram of material, In assessing the biological response to radiation, reference is made to "dose equivalent", because different forms of radiation do not produce the same biological response for the same quantity of energy absorbed. The SI unit is the "sievert". One sievert is equal to the product of the absorbed dose by a quality factor and any modifying factors. Expressing dose in sieverts allows a comparison of the relatively greater biological damage caused by some particles such as alpha particles and fast neutrons. For most beta and gamma radiation, one sievert is equal to an absorbed dose of one joule per kilogram.

Exposure to a low level of naturally-occurring ionizing radiation cannot be avoided. The dose received by individuals varies greatly depending on factors such as altitude, diet, housing type and geographical area. The average dose is 2.4 mSv (i.e. milli-sieverts or .0024 sieverts) annually, which mainly originates from decay products of uranium and thorium (1.37 mSv), cosmic rays (0.3 mSv), potassium 40 (0.3 mSv) and medical uses (0.4 mSv).

4.5.2 Exposure pathways

To assess the incremental radiation exposure due to Project operations (i.e. the increase above natural background levels), it is pertinent to consider the possible exposure pathways. Exposure to radiation from both natural and Project sources can occur through :-

- inhalation of airborne radon progeny and thoron progeny;
- inhalation of dust particles containing long-lived alpha emitters;
- external gamma radiation.

Radon (Rn-222) is the only gas in the uranium (U-238) decay chain, and thoron (Rn-220) is the only gas in the thorium (Th-232) decay chain. There is the potential for emanation of radon and thoron from exposed ore and process material containing uranium and thorium, so that increases above naturally occurring levels of these gases in air could occur. It is not the gases that are of interest, but their short-lived alpha-emitting decay products which may remain airborne for some time. Radon progeny comprise polonium-218, lead-214, bismuth-214 and polonium-214. Thoron progeny comprise polonium-216, lead-212, bismuth-212 and polonium-212.

Inhalation of airborne dust particles which contain increased radionuclide activity is a second possible exposure pathway. In this instance, the only significant sources of radiation are the long-lived alpha-emitters in the uranium and thorium decay chains. For the uranium decay chain the radionuclides to be considered comprise uranium-238, uranium-234, thorium-230, radium-226 and lead 210. For the thorium decay chain the relevant radionuclides are thorium-232, radium-228, thorium-228 and radium 224.

Gamma radiation is electromagnetic radiation similar to X-rays. The exposure pathway is direct and external.

4.5.3 Relevant legislation

The *Environment Protection (Nuclear Codes) Act* 1978 has been designed to limit the exposure of employees and members of the public to radiation. Because mineral sand deposits contain monazite and xenotime, which in turn contain small amounts of uranium and thorium, the Act and its accompanying Codes apply to the industry. Under the *Code of Practice on Radiation in the Mining and Milling of Radioactive Ores*,1987, the following incremental exposures are considered to constitute an acceptable risk, and must not be exceeded.

Members of the public	1 mSv/year
Non-designated employees	5 mSv/year
Designated employees	50 mSv/year

In addition to these absolute limits on exposure, the Code requires that all radiation exposure is kept "as low as reasonably achievable" (ALARA).

The *Code of Practice on the Management of Radioactive Wastes from the Mining and Milling of Radioactive Ores,* 1982 applies to the management of radioactive waste arising from all operations involving the mining and milling of material containing more than 0.02 per cent uranium or 0.05 per cent thorium.

The mineral concentrates of monazite and xenotime are transported under the *Codes of Practice for the Safe Transport of Radioactive Substances* 1982.

4.5.4 Radiation at WIM 150

Introduction

A comprehensive survey of background concentrations of radionuclides and background radiation levels was carried out from mid 1987 to early 1988 by Amdel (1988). Measurements of radionuclides levels were made on soil, surface waters, groundwater, sediments and air; and gamma measurements were made throughout the Lease Area. The range of background results related to the main exposure pathways are set out in Table 4.2. With the exception of groundwater measurements, the Lease Area was found to have levels of radionuclides which were variable and low, comparable with normal background levels found elsewhere in Australia.

Table 4.2 Background radiation levels, ranges of results.

Gamma radiation	0.04	to	0.12	μGy/hr
Radon	<2	to	23	Bq/m^3
Radon progeny	<5	to	32	Bq/m^3
Thoron progeny	<5	to	370	Bq/m^3
Long-lived alpha	0.0	to	0.38	mBq/m^3

Groundwater

Baseline measurements of naturally occurring radionuclides in Parilla Sand groundwater show significant spatial variability, especially for Ra-226 (Table 4.3).

The NHMRC recommended standard for radium in drinking water is 400 mBq/L. Where this level is exceeded the bore water is unsuitable for drinking.

Table 4.3 Range of background radionuclide levels in groundwater from bores into Parilla Sand.

Radionuclide	Range of results (mBq/L)	Location of maximum
U-238	<10 to 730	N.E. of Lake Taylor
Th-230	<5	-
Ra-226	10 to 3100	S.E. and S.W. of Lake Taylor
Pb-210	<10 to 270	Near southern margins of Pine Lake and Lake Taylor

Costean development

The construction of the western costean provided an opportunity to monitor radiation levels to which employees in a mine could be exposed. There are three sources of radiation which have the potential to contribute to doses :-

- *external gamma radiation*

The levels of gamma radiation were measured on a transect through the floor of the pit at heights of about one metre above the ore. The dose rate varied between 0.6 and 0.9 μSv/hr, whereas the rate measured outside the costean and outside the Lease Area varied between 0.06 and 0.1 μSv/hr (microSieverts/hour) .

- *radon and thoron progeny*

These airborne radionuclides were sampled on several occasions in 1987 and 1988 throughout the Lease Area, the surrounding areas, and in Horsham. Measurements were made in the western costean during excavation.

Radionuclide activity in costean air samples was not significantly different from background activity on the Lease Area (Table 4.4). Compared with levels in Horsham, only radon was slightly elevated.

- *radionuclides in dust*

Table 4.4 also shows the results of alpha activity of radionuclides in dust collected by high volume air samplers. The one result during costean development is within the range of the earlier background results, but higher than their average.

Table 4.4 Activity of radionuclides on the Lease Area and during costean development.

LOCALITY	Radon Bq/m^3	Radon [2] Progeny Bq/m^3	Thoron [2] Progeny mBq/m^3	Long-lived [3] Alpha mBq/m^3
Horsham all results July 1987-February 1988	4±2 [1]	11±8	110±83	0.26
On Development Lease July-December 1987	5±3	8±5	100±83	0.14± 0.12
West Costean December 1987 during excavation	9±5	7±5	85±47	0.28
On Development Lease February 1988	5±4	8±5	81±25	-
Off Lease July-December 1987	5±3	-	-	-
Off Lease December 1987 -February 1988	5±3	-	-	-

Note: 1. Where there was more than one sample, values are shown as mean ± one standard deviation.
2. Radon, radon progeny and thoron progeny results were from low volume air samplers.
3. Long-lived alpha emitters in dust were collected by high volume air samplers.

4.5.5 Occupational health

Pilot Plant operations

At the time of writing the Company's Radiation Management Plan (RMP) is before the Victorian Department of Health, which is the Appropriate Authority under the Act. Once approved, it will become a public document.

Predictions of radiation dose in the RMP are based on :-

- recordings of radiation levels during research into processing at the Adelaide laboratory of Amdel Limited;
- the measured activity levels of monazite and xenotime;
- the predicted amounts and concentrations of monazite and xenotime at different stages of the Pilot Plant processing;
- conservative over-estimates of the time operators will be in the plant and similar over-estimates of their proximity to radiation sources.

Using these conservative inputs to the RMP, the maximum dose estimated for a Pilot Plant operator is 3.52 mSv for non-designated employees.

The predicted maximum dose is the sum of three components :-

.	gamma exposure	3.5 mSv/year
.	radionuclides in dust	.006 mSv/year
.	thoron progeny in air	.015 mSv/year
	Total	3.52 mSv/year

Gamma radiation is clearly the major potential source of exposure in the Pilot Plant. Exposure to dust is limited because the plant uses wet-processing methods. Radon and thoron progeny are minor sources of radiation because the particles of monazite and xenotime are not subjected to chemical attack which would cause the release of radon or thoron.

For members of the public, gamma exposure can be ignored because of its rapid reduction with distance. In addition, because of dispersion with distance, the Pilot Project contribution to radionuclides in dust and thoron progeny levels will be significantly lower for members of the public than for workers. Hence, the incremental exposure to members of the public, if any, would be indistinguishable from background, and orders of magnitude below the public health limit of 1 mSv.

The RMP for the Pilot Plant provides for a number of safeguards to ensure that the dose levels of operators comply with the ALARA principle. These include :-

- storage of monazite in sealed drums in a locked brick building away from the Pilot Plant

- design of the Pilot Plant building to allow containment and clean-up of possible spillages;

- instruction of personnel and appointment of an on-site Radiation Safety Officer;

- monitoring of:-

  - gamma radiation,
  - employee dose rates, by use of TLD badges,
  - radionuclide in dust,
  - radon and thoron daughters in air,
  - surface contamination.

If predicted levels are exceeded, remedial measures are specified in the RMP.

Demonstration Plant

As the Demonstration Plant will be essentially a larger version of the Pilot Plant, a similar RMP will be adopted to comply with the ALARA principle and limit the exposure of employees and the public to levels below those specified in the Act.

Demonstration Mine

The RMP for the Pilot Project did not include an assessment of radiation doses which might be received by workers in the costeans, because the ore is being reclaimed from existing stockpiles. Moreover, the orebody concentrations of uranium and thorium are so low that the potential for exposure would be very limited, compared to the potential in the Plant, where monazite and xenotime are concentrated.

Employees engaged in the Demonstration Mining operation will be exposed to the radiation dose which will be the sum of gamma exposure, radionuclides in dust, and the inhalation of radon and thoron progeny. In the "worst case" an employee could be active in the pit for 170 hours per month, 12 months of the year.

Gamma levels in the pit would approximate those recorded in the costeans during excavation. Assuming a worker spends the maximum possible time in the pit, and receives the maximum incremental dose recorded in the costeans of 0.8 μSv/hr (Section 4.5.3), the annual incremental dose from gamma radiation would be 1.63 mSv.

The Project contribution to worker dose from dust and from radon and thoron progeny can be conservatively overestimated by assuming that the activity due to costean development equals the mean level plus the standard deviation (Refer Table 4.4); i.e.:

Radon progeny	= 12 Bq/m^3
Thoron progeny	= 132 mBq/m^3
Long-lived alpha emitters in dust	= 0.28 mBq/m^3.

In this case, and assuming a worker spends the maximum time in the pit, the additional dose, calculated from dose conversion factors in the Code of Practice, would be :-

.	radon progeny	0.41 mSv/year
.	thoron progeny	0.02 mSv/year
.	dust	0.05 mSv/year
	TOTAL	0.48 mSv/year

A worker in the pit would therefore receive a maximum incremental dose of 2.11 mSv/year, (i.e. the sum of the gamma dose of 1.63 mSv/year and the dust contribution of 0.48 mSv/year). This dose is less than half the upper limit recommended for non-designated employees. In practice, the dose would be less because workers would be shielded by machinery, and would not spend the maximum time in the pit.

For members of the public, gamma exposure can again be ignored because of its rapid reduction with distance. Furthermore, because of dispersion with distance, members of the public would be exposed to significantly lower levels of radionuclides in dust and radon and thoron progeny due to the Project, than pit workers. Thus, the incremental exposure to members of the public, if any, would be indistinguishable from background, and orders of magnitude below the public health limit of 1 mSv.

4.6 DUST

Wind acting on very fine clay particles of topsoil often causes the formation of a dust cloud near machinery during cultivation activities in the Wimmera. Similar disturbance and generation of dust is likely for a short period during the pre-stripping operations when the upper 15 centimetres of topsoil is removed.

During stripping there will be little wind-generated movement of the clay because it is damp and compact. The barren sand and the ore are coarser than the clay and are also compacted and damp, hence little movement is expected during mining. These predictions agree with observations during costean development, when little dust was generated.

On the existing stockpiles of topsoil, clay and barren sand from the costeans there has been formation of surface crusts which act as a seal and essentially eliminate dust generation. It is expected that this situation will apply to stockpiles from the Demonstration Mine.

Plate 4.2 View of the Project Area from the Western Highway. The costean is about 3km from the Highway. The mine pit and stockpiles will be about 700m closer and up to twice the height.

There will be no dust generation from the concentrates because they will be stored in enclosed areas. The monazite/xenotime concentrates will be stored in sealed drums in a lockable brick building.

On roads the ironstone and/or gravel surface will prevent significant dust generation.

4.7 VISUAL IMPACTS

The Project Area is visible from the Western Highway, Drung South Road and vantage points in the Grampians on Mounts Zero and Stapleton. The Western Highway is elevated about one or two metres above the surrounding countryside, whereas the Drung South Road is level with the surrounding countryside. The Grampians vantage points are at about 150 to 200 metres elevation.

The principal feature of the site visible from the roads will be the overburden stockpiles, which will be about 10 metres higher than the existing stockpiles (5 metres high) adjacent to the costeans. Plate 4.2 shows that the stockpiles will be of low visibility, but in any case the extent of the adverse visual impact is a subjective judgement, and dependent on the speed at which a vehicle passes the site and the purpose of the journey. Traffic on the Western Highway generally moves at 100 kph in this derestricted area and it is unlikely to have a high sightseeing component. The Drung South Road is used to some extent as a tourist route between the Grampians and Horsham although the Horsham-Mount Zero-Wartook route takes most of this traffic. On the positive side, there is potential for the site to be of minor tourist and landmark interest on a district landscape devoid of topographical features.

From the nearest Grampians viewpoint at a distance of about seven kilometres, the Project Area would encompass about four degrees of horizontal arc, or about one percent of a 360 degree view. The height of the individual components (the pit, plant building and dams) would limit their vertical visibility to less than one degree of arc. Therefore, the effect on the landscape from the Grampians will be slight. The limited visual effect is exemplified in Plate 1.1

4.8 NOISE

The major Project noise sources are likely to be scrapers and other heavy machinery, and some of the equipment at the processing plant. A consultant has carried out background noise measurements around the Project Area, including at occupied residences nearly, the closest of which is over one kilometre away from the Project Area. Background noise levels are relatively high due to traffic (Section 4.13) and wind (Section 4.2). The consultant will evaluate the likely Project-associated increase when more detailed information is available on mining machinery and the specifications of equipment to be installed in the plant. The Company will submit a Notification of Works to the EPA, and will comply with licensing requirements.

Permissible levels for noise emission to residential properties will be established specifically for the Project by the Environment Protection Authority. These permissible levels will be influenced by the existing background acoustic environment, which has been shown to be higher in the vicinity of the site and relevant nearby residences than at many rural locations, due to the influence of noise propagated from vehicle flow on the Western Highway, particularly at night.

Based on available noise data, it is anticipated that noise from the mining and processing plant can comply with Permissible Noise Levels, during the day and during most evening periods. Operation of the large mobile scraper equipment during night-time in compliance with Permissible Noise Levels will most likely require the custom design and fitting of noise suppression kits to the equipment.

4.9 FLORA AND FAUNA

The Project will be located on pasture land which, because it has been repeatedly cultivated, supports few native plants and is of very low value as a fauna habitat. A 1986 study of the Lease Area, which included some areas of more "natural" habitat, concluded that:

> "The loss of the vegetation and ephemeral wetlands on the site, (i.e., the entire Lease Area) together with the animal habitat that these form, will not significantly affect regional flora and fauna conservation values."

More detailed studies of the Lease Area were commissioned in late 1988. These studies, which entailed site visits and sampling by specialists in zoology, botany and limnology confirmed the limited biological value of the Demonstration Project Area. The Project will have negligible impact on the native flora and fauna of the Region. Loss of the remnant trees on the Project Area will be more than compensated for by tree plantings to be carried out by the Company in 1989. Local species of trees will be planted to the north and west of the Project Area in localities where there is no likelihood of future mining.

Continuing studies of the plants, terrestrial vertebrates and aquatic fauna of the WIM 150 Study Area are being carried out to acquire a database which adequately describes the biota and any seasonal variations that may be apparent. The results of these studies would be incorporated in an EES to cover the mining operation.

Consideration has been given to the possibility of birds being put at risk through exposure to tailings water containing traces of the flotation reagents. While there have been several isolated reports of bird deaths at tailings dams at Australian gold mining operations, no such problems are likely to occur at the WIM 150 site for the following reasons.

Tailings dams at gold mining operations often contain potentially toxic concentrations of cyanide. However a recent survey of State Conservation Departments by the Australian National Parks and Wildlife Service (ANPWS) produced little evidence of bird deaths associated with such operations throughout Australia. The most serious episode occurred at a gold mine in Western Australia during a long drought when a cyanide-containing tailings dam was the only significant water body in the area. The response to the ANPWS survey suggests that the risk to birds, even where the acutely-toxic poison cyanide is involved, is very low, particularly where alternative sources of water are readily available. Clearly, the risk factor where tailings areas do not contain toxic concentrations of other materials is insignificant.

The situation at WIM 150 is that the surrounding area is well supplied with many other, much more attractive water bodies. These include numerous farm dams regularly supplied by the RWC, the RWC open channel which carries water throughout the year, open water and wetlands associated with Pine, Taylors, Green and Dock lakes, and the streams, pools and waterways associated with Potters Creek and the Wimmera River system. Such water systems are particularly attractive to both aquatic and terrestrial birds because they provide an abundance of food, shelter and roosting or nesting sites for a wide range of species. In contrast, the tailings areas at WIM 150 will provide only small areas of free water, which will provide essentially no food, roosting or nesting opportunities. Furthermore, these areas will be subject to on-going disturbance from the mining and processing operations.

It is clear from the above that the water associated with tailings will have very little attraction for birds. However, even if some birds should frequent such areas they will not be exposed to any significant risk because of the nature of the reagents (which are essentially non-toxic), as discussed in Section 3.4.3.

Finally, in the event that any problem may arise, there are a number of measures which can be employed to discourage birds, including modification or removal of roosting features or the use of acoustic or visual features to frighten birds away.

The previous practice whereby shooting of wildfowl was commonplace has ceased. Shooting of birds on Company-owned land is prohibited at all times.

4.10 ARCHAEOLOGY AND HISTORY

A thorough survey of the Application Area was carried out by an archaeologist in late 1988. No evidence of aboriginal occupation was found. There are no sites of archaeological or historical significance which will be affected by the Project.

4.11 DEMOGRAPHY AND SOCIAL ASPECTS

4.11.1 Current population and employment trends

The WIM 150 deposit is within the Wimmera Statistical Division, which is experiencing a decline in population. Australian Bureau of Statistics figures show that in 1976 there were 54 456 persons in the Region, compared with 51 606 in 1986, a loss of 5.2 per cent. The population is ageing, because there is a tendency for younger people to leave the district to work in Melbourne or other centres. In 1976 38 per cent of the population was under 20 years of age, whereas in 1986 this figure was 32 per cent. The size of rural holdings in the Wimmera has increased steadily, while the number of people employed on each has decreased. Moreover, average annual income has declined in real terms - 71 per cent of the workforce earned less than $15 000 in 1986.

There is a widely recognised need in the Region for the development of new projects to arrest the decline in employment prospects and population. This concern has led to the recent formation by the local community of the Wimmera Regional Economic Development Council.

Mining currently employs few people in the Region (0.5 per cent of the 1986 workforce). The Project has the potential to increase mining's direct and indirect contribution to employment prospects, and thereby to assist in reducing the loss of young people from the Region.

4.11.2 The Project workforce

Total Workforce

As shown in Tables 4.5a and 4.5b, the total Demonstration Project workforce will be about 81.

In addition to this total employment over the life of the Demonstration Project, it is estimated that about 30 additional people will be employed by contractors during the construction of the Plant buildings and associated facilities.

Table 4.5a **Current WIM 150 workforce.**

CATEGORY	NUMBER
Melbourne-based permanent staff Melbourne-based consultants (full-time equivalent)	15 8
TOTAL MELBOURNE	23
Site (Horsham) based permanent staff Other site employees Site contractors (full-time equivalent)	3 2 5
TOTAL HORSHAM	10
TOTAL CURRENT WORKFORCE	33

Table 4.5b **Estimated additional and total Project workforce.**

CATEGORY	NUMBER
Melbourne-based permanent staff Melbourne-based consultants (full-time equivalent)	3 10
TOTAL MELBOURNE	13
Site (Horsham) based permanent staff Site contractors (full-time equivalent)	5 30
TOTAL HORSHAM	35
TOTAL ADDITIONAL STAFF	48
TOTAL DEMONSTRATION PROJECT WORKFORCE (CURRENT PLUS ADDITIONAL)	81

State employment

The additional employment generated by the Project as a whole can be estimated by applying a "multiplier" factor of 2, considered typical for projects of this type. The effect within Victoria would thus flow on to about 160 additional jobs.

Regional employment

Of the total Project workforce, 45 will be resident in Horsham, and of these perhaps half will be from the Horsham area. Most Melbourne-based staff will spend time on site and thus increase the economic benefits to the region. The additional Regional employment supported through a multiplier effect of 1.3 as a result of the Demonstration Project, can be estimated at 58 jobs. The total would in fact be somewhat higher if allowance is made for the additional construction workforce and for the effect of time spent by Melbourne-based employees in Horsham.

Future employment prospects

A commercial mine would require a workforce of about 150 and would entail correspondingly higher economic benefits to the Region than the Demonstration Project. Establishment of facilities to upgrade or agglomeration certain of the titanium minerals in the district could involve about 100 additional employees.

4.12 RESIDENTIAL INFRASTRUCTURE

It is anticipated that the Project workforce will reside in Horsham, which has a current population of over 12 000. The workforce and the additional workers employed indirectly by the Demonstration Project could be assumed to have on average two dependants each, leading to a Demonstration Project-associated population increase of about 100 people. These will be readily accommodated and there will be little impact on the use of existing infrastructure services.

4.13 TRAFFIC

Traffic generated by the Project can be viewed in the context of existing vehicle movements. The Western Highway carries a heavy volume of traffic both day and night (Table 4.6) About one-third of all vehicles are trucks, most of which are semi-trailers (Table 4.7). The sealed Henty Highway carries a moderate volume of traffic, of an unrecorded composition (Table 4.8). Traffic on the sealed Drung South Road is light.

Table 4.6 Vehicle movements on the Western Highway at Dadswell's Bridge. Average of Road Construction Authority counts on 18/2/87, 23/9/87 and 16/3/88.

	Day (1700-1900)	Night (1900-0700)	Total (24 hour)
West-bound	857	403	1260
East-bound	960	450	1310

Table 4.7 Types of vehicles using Western Highway at Dadswell's Bridge. Average of Road Construction Authority counts from 15/8/88 to 1/9/88, length categories shown in metres.

Category	Car	Rigid truck	Semi-trailer
Length class	(<5.6m)	(5.6-12.0m)	(>12.0m)
North-bound	770	109	273
South-bound	802	118	282

Table 4.8 Traffic movements on other roads. Road Construction Authority counts.

	Axle pair counts		
	Day	Night	Total
Henty Highway North of Wimmera Highway	1990	300	2290
Drung South Road South of Western Highway	130	10	140

Most deliveries required for the Project will be transported from Melbourne or Adelaide on conventional semi-trailers during the construction period. There will be of the order of one to three movements per day. Subject to approval by the Shire of Wimmera and the Road Construction Authority (RCA) mineral concentrates will be transported from the Plant along the Western Highway through the outskirts of Horsham and then south along the Henty Highway to Portland. Assuming that 22-tonne semi-trailers are used, there will be between three and eight concentrate truck movements per day. Against the existing volumes of traffic on the Western and Henty Highways, the additional Project traffic will represent an insignificant increase. There will also be an insignificant increase in traffic in Portland, where daily truck movements on the Princes Highway peak at over 700 during the grain carting season.

Car movements of about 100 vehicles per day will be mainly due to employees and business persons commuting from Horsham and the district. These will constitute an insignificant increase to the Western Highway traffic. Although there will be a relatively large increase on the northern part of Drung South Road, the total vehicle movements on this section will still be moderate.

Prior to commercial mining and in conjunction with the RCA, an investigation will be made of the alternative methods of transporting mineral concentrates (by road, rail or a combination), the requirements for any upgrading along the transport route, and the alternative export ports (Geelong or Portland).

5 EVALUATION OF THE PROJECT

5.1 ENVIRONMENTAL CONSIDERATIONS

The environmental effects of the Demonstration Project as discussed in Chapter 4 are minor, involving surface disturbance to about 30 hectares of farmland, minor visual effects, and only slight effects on radiation levels, groundwater, surface water, flora and fauna, and noise. These small effects in total are more than counterbalanced by the economic and social benefits of the Project. A further consideration is that through water purchases the Project will provide the RWC with a source of funds which could assist with water-saving schemes.

5.2 ECONOMIC CONSIDERATIONS

The Demonstration Project will provide small but significant economic benefits to the State. Moderate economic benefits to the Wimmera Region will accrue through a diversification of economic activity away from a reliance on agriculture, and direct and indirect job creation. With commercial mining, the benefits to the State and the Region would be very considerably increased.

5.3 SOCIAL CONSIDERATIONS

The Wimmera Region is experiencing a population decline, largely attributable to younger people seeking employment in Melbourne and other centres. The Project would employ people from within and outside the district and therefore assist in reversing the population decline.

5.4 CONSEQUENCES OF NOT PROCEEDING WITH THE PROJECT

Should the Demonstration Project not proceed the Company will be unable to adequately evaluate the viability of a future commercial mining operation. Apart from the loss of investment and employment over the Project life, the consequent abandonment of a commercial project would mean that major investment would not occur, revenue would not be generated and that associated benefits to the State and the Region would not materialize.

Additionally, if commercial mining does not proceed, the opportunity will be lost for improvements to the RWC system to greatly reduce water losses in certain areas and consequent land salination. Such works have the potential to enhance the ecology and value of the Wimmera River catchment.

6 PREPARATION OF THIS REPORT

6.1 AUTHORS

Wimmera Industrial Minerals Pty Ltd

Kinhill Engineers Pty Ltd

- Kent Hortle
- Dr Bryan Jenkins
  John Arup

6.2 SOURCES

The EES has drawn on information contained in reports prepared for the Company by the following consultants:

. Amdel (Radiation survey);

. Coffey and Partners (Groundwater).

. Anutech Pty Ltd. (Archaeology and history).

. Ecological Horticulture Pty Ltd. (Flora).

. Biosis Research Pty Ltd. (Fauna).

. Natural Systems Research (Flora and fauna).

. Watson Moss Growcott Acoustics Pty Ltd. (Noise).

. Rockwater Pty Ltd (Groundwater)

APPENDIX A

DRAFT AMENDMENT TO WIMMERA PLANNING SCHEME

LOCAL SECTION C2 - BALANCE OF SHIRE

A new Clause 3(6) shall be inserted:

6 Reserved Mining Area 1

(1) The area designated Reserved Mining Area 1 is shown on the Local Section Map.

(2) Notwithstanding anything to the contrary contained in this Local Section development and use of land within the Reserved Mining Area 1 for the purpose of mineral prospecting/exploration, mineral evaluation/development and mineral production may be undertaken without the consent of the Responsible Authority, provided the provisions of this clause are complied with.

(3) No buildings or works for the purpose of mineral prospecting/exploration, mineral evaluation/development or mineral production shall commence until a site plan has been submitted and approved in writing by the Responsible Authority. The site plan shall be generally in accordance with the Concept Plan for Reserved Mining Area 1 which forms part of the Map for this Local Section.

(4) The site plan shall show:

(a) the general location, size, extent and intended use of all mining, processing and associated facilities, buildings, works and development on the land;

(b) internal access roads, car parking and loading and unloading areas;

(c) the location of storage and disposal areas for overburden and tailings;

(d) details of water supply and wastewater disposal facilities, water recycling facilities and site drainage;

(e) details of domestic and non hazardous waste disposal sites;

(f) storage and disposal facilities for fuels and other chemicals;

(g) the extent of any erosion prevention works; and

(h) fencing.

(5) A landscape plan shall be approved in writing by the Responsible Authority prior to the commencement of any building or works.

(6) A land rehabilitation plan shall be approved in writing by the Responsible Authority prior to the commencement of any mining.

(7) Any alteration of the site, landscape or rehabilitation plan shall be made only with the approval in writing of the Responsible Authority.

(8) The erection of all buildings and plant and the carrying out of all works shall be in accordance with the site plan and the landscape plan.

(9) The alignment, design, construction and maintenance of all internal site access roads within the Reserved Mining Area shall be to the satisfaction of the Responsible Authority.

(10) All car parking, loading and unloading facilities shall be constructed to the satisfaction of the Responsible Authority.

(11) The use of any public road for the haulage of ore, excavated or like material, or equipment, shall be subject to prior approval by the Responsible Authority.

(12) The noise generated by mining operations, including vehicle movements, shall not exceed the permissible noise levels specified by the Environment Protection Authority.

(13) Dust and fumes resulting from any mining activity are to be controlled to the satisfaction of the Responsible Authority.

(14) The storage, use and disposal of any chemicals shall be to the satisfaction of the Department of Industry, Technology and Resources and shall be notified to the Responsible Authority.

(15) All earthworks, vegetation clearance, operation workings, roadworks and stockpile areas shall be located and carried out to minimize erosion and to the satisfaction of the Responsible Authority.

(16) Areas within the Reserved Mining Area shall be rehabilitated to the satisfaction of the Department of Industry, Technology and Resources and the Responsible Authority.

(17) The ore shall be mined by a dry mining technique in accordance with a works programme approved by the Department of Industry, Technology and Resources and to the satisfaction of the Responsible Authority.

(18) Tailings, water storage and retention dams must be installed in accordance with the site plan.

(19) All tailings and all waters used in the processing of materials, must be retained on site unless either removed for reuse elsewhere or deposited in mined-out areas in a manner approved by the Responsible Authority, or discharged in accordance with approvals granted by the Environment Protection Authority.

(20) The use and development shall not adversely affect the amenity of the locality to an unreasonable extent by reason of the emission of noise, vibration, smell, fumes, dust, wastewater, waste products, grit, oil or otherwise.

IN THE ADMINISTRATIVE APPEALS TRIBUNAL OF VICTORIA

PLANNING DIVISION

APPEAL NO P88/1745 APPLICATION NO 299

HEARD AT HORSHAM ON 4 OCTOBER 1988

Appellant Objector	Conservation Council of Victoria
Responsible Authority	Shire of Wimmera
Respondent Applicant	Wimmera Industrial Minerals Pty Ltd

NATURE OF APPEAL

Appeal against determination to grant a permit.

PROPOSAL

Mineral evaluation/development.

APPEAL SITE

1300 hectares of land adjacent to the Western Highway in the Parish of Drung Drung, approximately 15 kilometres south-east of Horsham.

PLANNING CONTROL AND ZONING

Wimmera Planning Scheme Chapter 2 - Rural A Zone.

DETERMINATION AND REASONS FOR DETERMINATION

This was an appeal by the Conservation Council of Victoria against a determination by the Shire of Wimmera, as Responsible Authority, to grant a permit for the mineral evaluation/development of approximately 1300 hectares of land at Drung Drung near Horsham. The permit was in the following terms:

"Stage 2 of Wimmera Industrial Minerals Pty Ltd program being Mineral Evaluation/Development and involving detailed exploration, bulk mineral sampling, pilot plant and further environmental studies, as follows:

(i) the excavation of some 3 to 5 costeans (open trenches) approximately 250 metres long (including ramps) by 30 metres wide and 14-20 metres deep, within the 1300 hectare application area;

(ii) the construction of a pilot plant with a capacity of around 20 tonnes of ore per hour;

(iii) the processing of an estimated 20,000 tonnes of ore from the existing and proposed costeans through the pilot plant with separation of commercial minerals (ilmenite, rutile, anatase, leucoxene, zircon, monazite and xenotime);

(iv) on-site storage of some part of these minerals, and transport of the remainder to domestic and overseas recipients for further process trials and product evaluation;

(v) continued studies of environmental aspects which would need to be addressed prior to seeking approval for full-scale mining;

(vi) construction and use of two tailings dams covering approximately 1 hectare each."

The permit was subject to the following conditions:

1. A review Committee shall be formed to advise the Council and the Shire Engineer on such matters that the Council or Engineer may refer to this Committee.

   The Committee shall consist of Officers from :-

   (a) Wimmera Shire Council
   (b) Dept. of Conservation, Forests and Lands
   (c) Rural Water Commission
   (d) Ministry of Planning and Environment
   (e) Dept. of Industry Technology and Resources
   (f) Department of Agriculture and Rural Affairs

   and any other authority, agency or person the Council considers necessary. The proponent shall call regular quarterly meetings of this Committee.

2. Costeans must be sited to maintain at least 100 metres clearance from roads, houses, watercourses, Rural Water Commission channels, and 200 metres from the Western Highway.

3. The proponent shall report the name and commercial composition concentration and volume of any chemicals proposed for use or stored on site to:-

   (a) Wimmera Shire Council
   (b) Country Fire Authority - Regional Headquarters Horsham
   (c) Environment Protection Authority
   (d) Rural Water Commission and any other authority, agency or person nominated by Wimmera Shire Council.

4. The location and design of the residue dams shall be jointly approved by the Shire Engineer and Department of Industry, Technology and Resources.

5. A testing and monitoring program shall be undertaken on the residue dams to the satisfaction of the Shire Engineer and any remedial works required for environmental reasons shall be as directed by the Shire Engineer.

6. Any public road used for haulage of ore, excavated or the like material and mining equipment shall be approved by the Shire Engineer in consultation with relevant authorities prior to commencement of haulage or equipment cartage.

   This approval may be withdrawn, in writing, at any time.

7. There shall be no discharge from the site caused by any workings connected with the mining operation.

8. No alteration or diversion of streams, drainage lines and the like shall be undertaken without the approval of the Rural Water Commission in consultation with the Shire Engineer.

Following an extensive exploration program mineral sands were discovered at Drung Drung near Horsham in December 1985. The Stage 1 program, which included the excavation of two costeans, the removal of ore for laboratory scale evaluations and a range of site investigations, was carried out on the site under the conditions of Planning Permit No 244 which was granted by the Shire of Wimmera in August 1987 and under the terms of Exploration Licence No 1257. The present application relates to Stage 2 of the work. It does not involve any commercial mining operations. The main objectives are to recover bulk samples of ore from some additional costeans, to operate a pilot plant to evaluate a range of mineralogical processes for recovering and separation of the minerals, to obtain sufficient samples of minerals for product evaluation by potential customers and to conduct further environmental investigations. The activities covered by the first three points are necessary because conventional mineral dressing and subsequent manufacturing processes may need to be modified to take into account the unusually small particle size of minerals in the deposit.

The deposit of minerals is contained in the Parilla Sand stratum which is a 10-15 metre thick layer of fine marine sands located 4-5 metres from the surface of the earth. The activities involve the excavation of up to five additional costeans for obtaining bulk ore samples. Costeans are simply trenches which are excavated to obtain ore samples and also to provide geological information on the nature of the deposit. The costeans will be about 15 metres deep and 200 metres long with relatively steep side walls. Low bunds will be provided around the perimeter to prevent surface run-off entering the costeans. Mechanical earth moving equipment will be used to excavate the costeans. The topsoil overburden and ore will be stockpiled separately beside the costeans. The establishment of the pilot plant and ancillary activities including storage of mineral concentrates will involve the erection of four buildings similar in scale and overall appearance to good quality farm sheds. A small ore stockpile will also be required, together with a typical "turkey's nest" style farm dam to contain the residual material from which the minerals have been removed and a small volume of process water which will be recycled to the pilot plant. Make-up water will be drawn from an existing farm dam on the application area. Because of the small particle size of the minerals in the deposit the physical (gravity) processes such as are normally used in mineral sand operations can not achieve an adequate mineral recovery. Accordingly the pilot plant operation will be used to investigate mineral dressing techniques involving flotation processes. The use of wet separation techniques will avoid the dusty conditions normally associated with mineral sand processing. The four main pilot plant processes may be summarised as follows:

1. Ore from the stockpile will be slurried in water and passed over a vibrating screen to reject oversized material.

2. Fines (less than 10 microns) will be removed by a cyclone and discharged to the residue dam.

3. The washed and graded material will be treated by froth flotation to produce a bulk mineral concentrate, while the tailings sand will be pumped as a slurry to the residue dam and the process water recycled to conserve both water and flotation reagents.

4. The bulk mineral concentrate will be separated into five product streams using a combination of floatation, wet high intensity magnetic separation and gravity. The five product streams are:

   (a) monazite;
   (b) xenotime;
   (c) ilmenite;

(d) zircon;
(e) high titanium fraction (rutile, anatase and leucoxene).

In relation to the minerals, monazite and xenotime a Preliminary Environment Report stated:

"The rare earth minerals monazite and xenotime invariably contain small amounts of the radioactive elements thorium and uranium. These elements are an integral part of each mineral, chemically bonded into its structure. They cannot be separated or removed by an physical means and thus will remain in the mineral concentrates when they are forwarded for process evaluation.

Tests carried out on samples from the WIM 150 deposit indicate that monazite and xenotime comprise approximately 0.,06 per cent and 0.02 per cent (by weight) respectively of the ore. The levels of thorium and uranium in the monazite are approximately 5.0 per cent and 0.2 per cent (by weight) respectively. For the xenotime the corresponding figures are 0.4 per cent (Th) and 0.75 per cent (U) respectively. Consequently the thorium content of the ore is approximately 0.003 per cent and the uranium content is approximately 0.0003 per cent."

Reagents will be used in the operation of the pilot plant in pH control, as frothers, as depressants and as collectors. In relation to such Dr J T Bellair stated:

"I have reviewed the product data sheets for a typical range of these reagents. With the exception of sulphuric acid, none of these is considered by the American Conference of Government Hygienists to warrant a Threshold Limit Value for industrial exposure, nor do any fit the category of potential environmental toxicants at the rate of usage envisaged."

Following the application for a development lease pursuant to the Mines Act 1958 the Minister for Planning and Environment directed that a Preliminary Environment Report be prepared pursuant to the provisions of the Environment Effects Act 1978. This was advertised on a Statewide basis. There followed upon the production of the Preliminary Environment Report the making of submissions concerning it, the Applicant's response to those submissions, the Ministerial assessment of the Report, the objection process and the consideration of the Responsible Authority. Pursuant to section 512(H) of the Mines Act a planning permit must be granted prior to the granting of a development lease. All activities involved in mining, mineral exploration etc are the subject of close scrutiny by the mining division of the Department of Industry, Technology and Resources of the State of Victoria. There was produced in evidence a copy of the proposed lease. It is of a most comprehensive nature as are the conditions attached to it. The conditions deal with a great range of matters including plans and proposals, fencing, access roads, internal roads, parking areas, plant areas, internal cartage, buildings, derelict and redundant plant, buffer zones and visual screening, soil retention, overburden dumps, waste discharge, drainage, operating hours, dust, noise, explosives, extraction, reclamation, security, radiation plan, submission of reports and expenditure requirements. Condition 22 dealing with "radiation plan" is in the following terms:

"Prior to the commencement of operations in the pilot plant the lessee shall submit to the Director-General for the approval of the appropriate responsible authority a Radiation Plan for the control of radiation exposure and dose assessment. Upon the approval of the appropriate authority with whatever conditions, modifications or additional requirements that may be considered appropriate, the plan shall be implemented. Also the licensee shall lodge a copy of the Approved Radiation Plan with the Shire Engineer."

The grounds of appeal relied on by the Conservation Council of Victoria were:

1. Radiation and Nuclear Implications including Nuclear Activities (Prohibitions) Act.

2. Non inclusion of recommendations of Ministry of Planning and Environment Assessment Report in decision to grant a permit.

3. General environmental concerns.

4. Inappropriate use of PER mechanism.

On the hearing Mr R Dean of Counsel appeared on behalf of the Conservation Council of Victoria, Mr R Gilmartin, Shire Engineer and Councillor B Gross appeared on behalf of the Shire of Wimmera, Mr John Atkins of Counsel appeared on behalf of the Department of Industry, Technolgy and Resources, Mr R Saunders appeared on behalf of the Ministry for Planning and Environment and Mr Robert Osborn of Counsel appeared on behalf of Wimmera Industrial Minerals Pty Ltd. Written submissions were presented by Mr Dean and Mr Osborn. In addition the Tribunal considered a written submission by the Minister for Planning and Environment. It is unnecessary to refer to these in detail. They will remain on the file as part of the permanent record of these proceedings. Mr Dean called to give evidence Mr L Dalton, formerly a principal research scientist with the C.S.I.R.O. and author of "The Nuclear Environment", Mr R Bolt, an Electrical Engineer who gave evidence concerning nuclear matters and Mr R J Nathan, a Hydrological Engineer. Mr Atkins called to give evidence Mr Keith Bowen, Executive Director, Minerals, of the Department of Industry, Technology and Resources. Mr Osborn called to give evidence Dr J T Bellair, a highly qualified and experienced environmental consultant.

Before proceeding further there are some matters to which we desire to particularly advert:

1. The Appellant's case seemed to us to rely heavily on assumptions that various officers such as Mine Managers, Inspectors of Mines, and indeed, the Commonwealth Government might not adequately perform their statutory duties. In this way, it was said that not only carriers and persons along the way might be affected by radioactivity but dangerously radioactive shipments of xenatine or monozite might be sent to Europe or America for refinement and thereafter find their way into nuclear reactors or nuclear weapons. It seems to us that there are no logical reasons for any such assumptions. Whether or not shipments of radioactive minerals sent to Europe or America for enrichment will find their way into nuclear reactors or nuclear weapons contrary to law is a matter for the Commonwealth and other Governments and not for this Tribunal.

2. <u>The distinction between mining and mineral exploration.</u>

   At some points in the evidence this distinction seemed to be heavily blurred. In particular the Appellant asserted that the Minister was in error in only requiring a Preliminary Environment Report pursuant to the provisions of the <u>Environment Effects Act</u> 1978 and not an Environment Effects Statement. An Environment Effects Statement is of course a much fuller treatment of a subject matter than is a Preliminary Environment Report. It also costs much more and takes much longer to produce. We can see no justification for requiring an Environment Effects Statement in a case, such as the present, which deals only with mineral exploration and not mining. The decision to require an Environment Effects Statement in respect to a planning permit depends fundamentally on whether the permit decision is one "which could have significant effect upon the environment". Such decisions are decisions of fact which the courts have consistently recognised must be left to the Minister, e.g. Puhlhofer v Hillingdon London Borough Council, [1986] A.C.484 at p.518. It is not for us to review the exercise of discretion by the Minister in this regard.

3. <u>The imposition of conditions on a planning permit in a case concerned with mineral exploration.</u>

   The Ministry for Planning and Environment asserted that it had proposed various conditions which were not but should have been included in the permit. This raises a difficult matter. One frequently finds in cases where two permits are required, as for example in the case of municipal tip where a works approval from the Environment Protection Authority is required as well as a planning permit, that each varies from the other in the requirements laid down as to a specific subject matter. In the view of this division of the Board this is highly undesirable. If an Applicant for a permit is entitled to anything it is certainty as to the obligations to which it is to become subject. In the present case no one would assert that mining is not a complicated or a specialist subject matter. The experts in this field are in the Minerals Division of the Department of Industry, Technology and Resources. For example a condition proposed by the Ministry for Planning and Environment namely 1.12 was as follows:

"Prior to the commencement of the pilot plant operation, the adopted and management plan for the handling of monazite and xenotime concentrates shall be made public. The plan should incorporate relevant aspects of the Health (Radiation Safety) Regulations 1984 of the Victoria Health Act 1958, the Code of Practice for the Safe Transport of Radioactive Substances, (1982) pursuant to the Commonwealth of Australia Environment Protection (Nuclear Codes) Act 1978, the Code of Practice on Radiation Protection in the Mining and Milling of Radioactive Ores 1987 pursuant to the Commonwealth of Australia Environment Protection (Nuclear Codes) Act 1978, the Code of Practice on the Management of Radioactive Wastes and the Mining and Milling of Radioactive Ores (1982) pursuant to the Commonwealth of Australia Environment Protection (Nuclear Codes) Act 1978".

In relation to this condition the Shire of Wimmera said:

"Council is not an expert on these matters hence control is questioned."

It seems to us that this answer on the part of the Shire of Wimmera embodied a great deal of common sense. The Shire is clearly not an expert on such Acts, regulations etc. However, the Minerals Division of the Department of Industry, Technology and Resources is an expert and should know what conditions to impose. We think, that based on the general consideration that the licensee should know clearly his obligations and that such obligations should be laid down by experts and not amateurs there is an overwhelming advantage in a situation where all relevant technical conditions are laid down in the one permit under the provisions of the Mines Act.

4. The Nuclear Activities (Prohibitions) Act, 1983.

It was contended on the part of the Appellant that no permit should be granted because it would be in contravention of the Act.

Section 6(1) of the Act provides:

"6(1) Notwithstanding Section 5, a person who is the holder of a mining title and who mines or quarries uranium or thorium in the course of mining or quarrying pursuant to his mining title for some mineral other than uranium or thorium shall not be guilty of an offence under this Act provided that:

(a) uranium of an amount greater than 0.02% by weight or thorium of an amount greater than 0.05% by weight is not removed from the land covered by the mining title;

(b) mined or quarried material containing uranium or thorium is treated in the prescribed manner; and

(c) he complies with such conditions (if any) as the Governor-in-Council may from time to time impose in respect of the mining or quarrying in which he is, or is to be engaged."

The prohibition imposed by section 6(1)(a) relates to uranium of an amount greater than 0.02% by weight or thorium or an amount greater than .05% by weight of the total weight of ore mined to that point of time pursuant to the mining title. If the amounts are in excess of those specified the uranium or thorium is not to be removed from the land covered by the mining title. If it is removed the section ceases to apply and the blanket prohibition contained in section 5 of the Act remains.

The Applicant's answer to this contention was as follows:

(i) If one mines "the ore" from the sands monazite and xenotime comprise only 0.06% and 0.02% by weight respectively of the ore;

(ii) the uranium and thorium only represents 5% and 0.2% respectively in monazite and 0.4% and 0.75% respectively in xenotime;

(iii) thus the level of uranium and thorium in "the ore" is only 0.003% thorium and 0.0003% uranium;

(iv) thus the mining enterprise is not prohibited.

It seems to us that the Act is precisely designed to cover such a case as the present. This is not a uranium mine. It is exploration for various minerals other than uranium or thorium but in the course of such exploration there may be produced uranium or thorium in quantities prima face less than those specified under the Act. If, of course, the quantities produced exceed those specified under the Act then the uranium or thorium may not be taken from the land covered by the mining title.

We accordingly reject the contention of the Appellant that no permit should be granted on the ground that any such permit would be for an illegal use. Clearly, a permit for an illegal use should not be granted as it would be a nugatory permit. That is not the present case. In the present case mineral exploration could take place in accordance with the provisions of the Nuclear Activities (Prohibitions) Act 1983 or it could take place outside those provisions. If outside the provisions of the Act it is illegal.

5. Radiation Considerations

Mr L Dalton called on behalf of the Appellant gave detailed evidence to the Board of the radiological aspects and hazards involved in the mining of monazite and xenotime. There was no contest in relation to this matter. Mr Dalton detailed various ways in which uranium and thorium could be dangerous to mankind. Dr Bellair did not dispute these contentions. His whole evidence was based on the fact that mankind had come to know the hazards involved and that Governments had laid down stringent prerequisites with respect to the mining, handling, transport of radioactive material.

It seems to the Tribunal that such prerequisites are adequate to take care of any of the problems which may arise in the case of the present mineral exploration proposal.

What we have said above is sufficient to dispose of most of the matters argued on this appeal. Other matters to which we should make reference are as follows:

(a) Water Use.

Mr R J Nathan, an Engineer experienced in the field of Hydrology and Water Resources gave evidence in the course of which he drew attention to various hydrological considerations including the fact that the volume of water required for the project had been under-estimated by approximately 15 megalitres. He stressed the general lack of water resources in the Wimmera Area. In our opinion this evidence did not carry the matter further. If the project is to proceed it will be essential for the Applicant to make appropriate arrangements with the Rural Water Commission. If such arrangements cannot be made then it seems unlikely that the project can proceed.

Mr Nathan also gave evidence that in certain circumstances the acquifer under the site could become contaminated with radioactive material as a result of the mining. In regard to this particular matter we draw attention to Condition 7 with which the Applicant must comply. That condition is in the following terms:

"7. There shall be no discharge from the site caused by any workings connected with mining operations."

(b) Salinity

It was contended that there was a likelihood of salination of soils on the site. This is an increasing problem not only in the Wimmera but also in various other areas of Victoria.

In relation to this matter we think that it will no doubt form part of the Environment Effects Statement which it will be necessary for the Applicant to produce prior to the permitting of mining on the site. At the present time and at the present stage of development of the site the issue does not seem to be of importance.

(c) Rehabilitation of the site.

This is a matter which is dealt with in the proposed conditions for the development lease. Condition 20 is as follows:

"20.1 At least twelve months prior to the termination of the term of this lease or the cessation of pilot plant works the lessee shall lodge a satisfactory proposal for the final reclamation of the excavated area.

20.2 The proposal shall include timetables and programs of any proposed landfill operations and the final removal of all plant, buildings, equipment, stockpiles and rubbish from the site in order to leave the area in a neat and tidy condition.

20.3 On completion of operations all equipment not required for final reclamation works and all plant and rubbish shall be removed from the site and the area left in a neat and tidy condition to the satisfaction of an Inspector."

In view of this detailed provision it seems unnecessary to deal with the matter in the planning permit further than it is already dealt with in Condition 5.

In our opinion there is no town planning consideration which could present an obstacle to the grant of a permit. We do however consider that there should be a further condition added to the permit to the effect that the Applicant will comply with all conditions and standards laid down by all relevant authorities.

The appeal will be disallowed. It is directed that a permit issue subject to all conditions contained in the Notice of Determination dated 29 July 1988 and with a final condition added as follows:

"9. The applicant shall comply with conditions and standards laid down by all relevant authorities."

APPEAL NO P88/1745 APPLICATION NO 299

DATED 03 ... 1988

Russell D. Barton

R D BARTON
PRESIDING SENIOR MEMBER

D Brian Logan

D B LOGAN
MEMBER

Mr R Dean of Counsel instructed by Minter Ellison, Solicitors, appeared on behalf of the Appellant Objector, the Conservation Council of Victoria.

Mr L Gilmartin, Shire Engineer, and Councillor B Gross, appeared on behalf of the Shire of Wimmera.

Mr J Atkins of Counsel, instructed by the Victorian Government Solicitor, appeared on behalf of the Department of Industry, Technology and Resources.

Mr R Saunders appeared on behalf of the Ministry for Planning and Environment.

Mr R Osborn of Counsel instructed by Arthur Robinson and Hedderwicks, Solicitors, appeared on behalf of the Respondent Applicant.

RDB:JA 10.10

IN THE ADMINISTRATIVE APPEALS TRIBUNAL OF VICTORIA

PLANNING DIVISION

APPEAL NO P88/1745 APPLICATION NO 299

HEARD AT HORSHAM ON 4 OCTOBER, 1988

Appellant/Applicant	Conservation Council of Victoria
Responsible Authority	Shire of Wimmera
Respondent/Applicant	Wimmera Industrial Minerals Pty Ltd

NATURE OF APPEAL

Appeal against determination to grant a permit.

PROPOSAL

Mineral evaluation/development.

APPEAL SITE

1300 hectares of land adjacent to the Western Highway in the Parish of Drung Drung, approximately 15 kilometres south-east of Horsham.

PLANNING CONTROL AND ZONING

Wimmera Planning Scheme Chapter 2 - Rural 'A' Zone.

CORRECTION OF DETERMINATION

The Department of Industry, Technology and Resources has drawn the Tribunal's attention to a clerical error which appears in this decision. On page 9 shortly below the middle of the page there appears the following statement:

> *"(ii) the uranium and thorium only represents 5% and 0.2% respectively in monazite and 0.4% and 0.75% respectively in xenotime;"*

In the above statement the words *'uranium'* and *'thorium'* have been transposed. The correct statement is:

> *"(ii) the thorium and uranium only represents 5% and 0.2% respectively in monazite and 0.4% and 0.75% respectively in xenotime;"*

The matter is correctly stated in the extract from the Preliminary Environment Report quoted on page 5 of the determination.

The determination is corrected accordingly.

DATED 09 [illegible] 1989

Russell D. Barton

R D BARTON
PRESIDING SENIOR MEMBER

D Brian Logan

D B LOGAN
MEMBER

APPEAL NO P88/1745

Appearances

Mr R Dean of Counsel, instructed by Minter Ellison, Solicitors, appeared on behalf of the Appellant/Objector, the Conservation Council of Victoria.

Mr L Gilmartin, Shire Engineer, and Councillor B Gross appeared on behalf of the Shire of Wimmera.

Mr J Atkins of Counsel, instructed by the Victorian Government Solicitor, appeared on behalf of the Department of Industry, Technology and Resources.

Mr R Saunders appeared on behalf of the Ministry for Planning and Environment.

Mr R Osborn of Counsel, instructed by Arthur Robinson and Hedderwicks, Solicitors, appeared on behalf of the Respondent/Applicant.

RDB:AM 21.11

APPENDIX 3

WIM 150 Project, Drung South, Shire of Wimmera near Horsham, Victoria: Brief Project Description", Wimmera Industrial Minerals Pty Limited, 28 June 1991.

BACKGROUND

Wimmera Industrial Minerals Pty. Limited (W.I.M.) is a wholly owned subsidiary of the Melbourne-based mining company CRA Limited, and was established to develop mineral resources in the Wimmera.

In 1985, as a result of an extensive exploration programme, CRA announced the discovery of titanium minerals, zircon and rare earth minerals at Drung South near Horsham. The deposit, was named WIM 150. Since that time, the discovery of further deposits have been announced in the Shires of Kowree (WIM 50), Arapiles (WIM 100) and Dunmunkle (WIM 200 and WIM 250), all within a radius of 60 km from Horsham. Together these deposits form a major mineral resource which, providing viable mining and processing technologies can be developed, would provide the basis for a long term mining industry in the area, perhaps in excess of 100 years.

Since the announcement of the WIM 150 deposit, W.I.M. has been carrying out extensive research and studies to evaluate the commercial potential. The minerals, and the sand in which they are located, are not typical of deposits currently mined in Australia or elsewhere in the world because of their extremely fine grain size. Consequently present recovery and processing techniques are unsuitable and W.I.M. has been actively developing new treatment methods.

In 1988 W.I.M. sought approval to operate a Pilot Plant on company owned land at WIM 150. A Preliminary Environment Report was prepared in support of that application and following assessment by the Minister for Planning and Environment a Planning Permit was issued by the Shire of Wimmera. The Pilot Plant is used for the development of new methods for the concentration and separation of minerals.

In 1989 W.I.M. sought approval to further its development of appropriate mineral processing technologies by the installation and operation of a Demonstration Project at the site. A planning scheme amendment (No. L2 to the Wimmera Planning Scheme) and an Environment Effects Statement (EES) were prepared as well as an application for a mining lease. A Panel was appointed to consider the EES and planning scheme amendment. Approval was granted for the Demonstration Project, subject to the recommendations of the Panel and the Minister, at the end of 1989. The Demonstration Project is scheduled to commence operation during 1991.

The company now proposes to seek approval for full scale mining and mineral processing of the WIM 150 ore body.

APPROVALS

To carry out the proposed mining and processing operation W.I.M. will require approvals from several authorities.

A planning scheme amendment will be required to authorise the project under the Wimmera Planning Scheme. A works approval may be required from the Environment Protection Authority for emissions to the environment. A mining licence will be required from the Minister of Manufacturing and Industry Development.

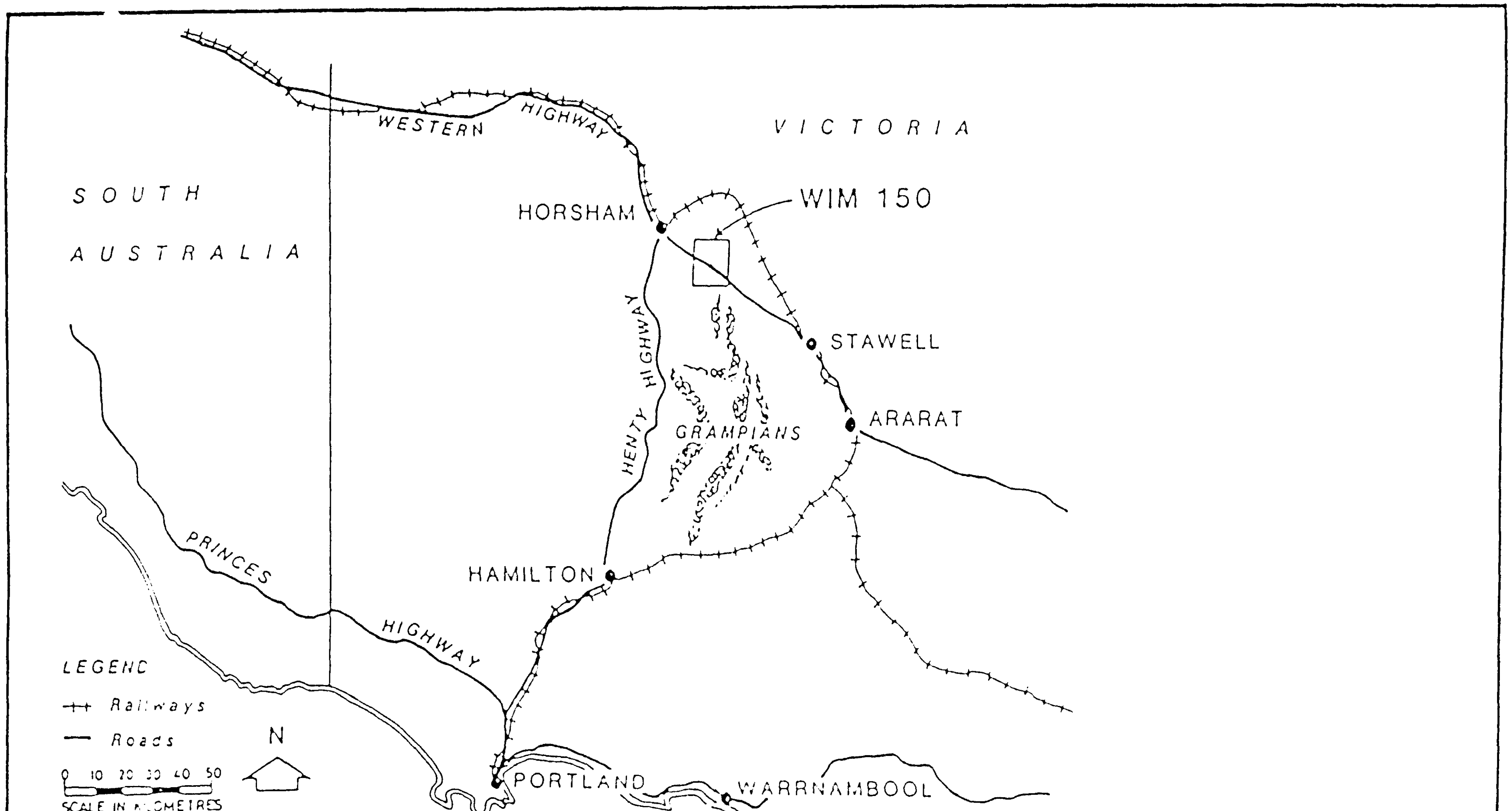
Prior to applications being made for these approvals the Minister for Planning and Housing has required W.I.M. to prepare an Environment Effects Statement (EES). Following an initial public scoping phase, in which the subjects to be covered in the EES will be determined, the EES will be prepared. It will be placed on public exhibition during which time submissions can be made to the Minister, by any party. The Minister may then appoint a Panel to hold an inquiry into the project. After considering any submissions and the recommendations of any Panel which may be convened, the Minister will assess the project. Any authority responsible for granting an approval for the project must take into account the Minister's assessment. Applications for such approvals may be lodged prior to the Minister's assessment of the EES; they could be processed simultaneously with the EES. However, no approvals can be granted until the Minister's assessment is released.

Approval will be required from the Commonwealth Government for the export of products of the WIM 150 project. This in turn, means that the Minister for the Arts, Sport, the Environment, Tourism and Territories (DASETT) may require the preparation of an Environmental Impact Statement (EIS) or Public Environment Report (PER) for the project.

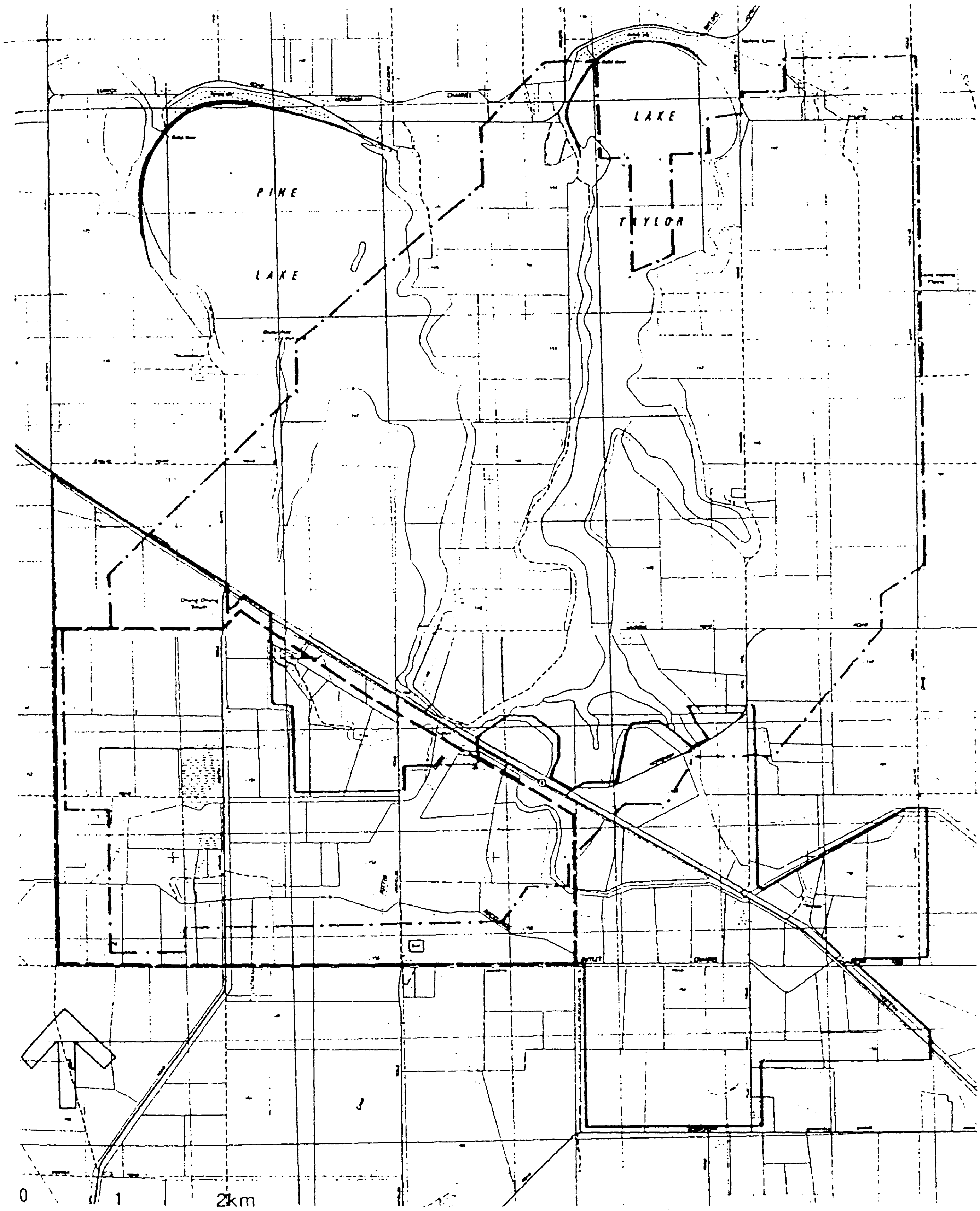
THE PROJECT

The location of the WIM 150 deposit is shown in Figures 1.1 and 1.2.

The area outlined in Figure 1.2 defines the limits of a resource containing potentially commercial grade ore, i.e. containing more than 2.5% by weight of total minerals. This "core" averages 4% minerals. Around this core is an extensive "halo" of mineralised sands grading downwards from 2% which is not regarded as commercially recoverable.



REGIONAL LOCALITY MAP Figure 1.1



LAND OWNED BY WIM

OREBODY CORE

EXISTING DEVELOPMENT LEASE

WIM 150 PROJECT

Figure 1.2

June 1991 GHD

Mining will be carried out initially on that part of the resource lying to the south of the Western Highway (see Figure 1.2) on land which is already owned by W.I.M. This is sufficient for 8 to 10 years operations at the proposed scale of mining. W.I.M. will need to gain access to private land within the WIM 150 deposit beyond this period. A framework for negotiation for purchase of land has been adopted by W.I.M. The aim of such framework is to ensure that existing landowners can continue their farming operations with confidence as to their financial outcome in the case of future mining. Also, in the event of current owners wishing to sell, incoming buyers would also be aware of the outcome and approach their investment with similar confidence.

The mining operations will include surface stripping of soil and clay overburden, followed by dredge mining. The minerals will then be concentrated and the individual minerals separated from the concentrate for subsequent processing. The mineral processing involves alterations to the physical or chemical properties so that the mineral product meets market specifications. The site will be progressively rehabilitated as mining proceeds.

The scale of the operations will be determined by market factors, technology limitations and economic feasibility. Present indications are that the full scale mineral production target will be approximately 400 000 tonnes which will be achieved by the extraction of approximately 15 million tonnes of ore per annum. From this will be produced the following concentrates:

• upgraded ilmenite	160 000 tonnes p.a.
• high titanium minerals (rutile, anatase, leucoxene)	120 000 tonnes p.a.
• zircon	120 000 tonnes p.a.
• rare earth minerals (monazite, xenotime)	12 000 tonnes p.a.

At the proposed mining rate the life of the WIM 150 ore body is estimated to be approximately 30 years.

The life of the processing plant is much longer and could be used to process other mineral deposits within the Wimmera Region.

After mineral processing, the products which will leave the site are:

- upgraded ilmenite
- high grade titanium agglomerates
- premium grade zircon
- rare earth concentrates.

The project does not include the processing of titanium minerals to titanium pigments, nor the processing of monazite and xenotime to rare earth chemicals.

The total capital expenditure at the site is currently estimated at $300 million for the mining, concentration and processing operations.

MINING

The WIM 150 resource is one of several identified mineral deposits contained within the Parilla Sands. The Parilla is a marine sand formation of Miocene to Pliocene age (5 to 2 million years ago) present over much of the western Murray Basin. Within the core of the WIM 150 deposits the sand varies in depth from 10 to 15 metres and is underneath 4 to 5 metres of a heavy sandy clay overburden.

Surface Stripping

Before the ore can be dredged from the Parilla Sands a sufficient area of the ore body needs to be exposed. This will be done by removing the topsoil and clay overburden to a predetermined depth using scrapers, bulk loaders or similar equipment. In order to preserve the biological activity of the removed materials they will be immediately used in the rehabilitation of already mined areas. There will be no long term stockpiling of stripped materials. Material excavated to form the original dredge pond will be stored and then resumed for use in the final rehabilitation program.

Dredge Mining

Once the topsoil and overburden have been removed the ore will be extracted using a floating dredge. The dredge pond will be excavated near the base of the Parilla Sands and because this formation is an aquifer, it will generally contain sufficient depth of water to float a dredge typically used in mining. In those restricted areas where the water table is low, it will be necessary to raise water levels in the dredge pond above the present water table. This will be done by the addition of water recycled from tailings ponds and groundwater from the Renmark aquifer.

The concept for the mine as currently envisaged is that it will advance in a continuous dredge path for the life of the mine on a front of approximately 200 to 300 metres in width. The width of the mining path will vary according to ore grade and other factors and the dredge pond at ground level will extend for a length of up to approximately 300 m. The rate of advance of the operation will be approximately 8-10 m per day.

A slurry of ore will be pumped from the dredge to a primary concentration plant mounted on a barge also floating in the dredge pond. This plant will separate the valuable minerals from the barren materials. The major part of the mined material remaining after concentration of the valuable components is known as "tailings". The tailings will be deposited in the mined out area behind the dredge.

Prior to land rehabilitation the area exposed at any one time due to stripping, mining and tailings dam operations is unlikely to be more than 200 hectares.

TAILINGS

Behind the dredge pond, a worked-out area will be bunded off to form one or more ponds to receive the tailings. The number of ponds will depend on the settling and compaction behaviour (at present under investigation) of the two major fractions of the tailings, i.e. a relatively fast-settling and compacting sand and a slower settling "slimes" or clayey fraction amounting to about 15% of the excavated material. During and after filling, the contents of these ponds will drain and compact, with the bulk of their contained water returning to the dredge pond.

CONCENTRATION

The concentration process recovers the valuable minerals from the ore. Concentration will be carried out on a barge floating in the dredge pond.

The first stage of the operation will be to screen off gravel and coarse sand which accounts for about 5% by weight of the mined material. The second will be to remove the 15% of slimes by cyclone (centrifugal) separation. Neither of these operations uses chemicals.

The unusually fine grained nature of the ore and minerals in the WIM 150 deposit means that the conventional techniques for bulk concentration of the minerals are not appropriate. W.I.M. is presently developing two techniques and will use one or both of them.

The first technique being developed relies on a gravity principle using a centrifugal jig whereas the second technique exploits the differences in surface chemistry between the commercial minerals and the tailings by using a flotation process.

Each of the possible proposed processes will use water from the dredge pond. Physical processes (centrifugal jig) should have no impact on the quality of this water. With the flotation process it will be important to ensure that there is no adverse environmental effects from chemicals in the water returned to the dredge pond.

SEPARATION

Following the concentration process, the bulk concentrate will be pumped as a slurry to a secondary separation plant. The plant will be in a building close to, but not on, the ore body.

The separation techniques to be used will be mainly selective flotation using chemical regimes specific to the individual minerals. As the process is sensitive to water quality it will be necessary to use water from the Rural Water Commission supply.

Maximum in-plant recirculation of water will be practiced to reduce the consumption of water and chemicals and minimise the effect of any residual chemicals discharging to the dredge pond with the separation plant tailings.

MINERAL PROCESSING

W.I.M. has been carrying out extensive research in laboratories and Pilot Plants both in Australia and overseas to establish mineral processing technologies which will modify the properties of the minerals mined at the site such that they meet market specification.

High Titanium Mineral Processing

High titanium minerals are principally used in the production of titanium dioxide pigments. The process used to produce these pigments requires a specified minimum particle size. Because the WIM 150 high titanium mineral concentrates have a particle size smaller than that required, W.I.M. in association with CSIRO, has developed an agglomeration process whereby the mineral particles are bonded together to produce a particle approximately 5 times the original size.

The high titanium mineral agglomeration process will be carried out in a plant on the site. The process involves the drying of the concentrates, grinding, combining the concentrates with a bonding agent, followed by firing at high temperature.

The firing process requires fuel, but is not sensitive to the type of fuel. A solid fuel with a high-melting ash is presently preferred but oil or natural gas may be considered. Gaseous emissions from the firing process will be passed through appropriate scrubbing devices before discharge to the atmosphere.

Ilmenite Processing

Ilmenite is also used in the making of pigments but in its natural state, is a lower grade source of titanium oxide. The pigment industry has two major production processes, each requiring specific ilmenite feedstock characteristics. One process requires a feedstock which is soluble in sulphuric acid and meets rigid chemical specifications. Traditionally ilmenite used in this process is either the natural mineral or the 'slag' after smelting to remove part of the iron content.

The other process requires ilmenite from which most of the iron has been removed and has specific particle size and chemical specifications. Natural ilmenite is rarely used in the process. Instead either a 'slag' or a 'synthetic rutile' is made which removes the iron from the ilmenite by a chemical process (the Becher Process used in W.A.).

The W.I.M. ilmenite does not meet the characteristics required for either of these processes and will therefore have to be processed on-site to convert it to a marketable product.

W.I.M. has developed two possible processes for conversion of the ilmenite.

The first process produces an acid soluble enriched product (acid soluble titania (AST)) from which most of the iron has been removed. This would compete directly with slag commonly used in the production of pigments.

The second process will produce a synthetic rutile which would be agglomerated for market in the same manner as outlined for the high titanium minerals.

The process routes are similar for both products. The technology and process conditions vary.

Unit operations consist of:

- high temperature reduction in a rotary kiln or other appropriate reactor using brown coal char as the reducing agent to substantially convert the iron content of the ilmenite to the metallic form;
- separation of the metallised product from residual char which is recycled;
- aeration of the metallised product in aqueous suspension to separate a hydrated iron oxide waste from the high titanium product;
- acid leaching to remove residual iron and other impurities;
- neutralisation of the acid leachate (AST) or acid regeneration (synthetic rutile);
- calcining of the titanium product;
- agglomeration (if synthetic rutile is the product).

Air emissions, after particulate removal, are those normally encountered in combustion processes. The W.I.M. processes (unlike the Becher process) will not add sulphur beari g materials to the reduction stage.

Waste materials from the processes are a hydrated iron oxide from the aeration stage and an iron bearing gypsum from the AST process or dry ferric oxide from acid regeneration. It is proposed to return these materials to ground as mine fill.

Zircon Processing

Zircon is used in foundry sand where a specific particle size is required and in ceramics manufacture where rigorous colour and chemical composition characteristics are needed in the feedstock. The Zircon mined at the WIM 150 site does not meet these characteristics and would require on-site processing to produce a marketable product.

The Zircon will be cleaned using acid. The acid used in this process would be either neutralised after use or re-used in the ilmenite processing operations.

Natural zircons contain varying small amounts of uranium and thorium within their crystal structure. It is probable that for some applications or with increasing stringency of regulations relating to radioactive materials, certain safety codes may have to be invoked with respect to the handling and treatment of industrial zircon. W.I.M. has demonstrated that it is technically feasible to remove up to 80% of the radioactivity from zircon. Uranium and thorium are not removed, but their radioactive p ogeny, particularly radium, can be displaced by the treatment. Should such a process be adopted, the small amounts of radium would be bound with the iron residues from ilmenite processing.

Chemical Supply and Storage

The mineral processing operations will require the use of several chemicals to clean and agglomerate the minerals. The chemicals will be stored on-site in tanks or in the case of solids, in an area designed and built in accordance with relevant Government regulations.

REHABILITATION

W.I.M. has been sponsoring research into appropriate rehabilitation practices for the site. It is proposed to rehabilitate the land to prior use or appropriate alternatives.

Rehabilitation of mined land to crops has not been practised in Australia although rehabilitation to pastoral activities is well known. Rehabilitation to cropping is successfully practised in the United States and Canada where there are strict requirements for demonstrated agricultural productivity after rehabilitation. Successful rehabilitation of mined land will depend on careful attention to soil chemistry and structure both during and after soil replacement.

The rehabilitation activities proposed by W.I.M. provide opportunities not economically available to farmers to improve soil chemistry and drainage. This could be accomplished by re-forming the surface profile, applying soil chemical modifying agents, the use of deep-rooted pioneering crops and the development of a long term rehabilitation scheme which will enable farm layouts including trees, fences, drains, etc. to enhance productivity and provide more "balanced" populations of insects and birds. This will add to the aesthetic and practical value of the rehabilitated land.

The land to be mined and rehabilitated first will be that owned by W.I.M. The company will be able to demonstrate its rehabilitation techniques on a range of different soil types found in the area.

It is anticipated that once land enters the stripping - mining - rehabilitation cycle it would be out of conventional agricultural production for approximately five years. A further period may be required to rehabilitate to agreed productivity levels. U.S. and Canadian practice suggests a total cycle of 10 years, depending on climate. At this rate the total area out of conventional agriculture at any time is estimated to be approximately 1 000 hectares.

WORKFORCE

Currently W.I.M. employs 25 people at the Drung South site. At the proposed scale, the mining and mineral processing operations are likely to require the employment of up to 320 people. The workforce will be employed on a shift basis 7 days per week. It is anticipated that most of the employees will be recruited locally.

INFRASTRUCTURE AND SERVICES

Water Supply

Annually the project will require approximately 6.0 GL (6 000 million litres) of water for all operations including dredging, concentration and mineral processing. At this stage it is anticipated that this will be obtained from the Rural Water Commission system (3.0 GL) and from bores to the Renmark aquifer (3.0 GL).

Electricity

The project will have a connected electrical capacity of about 18 MW.

TRANSPORT OF PRODUCT

After processing, the mineral will be stockpiled on site while awaiting transport to either the port of Geelong or Portland, for export.

The annual mineral production at the site will be approximately 400 000 tpa, with approximately 11 000 tonnes transported each week. A combination of rail and road transport options are being considered including the possibility of establishing a rail head at Deep Lead for receival, storage and loading of the mineral product. Approximately 55 trucks per day would be required to transport the product from the site.

APPENDIX 4

National Party Parliamentary Mining Committee, "Investigation and Report on a Proposal to Mine Heavy Mineral Sands in the Wimmera", National Party, October 1990.

INDEX

CHAIRMAN'S FOREWORD

The National Party Parliamentary Mining Committee wish to sincerely thank all those who have assisted this Committee in its Inquiry into the Mining Sands in the Wimmera District, and the proposed new Mineral Resources Development Bill so far as it affects that project.

In particular, the Committee appreciates the enormous amount of time and trouble taken by many individuals, community groups and Municipal Councils, in preparing submissions to the Committee, giving evidence in person and answering questions put by the Committee Members.

The Committee acknowledges also the assistance given by representatives of the mining industry and the Victorian Chamber of Mines, and appreciates the forthright manner in which their contribution was made. Facilities readily made available by Municipal Councils, and their officers, together with an inspection tour organised by the Shire of Dunmunkle, were particularly appreciated.

The Shadow Minister for Minerals and Energy, Jim Plowman and the Shadow Minister for Local Government, Planning and State Growth and Member for Western Province, the Hon. Bruce Chamberlain gave the Committee valued assistance and advice during the public hearing in Melbourne. This assistance from our Liberal Party friends and colleagues is acknowledged and appreciated.

On the organisational side, very considerable assistance has been rendered by both the electronic and print media. The Committee acknowledges the valuable contribution by Mr Alan Finch, Electorate Officer to Mr Bill McGrath MP, for his tireless efforts in making local arrangements, Miss Sally Freeman for the design of this Report, Miss Fiona Langley for her assistance in acting as Secretary to the Committee, and particularly Research Officer, Mr Andrew Maughan for his work in preparing this Report.

DAVID EVANS MLC

BILL McGRATH MLA

ROGER HALLAM MLC

EXECUTIVE SUMMARY

The National Party Parliamentary Mining Committee was established in June 1990 to gain and foster a better understanding of the often competing interests of farming, mining and the community, particularly in the Wimmera Region.

CRA Limited subsidiary, Wimmera Industrial Minerals (WIM) has discovered that approximately 80,000 acres of Wimmera land contains mineral sands with mining potential. Five deposits, all within a 60 kilometre radius of Horsham, have been identified by WIM as containing sufficient "heavy mineral" quantities to warrant commercial mining. These deposits are generally located on grazing and cereal farm land.

The Committee conducted an Inquiry into the proposed mining activities. Submissions were made to the Committee at five public hearings held in the region and in Melbourne. Written submissions were also made.

This Report is intended to provide a background to the issues involved, summarise submissions made to the Committee and arrive at a sensible and realistic conclusion which takes account of all parties' interests.

The existing and proposed legislation governing mining in Victoria (summarised in the Report) have influenced the conclusions determined by the Committee.

Farmer/landowner and community concerns about the proposed mining may be summarised as follows.

1. Uncertainty concerning the effects of mining and the lack of predicability with respect to the future of farming families.
2. Whether rehabilitation of mined areas will return the land to its former productive capacity.
3. The level of compensation payable.
4. The effects of mining on water price, supply and quality and the possible effects on salinity.
5. The impact of mining on local employment, clubs and facilities.
6. The possible effects of any increase in radiation levels due to mining.
7. Whether mining interests would be required, or willing, to contribute funds to the municipalities to help pay for any financial burden their activities may place on the area.

Submissions made by the mining community addressed many of the issues referred to above. They also focused on the benefits of mining to the broader community and the superior economic returns offered by mining compared to farming.

The conclusion arrived at by the Committee is intended to help provide a fair and reasonable outcome for all interested parties. It can be summarised as follows.

1. It is likely that mining will proceed in the Wimmera under existing or proposed legislation provided WIM satisfies the prescribed requirements and associated public scrutiny of the project.

2. WIM should provide further information and assistance to the public with respect to the proposed mining, and

   (a) an undertaking to purchase at market value, plus a solatium, any farming land that it may intend to mine;

   (b) ensure public consultation and the provision of information to local people particularly on a face to face basis;

   (c) provide to the public its intended timetable for mining and the approximate time and order in which properties will be required;

   (d) provide to the public further information concerning possible extraction methods to be used, chemicals and waste products which may result from such methods, expected percentage of land that will not be adequately rehabilitated, the proposed location of employees and the mineral content of ore bodies under individual farmer's land;

   (e) conduct a test/demonstration project on a reasonable sized area to demonstrate the standard of rehabilitation which could be achieved following mining;

   (f) provide to the public further information expressed in layman's terms about the levels of radioactivity and radon gas which may result from the mining process;

   (g) agree with the Rural Water Commission to pipe water in the Wimmera-Mallee system to save a sufficient amount for the proposed mining operations.

3. WIM should undertake to negotiate with local Municipal Councils to provide financial assistance, in addition to any rates which may be payable, as compensation for the additional burden placed on community resources, particularly local roads, due to mining operations.

1. INTRODUCTION

The National Party have for some time been concerned about the often competing interests of farming, mining and the community particularly in the Wimmera Region where approximately 80,000 acres of potential mineral sand mining is proposed.

To enable the National Party to better understand the interests of the three groups, a three member Parliamentary Mining Committee was established in June 1990. The Committee Chairman is the Honourable David Evans, MLC, Member for North Eastern Province, who at the time of establishment was also National Party spokesperson on mining. The Honourable Roger Hallam, MLC, Member for Western Province and Mr. Bill McGrath, MLA, Member for Lowan, complete the Committee.

On 6th June 1990, David Evans as Committee Chairman, wrote to various people and organisations concerning the proposed mining developments. The letter invited written submissions and announced that the Committee would be holding public hearings to allow all interested parties to present their views on the proposed developments.

The developments of major interest were those proposed by Wimmera Industrial Minerals (WIM), a fully owned subsidiary of CRA Limited. The interests of other mining companies in the area were also considered relevant.

Terms of reference for the Inquiry included:

1. Any limitation on large scale exploration licences, and the term for which they remain in force.
2. Requirements which need to be met in order to hold licences for a particular term.
3. The effect on landowners and farming operations in the licence areas.
4. The effect on land valuations of granting of an exploration licence and exploration in the licence areas.
5. Effect on possible sales of land.
6. Future of sustainable agriculture after mining operations are completed.
7. Water requirement for full scale mining and effect on Wimmera-Mallee water supply.
8. Disposal of waste water.
9. Effect on municipalities, rating values, roads and demand for services.
10. Employment effects.
11. Comparison between economic value of mining and farming.
12. Effect of legislation restricting mining access to public land, and the resulting pressure on private land.

Response to this initiative was significant. Twenty-eight written submissions were received and approximately forty-two people or organisations gave evidence at the public hearings. These people and organisations are listed in Appendix A.

Public Hearings were held at Rupunyup, Nhill, Noradjuha and Horsham on 23rd and 24th July 1990 and in Melbourne on 7th August 1990.

Committee members David Evans, Roger Hallam and Bill McGrath visited the WIM 150 excavations and the experimental separation plant in 1989.

The Liberal Party Spokesman on Mining at the time of this initiative was the Honourable Bruce Chamberlain, MLC, Member for Western Province. The new Coalition Spokesman on Mining is the Jim Plowman MLA, Member for Evelyn. Both Members were invited to participate in the hearings.

Most parties were pleased to be given the opportunity to have their say on a matter that affects their future livelihoods. Many thanked the Committee for their interest and work in the area.

This Report is intended to provide a background to the subject of sand mining in the Wimmera, summarise submissions made to the Committee and arrive at a sensible and realistic conclusion which takes account of all parties' interests in the light of the existing legislative framework.

It is also accepted that a new Mineral Resources Development Bill is currently before the Victorian Parliament, and that submissions made by both community and mining interests are relevant to consideration of that Bill, and will assist in framing amendments to it.

2. BACKGROUND

2.1 CRA LIMITED, DISCOVERY OF HEAVY MINERALS

In 1985, CRA Limited subsidiary, WIM, announced the discovery of " heavy minerals" in what appeared to be commercial quantities at Drung South, near Horsham. The deposit has been named WIM 150.

Since 1985, and following further exploration, WIM have confirmed that some 80,000 acres of Wimmera land have substantial mineral potential. In addition to the Drung South deposit, four other deposits containing similar proportions of the various minerals have been located by WIM. These have been named WIM 50 (Shire of Kowree), WIM 100 (Shire of Arapiles), WIM 200 and WIM 250 (Shire of Dunmunkle).

2.2 LOCATION OF THE MINERALS

All of these deposits are within 60 kilometres of Horsham which is about 300 kilometres northwest of Melbourne. They are generally located on cereal farming and grazing land. Appendix B contains maps, provided to the Committee by WIM, which more accurately indicate the location of the deposits.

2.3 THE MINERALS AND THEIR USE

The heavy mineral sands contain the titanium ores (rutile, anatase, leucoxene and ilmenite), the zirconium ore (zircon) and rare earth minerals (monazite and xenotime). Australia is currently the world's largest exporter of these minerals.

Titanium ores are the source of titanium dioxide pigments used in the paints, plastics and paper industries. Zircon is primarily used as a refractory material and as a ceramic glaze. The rare earth minerals contained in the deposit have specialised applications in electronics, high strength magnets, steel alloys and high strength ceramics and other high technology fields.

Titanium metal is used in high strength alloys in modern aircraft.

2.4 EXTRACTION PROCESS

The Wimmera mineral sands discovered, are not typical of deposits currently mined in Australia or elsewhere in the world because of their fine grain size. As a result, existing recovery and processing techniques are unsuitable. Commercial development of WIM 150 has been delayed until a suitable method can be found. Further research is being conducted by WIM to determine new treatment methods, including flotation and mechanical jigging, which may be more appropriate. WIM anticipate the results of this research may be available later in 1990.

3. LEGISLATIVE FRAMEWORK

Analysis of the issues relevant to sand mining in the Wimmera would be incomplete without an understanding of the existing legislation. Particularly, the Mines Act 1958 (the Act) and the proposed Mineral Resources Development Bill (No. 2) (the Bill).

Many submissions made to the Committee argued for change to the existing Act or the proposed Bill. Some sought changes which attacked the fundamental nature and underlying principles of mining legislation.

For example, landowner submissions were generally in favour of a right to veto mining on their land.

The Act provides that the Crown owns a wide range of valuable minerals in Victoria, but not ordinary rock, soil, gravel or clay. Such minerals generally include gold, silver, uranium, and thorium and include those in the heavy mineral sands.

Similar ownership provisions exist in all other States. The Bill retains this position because the Government holds the view that mineral wealth should be developed in a way that provides a benefit to all Victorians rather than to enrich a few on an ad hoc basis. The Victorian Chamber of Mines basically endorses this stance. A landowner right of veto would change the whole nature of control over minerals in Victoria and is unlikely to be supported by the Parliament.

However, the Committee is of the view that there needs to be a clear legislated opportunity for a landowner to object to the issue of a mining permit, on economic grounds, and to be able to state his or her case before an independent arbiter or the Minister.

Recommendations made by witnesses in their submissions to the Committee will significantly influence debate on the Coalition attitude to the Bill, and amendments to it.

Set out below is a summary of provisions of the Act most relevant to the Inquiry. This is followed by a brief description of provisions of the Bill. Where appropriate, the provisions which alter the existing regime are noted.

This summary is meant to provide a broad overview only. Those who require a more detailed understanding of the legislation should seek an opinion from a legal expert.

3.1 REVIEW OF THE MINES ACT 1958 AND RELATED LEGISLATION

Ownership and Access

The issue of mineral ownership is discussed in detail above. Briefly, the Crown owns all valuable minerals in Victoria.

Provided the necessary mining titles have been obtained and the prescribed procedures have been met by the mining company, the landowner is required to give the miner access to those minerals.

Land may be included in mining titles under the Act without the landowners consent, but provisions protecting certain improvements to the land and requirements for compensation to be paid to the landowner before exploration or mining is allowed partially protect the landowner.

Protection of Improvements

Some improvements on private land are protected and cannot be entered for pegging, exploration or mining without the consent of the landowner. These include land on which a garden, orchard, vineyard, residence, factory, windmill, bore, spring, lake, artificial reservoir, dam, sheepwash or woolshed is located. Similar protection applies to exploration within a radius of 100 metres from these improvements.

Compensation

Compensation is to be paid to the private landowner for loss of the use of the land for the period the land is used for exploration and mining purposes.

Before a mining title or authority may be granted, the Minister must be satisfied either that compensation has been paid, the landowner has consented in writing or the land has been purchased.

If no agreement between the miner and the landowner with respect to the amount of compensation can be reached the matter can be referred to the Land Valuation Board of Review which will determine the amount of compensation payable.

In essence, compensation is limited to the direct financial loss suffered by the landowner. Specific heads of damage are listed within which the financial loss must fall. These include financial loss due to deprivation of possession of the land, severance of land from other land, required rights of way, damage to the surface of the land and cost of removal of debris that is not covered by the rehabilitation requirements.

Environmental Controls and Rehabilitation

Environmental controls are applied under the Mines Act 1958, the Planning and Environment Act 1987 the Environment Protection Act 1970 and the Environment Effects Act 1978.

The Environment Effects Act requires the preparation of an Environmental Effects Statement (EES) or in some cases a Preliminary Environmental Report. The EES is made public for comment.

The Mines Act and the Planning and Environment Act also provide opportunities for the public to object and or comment on mining proposals.

Often as a result of public debate, environmental controls are included as conditions on mining titles or on planning permits. These typically relate to the hours of operation, noise levels, discharges from the site and rehabilitation. Rehabilitation is a condition on most mining titles. On private land, the conditions are established following consultation with the relevant planning authorities.

The miner is responsible for rehabilitation. A rehabilitation bond must be lodged with the Department prior to the grant of title and is returned only after inspection by the Mines Inspector and a Department of Conservation Forests and Lands Officer or planning authority representative. The amount of the bond is determined by the Department.

3.2 REVIEW OF THE MINERAL RESOURCES DEVELOPMENT BILL (NO.2)

At the time of writing this Report, the Bill has been debated in the Legislative Assembly.

If enacted, the Bill will repeal the existing Mines Act 1958 and replace it with a new regime governing mining in Victoria.

The Victorian Chamber of Mines have prepared a comparison of provisions protecting landowners under the Act and the Bill. This is included in Appendix C.

Issues raised in this Inquiry which may be addressed in the Bill include the following:

Mining Tenements

Mining Tenements have been simplified. The thirteen tenements available under the Act have been consolidated to three. These are an exploration licence, a mining licence and a miner's right.

Royalties

The holder of a mining licence is required to pay royalties at rates specified in the licence or, if the rates are not specified in the licence, according to the royalty rates prescribed (Clause 12).

Authority to Enter

Landowner or occupier consent or an "authority to enter" is required before an applicant is allowed to enter private land to mark out a mining licence (Clause 20). Prior right of a miner is established by registering a claim on a grid map reference. No more pegs at the dead of night.

Improvements

Protection similar to that offered under the Act is offered in the Bill to improvements to the land and the surrounding 100 metre area. Improvements added to the protected list include milking sheds, churches, hospitals, public buildings, cemeteries, Historic Buildings, and particular archaeological and Aboriginal sites (Clause 45).

In contrast to the Act, the Bill gives the Minister power, acting on the advice of the Mining and Environment Advisory Committee, to override the protection and authorise a licensee to do work on the protected land. The Minister's power does not allow him to override protection for a Historic Building, an archaeological and aboriginal site or an aboriginal sacred place (Clause 46).

Authority required to commence work

Once a mining licence has been granted, the licensee must obtain any necessary planning or other consents and enter into compensation agreements with private landowners where applicable. The licensee must then apply for an "authority to commence work". The licensee may commence work when this authority is registered (Clause 39).

Compensation

Compensation is payable at exploration and mining stages. If the parties are unable to agree on compensation, the matter may be referred for determination by a Land Valuation Board of Review established under the Valuation of Land Act 1960.

The areas for compensation are broader than under the Act. New heads of damage include (Clause 85):

- loss of amenity, including recreation and conservation values;
- loss of opportunity to make any planned improvement on the land; and

- any decrease in the market value of the owner or occupier's interest in the land.

Provision is also made for an additional compensation payment by way of solatium of up to 10 per cent of the value otherwise assessed "to compensate the owner or occupier for intangible and non-pecuniary disadvantages that are not otherwise compensable and that result from the approval of the work plan or the doing of work under the licence" (Clause 85).

The Committee is of the view that the 10 per cent solatium is inadequate, and a figure of up to 20 per cent would be more reasonable.

Rehabilitation

The holder of a mining licence is required to rehabilitate the land in accordance with a rehabilitation plan approved by the chief administrator (defined under the Conservation Forests and Lands Act 1987) (Clause 78). Such plan must take into account any special characteristics of the land, the surrounding environment and the need to stabilise the land. In the case of private land, the plan must be prepared by the licensee after consultation with the owner of the land (Clause 79).

A rehabilitation bond must be entered into to ensure rehabilitation work takes place to a reasonable standard (Clause 80). The bond amount is determined by the Minister, and in the case of private land, in consultation with the local Municipal Council. The bond may be retained for up to six years after completion of the work. It can not be returned until the Minister and chief administrator are satisfied that the rehabilitation, as contained in the rehabilitation plan, is likely to be successful and in the case of private land, the Minister must not return the bond until the land owner has been consulted (Clause 82).

If not satisfied with the rehabilitation, the Minister may take any action necessary to rehabilitate the land at the cost of the licensee. Such action may only be taken after the licensee has been requested to rehabilitate the land and has failed to do so within a reasonable period of time (Clause 83).

There appears to the Committee to be good reason to give the landowner power under the legislation to initiate this action by the Minister.

3.3 MUNICIPAL RATES AND PLANNING

Rates

Under the Local Government Acts 1958 and 1989, properties used for mining purposes are not obliged to pay municipal rates. These Acts are to be amended so holders of mining licences will no longer be exempt (Clause 129).

Planning

Use of land in Victoria is generally controlled by the Planning and Environment Act 1987. Each municipality has its own planning scheme which may regulate the issue of planning permits for mining activity. The Local Council in most cases is the responsible authority for issuing planning permits.

A procedure is established for the amendment of planning schemes to allow mining activity.

The Bill does not change this system except that the Mines Minister will be authorised as a planning authority under the Planning and Environment Act where a planning scheme amendment is sought by a mining proponent. The Minister may also seek, as a planning authority, amendments to planning schemes in relation to exploration and mining. A Mining and Environment Advisory Committee will be established under the new Act to advise the Minister when performing the function of a planning authority.

4. THE SUBMISSIONS AND THE HEARINGS

The Committee believes that the hearings have given a valuable opportunity to the community to voice its concerns with respect to proposed sand mining in the Wimmera.

Submissions and evidence were presented to the Committee by a broad range of individuals and organisations representing different interests. The level of time and effort committed to the submissions was impressive and indicated to the Committee the importance of the issue to the various parties.

These submissions effectively conveyed the basic concerns of the parties, but on occasions lacked supportive evidence. The Committee understands that this may be partly due to the lack of financial resources available to certain parties or to the lack of comparable mining projects. Even in the absence of supportive facts, each argument was assessed on its merits and given the relative weight determined appropriate by the Committee.

People and organisations who made submissions basically represented the farming/landowner, Municipal Council and mining sectors. A number of submissions also voiced community concerns relating to health, small business, fishing and tourism. However, no-one working in small business or tourism made a written or verbal submission.

Set out below is a summary of the various arguments presented to the Committee.

5. FARMER/LANDOWNER AND COMMUNITY CONCERNS

5.1 UNCERTAINTY

Uncertainty was the most significant concern currently affecting the landowners and their families.

Confusion on the effects of mining and lack of predicability with respect to the future of their properties was a constant theme.

Submissions indicated that up to 90 families could be affected.

Ian Morgan illustrated the frustrating nature of this uncertainty by explaining that he can not make a reasonable decision whether to expand his farm to include his three sons until he knows which land may be required for mining and if so when. Meanwhile, he notes, time slips away.

George Bennett commented that "the farmers are in the dark" and that they do not even know the quality of minerals under their land and whether such minerals are of commercial value to the miners.

Added to this uncertainty is the feeling amongst the farmers that they no longer control their own destiny. David Matthews, a district farmer who also represented the Wimmera District Council of the Victorian Farmers Federation noted that the cherished independence of the affected farmers was lost. Errol Laverty made similar comments that the farmers' futures were no longer in their hands and that they now have little say in what happens to their land.

Some farmers such as Frank Drum were even uncertain as to whether their land would be returned to them after mining was complete and if so, in what state? The issue of rehabilitation adds to the uncertainty and is discussed below.

Many submissions argued that because farmers were living with uncertainty 24 hours a day it was affecting their whole family and their lives. Robert McDonald and Richard Hobbs noted that bed wetting by school children of affected families had become more prevalent. School teachers had also commented on the detrimental effect the uncertainty was having on the children. Doug McHenry commented on the traumatising affects the uncertainty was having on families. Dr. Rod Sutherland confirmed that these could be the results of the existing lack of predicability facing families. Dr. Michael Axtens added that depression and loss of self esteem could also result from farmers losing their livelihood.

Both Marshall Baillieu of WIM and the Victorian Chamber of Mines acknowledged the problems associated with the lack of predictability. Suggestions were made by these organisations and the landowners that a framework advising landowners of the likely sequence of mining would help reduce the uncertainty. The Company did however note that it was difficult to make any firm timing commitment until it overcomes the technical problems of processing the mineral sands.

The VCM also argued that speedier granting of mineral titles would lessen the period of landowner uncertainty and that the proposed Bill may facilitate such a reduction in application delays.

Another factor adding to the uncertainty is that few landowners know what their rights and obligations are when dealing with the representative of a mineral exploration company. The VCM noted that after consultation with the Victorian Farmers Federation it produced a booklet explaining landowners' rights, particularly in regard to compensation. The booklet is titled "Landowner Information on Mineral Exploration and Mining On Private Property".

5.2 RESTORATION/REHABILITATION

Another major concern of farmers related to the restoration or rehabilitation of their land following mining.

Confusion over the meaning of these two words was apparent in submissions. The legislative obligations imposed on the mining companies with respect to rehabilitation also appeared to be unclear. To some, rehabilitation meant "digging a lake and planting trees around it", but this interpretation was vigorously denied by mining representatives.

As noted above, existing and proposed legislation requires the miners to "rehabilitate" the land. The Mineral Resources Development Bill requires that the rehabilitation plan, to be approved by the chief administrator, must take into account any special characteristics of the land, the surrounding environment and the need to stabilise the land.

The Acting Secretary of the Shire of Dunmunkle, Mr. Robin Webb, noted in his submission that the standard of rehabilitation would depend on the decision of the chief administrator and that this mechanism was grossly inadequate for ensuring that appropriate rehabilitation takes place. He then suggested that Local Government's role should be expanded at this level to include setting and overseeing of the rehabilitation requirements and active involvement in the determination rather than just consultation by the Minister.

The general feeling amongst farmers, as indicated by Jim Starbuck and David Matthews, was that the "rehabilitation" requirement was insufficient and that only "restoration" was acceptable. This was based upon the belief that productive wheat and grazing land would be lost forever if mining was to proceed.

This view was adopted largely due to the soil composition of land in the area. It was generally accepted that the layer of top soil in the region was thin (three to five inches In most places), and that soil types varied significantly often in the same paddock. This led to the belief that spreading the top soil back over the land following mining would be near impossible and accordingly returning the land to its original productive capacity could not be achieved.

Duncan Bell representing the VCM submitted that community attitudes with respect to mining were coloured by events of 50 or 100 years ago. Therefore farmers must be able to see what happens in todays rehabilitation before they can be confident. Mining companies now have expertise in hydrology and botany that is often more advanced than the expertise of Government departments. For example, mining industry technology has been used to overcome a eucalyptus die back problem at Healesville. Above all, the VCM submission noted that mining companies must be prepared to be good corporate citizens in returning land to an attractive, productive state.

Marshall Baillieu representing WIM noted the success of rehabilitation programmes along the East Coast of Australia after sand mining but also noted WIM's concern with respect to the exactitude of rehabilitation being demanded in the Wimmera.

Colin Bills, also representing WIM, noted that technology advances in land rehabilitation which will be described in the Environmental Effects Statement will also give a picture of the final condition of the land after mining. He also noted that whilst it will not be possible to "exactly" replace the trees and top soil, with planning requirements and expertise in soil and tree replacement, land will be both attractive and productive. Further, he stated that the trials were being prepared.

In support of the WIM submission, the VCM presented examples of successful rehabilitation following sand mining elsewhere in Australia. The AMC Wetlands Centre at Capel in Western Australia and the Myall Lakes region, north of Newcastle in New South Wales were both referred to. The VCM noted that neither of these projects dealt with the return of a site to farmland. However, areas in the Hunter Valley in New South Wales were discussed where several thousand hectares of coal mining operations have been returned to cattle grazing in the past decade.

Although there is no immediate precedent in rehabilitating country similar to the Wimmera to its original use, the VCM did not see this as an insurmountable problem. As noted by Colin Bills, work is being carried out by WIM to establish the base line data that any rehabilitation plan will need. Ultimately, the WIM Environmental Effects Statement that must precede commercial mining will analyse the options.

Dr. Bob Creelman, representing Fidunu Mining Company, a fully owned subsidiary of Dennison Mines Ltd of Canada, also ventured that rehabilitation of mined land had been successful elsewhere. He did however acknowledge, along with WIM and VCM, that further research was required on the issue. This latter view was echoed by the farming community.

Frank Drum accepted that if the miners could restore the land to its original productive capacity then mining on the land would be more acceptable. Robert McDonald and Richard Hobbs also demanded that the land should be returned to its productive capacity following mining.

Gil Hopkins noted the general acceptance by the miners and farmers that further research concerning rehabilitation was required. He went on to say the results of any demonstration project would have to be near perfect.

The ability of the miners to return the land to its original productive capacity obviously affects the decision of farmers to sell to the miners. The uncertainty of both the miners and the farmers as to whether the miners could comply with these requirements led to the suggestion by Councillor John McHenry that a test site of at least 100 acres was imperative. He noted that only when the results of rehabilitation tests were known by farmers could they make an informed decision on whether to sell their land. This view was also raised by the Dunmunkle Land Protection Group which proposed that miners crop or graze the land following rehabilitation to prove its productive capacity was not reduced.

Another environmental issue of concern to Doug McHenry and the Toolondo and District Survival Committee was the permanent loss of old trees, particularly buloke and red gum, and native species of flora and fauna. The group was also concerned that wetland in the mining area would be destroyed forever. This, they submitted, would destroy the natural habitat for particular wildlife (including the rare red tailed black cockatoo and the brolga) and upset the ecosystem. The Wimmera Branch of the Australian Conservation Foundation expressed similar concerns.

In raising the issue of the rehabilitation bond, David Matthews suggested the size of the bond should be substantial and secured before mining commences to ensure complete restoration will be carried out. The Shire of Dunmunkle also argued that more stringent controls were required prior to release of the bond. The VCM submission noted that a larger rehabilitation bond was a likely outcome under the proposed Bill due to concessions made by the mining industry.

5.3 WATER

Concerns were raised about water supply, cost increases and contamination and on the effects of mining on the water table and salinity levels. Areas of equal concern were surface water, underground water and the Wimmera Mallee Domestic Stock Supply System.

Price

The potential for water price increases during mining was raised in a number of submissions. Such concerns do not appear to be based upon any predictions made by the Rural Water Commission (R.W.C.) but rather upon the assumption that there would be greater demand for water but no more supply.

Supply

The Dunmunkle Land Protection Group submitted that the local people felt that there was insufficient water supply in the Wimmera-Mallee Domestic Stock Supply System to support both agriculture and mining in the area. This was supported by other landowner submissions. However, the possibility of an increased supply brought about by water saving through piping was not acknowledged.

The Land Conservation Council in 1986 recommended the implementation of a piping scheme in the Wimmera as a means of saving water currently lost through extensive seepage in delivery channels. The Council at that time advocated the use of this water for environmental flows as a priority to mining.

Marshall Baillieu of WIM told the Committee that WIM was prepared to consider financing the piping of significant sections of the Wimmera-Mallee system, and that the water saved would be sufficient for WIM's requirements. Losses of up to 90 per cent occur in some areas and farm water supplies could be unaffected if current negotiations between WIM and R.W.C. can be satisfactorily concluded.

The Committee considers the additional cost of reticulation to individual farms, because of different land levels, will need to be satisfactorily addressed. It was submitted by Jenny Barnett of the National Parks Association that as a goodwill gesture to the community, WIM should ensure sufficient water is piped to supply the mining operations and a further 25 per cent for farmers and other users and environment flows.

Contamination

Contamination of surface water, underground water and the Wimmera Mallee Domestic Stock Supply System from mining in the area was a widely held concern.

The landlocked nature of much of the water supply in the area heightened the community fear of long term detrimental effects.

The disposal of waste or run off water was seen as a possible major cause of contamination. The possible exposure of shallow aquifers in the dredging process resulting in contamination was also regarded as a potential problem. The adequacy of potential safeguard measures was also queried particularly in the event of flooding.

Joan Bennett drew attention to the quality of water from limestone aquifers, and the long term effects of possible contamination, and the need to "cap" test bores to stop leakage between aquifers at different levels.

It was noted that insufficient information concerning the mineral extraction process resulted in a degree of uncertainty as to the precise nature of the contaminants. However, those of main concern were radioactive minerals, saline water and chemicals used in the extraction process.

WIM submitted that due consideration will be given to these concerns in any Environmental Effects Statement required prior to mining.

VCM submitted that the mining industry has experience in successfully operating in water catchment areas and in areas where nil discharge conditions are imposed.

Radioactivity is considered separately in this Report.

Salinity

The effects of mining on salinity in the area was raised in most submissions.

It was generally argued that salinity levels would rise during mining due to the disposal of saline waste water, the removal of trees, alteration of the soil profile and the greater volume of water flowing through the system with consequent increases in leakage.

It was also submitted that the height of the tailings dam above the ground level could also increase hydraulic pressure and cause salinity problems. The Avon Plains Landcare Group and the Dunmunkle Land Protection Group referred to a court case involving Lake Batyo Catyo. The facts of that case indicated that rises in water levels in lakes or dams above ground level causes the surrounding water table to rise in similar proportions.

While the deleterious effects of increased salinity levels on the productivity of farmland was the major concern, the Wimmera Anglers Association was concerned with the effect of salinity and contamination on fishing in the area. Peter and Debbie Funcke were similarly worried about the effects of poorer water quality on the productivity of their fresh water aquaculture venture near the Richardson River.

Generally most submissions called for more detailed information and research regarding the use and disposal of mine water.

In response to concerns about salinity and the environment, VCM argued that the Australian mining industry has gained a world reputation for rehabilitating mined areas. The use of salt resistant eucalypts, developed by Alcoa, to help fight salinity and protect the jarrah forests of the Darling Ranges, was one example given.

VCM also submitted that the mineral sands operation proposed for the Wimmera is one where rehabilitation poses relatively few problems. Because the mined area would move progressively across the mineral deposit, it is possible to plan rehabilitation with greater precision than in the case of a less uniform ore body in more rugged terrain. The submission continued, it is anticipated that most of the land mined in the Wimmera would revert to agricultural use. Finally, before a detailed proposal for rehabilitation is drawn up, WIM would consult with landowners, relevant government departments, local councils and other interested bodies.

John McHenry referred to the need for continuing assessment and monitoring to ensure that rehabilitation was satisfactory.

5.4 GENERAL COMMUNITY CONCERNS

The effect of mining on the wider community was an issue raised in many submissions.

It was suggested that mining would have a detrimental effect on small business and tourism in the area. However, little evidence was given to substantiate these claims and unfortunately no-one directly involved in tourism or small business made a specific submission to the Committee.

Considerable emotion was displayed concerning the potential loss of local heritage due to families forced to sell their land and move to alternative districts. Some of the families affected have farmed the area for up to six generations. It was evident that the impact of such an upheaval was significant on the families themselves, the small towns and the general community. Erosion of community spirit was also evident due to the surrounding uncertainty.

In its submission, the Toolondo and District Survival Committee suggested that families leaving the area could result in the closure of the State Primary Schools at Noradjuha and Clear Lake. It also suggested that survival of sporting clubs and fire services in the district may also be placed in jeopardy with consequent effects on the maintenance of facilities such as halls and recreation reserves. The submission reflected the general feeling that the mining community would centre its activities around Horsham rather than the surrounding towns. It failed to acknowledge that mining could introduce new members into the area possibly boosting the support of these groups and facilities.

There is considerable uncertainty as to whether the communities surrounding Horsham will benefit from mining in the area. The contribution WIM is willing to make to allay these areas of broader community concern and the willingness of the local community to embrace such contribution will be crucial in this issue.

5.5 RADIATION (NUCLEAR ACTIVITIES (PROHIBITIONS) ACT 1983) AND HEALTH

A number of submissions raised concerns over the possible release of radon gas and increase in the level of radioactivity resulting from the mining process.

Radioactive thorium and uranium are contained in the rare earth minerals monazite and xenotime which are present in the orebody in extremely low levels. According to the WIM submission, the respective levels by weight of thorium and uranium in the orebody are approximately 0.003 per cent and 0.0003 per cent.

WIM have confirmed that they are not mining for thorium or uranium and that neither of these substances will be produced at the mine.

Dr. Michael Axtens representing Doctors Opposing the Nuclear Threat and David Mudie both suggested that in processing the sands into their individual minerals, the radioactive substances would become more concentrated. Dr. Axtens further suggested that this radioactivity may be released into the water used in the process, becoming a potential contaminant if released or contained on site. In arguing that no level of radioactivity was safe, Dr Axtens noted that radiation limits set by governments have been progressively revised downwards over the years. He also argued, as did David Mudie, that importers were increasingly turning to countries with clean nuclear records and that Australia's reputation could be tarnished if sand mining was allowed to proceed. Dr. Axtens generally disagreed with the position adopted by governments who allow radiation levels which do not impose an unacceptable burden on society due to health effects. While arguing that sand mining should not proceed for these reasons, Dr. Axtens suggested that the most pessimistic calculation of radiation risk should be adopted.

WIM's submission noted that such an approach has been adopted in tests performed to date and that recorded levels were still well below recommended maximum levels.

WIM's submission also noted that its proposed mining activities comply with the Nuclear Activities (Prohibitions) Act 1983. The Minister for Industry and Economic Development Hon. David White was quoted by the Company as acknowledging this with respect to WIM 150. It was also noted that the Victorian Solicitor - General has advised the Victorian Government that the WIM 150 proposal is entirely legitimate.

On the issue of health, WIM acknowledge that radiation will be elevated to levels above those the community is exposed to on a daily basis from the sun and natural conditions. But this, it submitted, is still at extremely low levels and confined to close proximity to the mining and processing areas. The submission states the surrounding districts will not experience any measurable effect in regard to additional radiation, and radiation levels will be below the levels existing in many residences due to radon gas.

So far as the exposure of workers in the WIM plant and operations are concerned, WIM stated the expected slightly elevated radiation levels will be well below the maximum exposure limits set by statute. Further, the Company has established a Radiation Management Plan to protect against workers at the pilot plant being subjected to dangerous levels of exposure. It is assumed a similar Plan will be adopted for subsequent mining activities.

The issue of radon gas was also raised. Dr. Axtens noted the impact of the gas in poorly ventilated areas, particularly in the United States where it is reported to be the second largest cause of lung cancer after smoking. Nevertheless, no firm evidence was adduced to establish a link to this with mining activities.

WIM acknowledged that the levels of radon gas were slightly elevated during and shortly after construction of a costean but that these levels barely exceeded those typically found in an Australian home. It was further submitted by WIM "to keep things in perspective", that ploughing a field similarly increases the level of radon in the atmosphere.

Dr Sutherland noted that radioactivity is an emotive word, often not understood, and that it is easy to over-react. These matters will be further considered in the Environmental Effects Statement which will form part of the process of public scrutiny called for by David Mudie and Dr. Axtens.

5.6 COMPENSATION

Farmers faced with the prospect of having their land mined generally have two alternatives. They can sell to the mining company provided the company is interested in buying, or they can retain ownership of the land and receive compensation.

Farmers were basically unhappy about either alternative.

It was submitted that if they sell, the price paid for the land may be depressed because only the miners are interested in the land. It was argued that a lack of "agricultural" buyers exist because of the uncertainty created by proposed mining. Suggestions were made that land values in the area were already depressed for this reason. The Committee accepts this as a possible factor but also notes that tight economic circumstances and depressed prices for wool and wheat may also have an impact on existing land values at this time.

The Toolondo and District Survival Committee argued that the miners should be forced to buy for at least twice market value to adequately compensate the land owner for costs incurred such as:

- relocation of family
- relocation of plant and equipment
- worry and trauma
- lost income as a result of relocation
- lost local markets for produce
- lost development on farm
- goodwill in agricultural circles
- goodwill in community and service centres
- stamp duty
- legal costs
- capital gains tax

The Committee acknowledges that many of these costs are valid but notes that under existing legislation there is no requirement that the miner purchase the land. Amendments to the Mineral Resources Development Bill would be required to achieve this objective.

Incorporating some of these costs into the compensation provisions for farmers intending to retain ownership may be more feasible, particularly as it was submitted that even if the farmer decided to retain ownership, or the mining company was no longer willing to buy, compensation payable would still be insufficient. Again, amendments to legislation may need to be considered. It may be necessary to increase solatium in Clause 85 of the Bill from 10 per cent to say 20 per cent.

The VCM on the other hand noted that industry experience reveals that in a great majority of cases compensation agreements are amicably arrived at.

The VCM submission also noted that where purchase of land was justified, the mining companies would take into account non economic factors in negotiating a fair purchase price. These included the strong attachment to the family farm that exceeds that felt for a purely economic asset and the difficulties of uprooting ones family from a community and making a fresh start elsewhere.

5.7 ECONOMIC ISSUES

Several submissions attempted to make financial comparisons between farming and mining. Such comparisons generally failed to consider many critical relevant factors.

For example, it was submitted by the Dunmunkle Land Protection Group that the future value in 100 years time of an annuity of $150 per acre invested at 10 per cent per annum amounted to $26,669,419. The Committee assumes an error was made in writing the submission as the future value of such an income stream invested for 100 years at 10 per cent per annum is actually $20,669,419. This is equivalent to $51,074,696 per hectare. This future value was compared with a per hectare return of $1,000,000 estimated by WIM to be the approximate value of minerals contained in each hectare.

Problems with this comparison include:

- $150 per acre appears to be the return for premium land and is unlikely to be the average return over the district. Other submissions suggested returns of less than $100 per acre were more accurate. The future value of $100 per acre annuities at 10 per cent in 100 years amounts to $13,779,612.
- The compounded analysis assumes that no income is earned on mining land prior to and after mining.
- The analysis considers only gross returns. It fails to take account of profit margins and therefore actual returns to the land user and taxation revenue to the Federal Government.
- The analysis fails to consider the capital costs of the different land use.
- No allowance was made for investment of the $1,000,000 once earned by WIM. If for example, WIM invested this amount at 10 per cent for 100 years the future value of this sum would be approximately $13.78 billion without including revenue which may be derived from the land after mining.

The VCM also presented economic comparisons between farming and mining to indicate that a mining operation which temporarily uses a small proportion of farm land, can bring significant benefits to Australia and to local communities.The first concerned a proposed gold mine near Bendigo. Comparison was made between equivalent areas of mining and farming land. The value of mine output was estimated at $8.6 million to $14.7 million per annum over 7 years compared with $26,000 to $67,000 per annum from agricultural (wool) output in the same period. The net advantage to Australia of transfering the land area to gold production over the seven year period is therefore between $59 million and $102 million. Even if no further agriculture production was possible from the mined area, it would be 880 -3,900 years (depending on prices) before the value of agricultural production foregone exceeded the value of mine production.

The second example was provided for the Wimmera area. It was assumed that the total area affected at any one time would be 500 hectares. At the anticipated mining rate of 20 million tonnes per annum the expected income was calculated to be $150 - 200 million per annum, equating $300,000 to $400,000 per hectare. This was compared with a farm Income of $400 per hectare for a high yielding crop.

Some of the criticisms mentioned above equally apply to these examples. Nevertheless, the general pattern indicates that from a purely economic viewpoint, mining can provide a much higher return than farming, even when rehabilitation costs and loss of alternative production is taken into account.

Broader economic issues were also raised.

One was the fact that CRA Limited (the 100 per cent owner of WIM) is only 51 per cent Australian owned and therefore 49 per cent of its profits will go offshore. However, calculations above indicate that more revenue will be earned through sand mining which will provide greater taxation revenue that benefits all Australians.

Employment effects of mining were also considered.

The Dunmunkle Land Protection Group submitted that up to ninety families could be affected by mining in the Dunmunkle Shire and that the overall effect on employment would be negative.

In contrast, WIM have submitted that between 150 and 250 new jobs will be created by mining. The Company further submitted that a multiplier effect of 1.5 usually applies to projects of this nature.

In addition, Marshall Baillieu referred to a possible development of further processing which could create up to 100 additional jobs.

The Committee notes that because the deposits are so vast it could be 100 years or more before all the known deposits are likely to be mined. The actual area under mining at any one time will be about 100 hectares. WIM estimate that this area will be required for one year prior to mining to be prepared. The 100 hectares will take one year to mine and six to eight years to rehabilitate, according to WIM. Rehabilitation will be progressively carried out to allow fully productive farming after completion of mining. Therefore, the expected area under mining at any one time according to WIM will be about 1000 hectares. Accordingly, the actual reduction in farming population at any one time will be relatively small.

6. MUNICIPAL COUNCIL CONCERNS

Submissions were made by the Dunmunkle, Wannon and Lowan Shire Councils and also Councillor John McHenry representing the Shire of Kowree.

Issues peculiar to Councils which were raised generally related to their powers under legislation relating to planning and the collection of rates.

The Shire of Dunmunkle was concerned that the Victorian Government intends the Department of Industry and Economic Planning to become both the "Planning Authority" and "Responsible Authority" under the Planning and Environment Act for dealing with Planning Scheme Amendments and Permits relating to mining issues. The Act provides the Minister for Planning and Urban Growth with the power to implement such a change removing the planning control currently held by the Shire Councils.

The Shire of Lowan was similarly concerned about the general lack of consultation required with local municipalities on planning, environmental and economic matters. It suggested the Mineral Resources Development Bill No. 2 incorporate greater consultative requirements with Local Government.

The loss of rating revenue due to mining was another major Local Government concern. Land used exclusively for mining purposes is currently not rateable pursuant to the Local Government Act. This was seen to be unfair given the additional costs that municipalities are likely to incur as a result of heavy traffic on local roads due to mining in the area. The effect on local roads and public facilities was raised not only by Shire Councils but by a number of other witnesses. The general call was for contributions to be made by the mining companies to the community to compensate it for the increased costs the community incurs as a result of mining.

In its submission, the VCM accepted that where land is dedicated to a mine, then the land directly affected by the operation should be rateable. The submission continues, exploration makes no special call on council services and should therefore not be rated.

The Committee notes that the Government intends to amend the Local Government Act so that mining companies will be required to pay rates. This may remove some of the above concerns although it remains uncertain how the rates are to be calculated.

The VCM agreed that the rate should be higher than the discounted rate usually paid by farmers but argued that the rate should not be assessed with reference to the value of the mine.

It was noted by the Committee that WIM acknowledge the social responsibility it has to the local community. It may therefore be appropriate that WIM agree to contribute to the municipalities an agreed annual sum, in addition to rates, to help pay for the financial burden it places on the area, particularly for non-main roads providing access to the mine. Marshall Baillieu in evidence at Horsham, accepted this may be necessary.

Duncan Bell, giving evidence in Melbourne, acknowledged that Western Mining Co. had been prepared at times to make specific funding contributions to local roads, but not to highways. The Committee strongly endorses this approach.

Local Government consultation concerning the rehabilitation process was also called for because the long term value of land in the area will determine the amount collectible in rates. It is mentioned above that the VCM accept this as a fair proposition.

7. ADVANTAGES OF MINING

In submissions to the Committee, those representing mining interests stated that any analysis of mining proposals often centre too heavily on the negative aspects of mining, rather than the benefits that mining has to offer the nation and the community in general.

Mining sector submissions were received from executives of mining companies, and mining consultants, from organisations including Wimmera Industrial Minerals Pty Ltd, CRA Limited, Fidunu Mining Company, Denison Mines Ltd and the Victorian Chamber of Mines (VCM).

Points from some of these submissions have been referred to in Parts 5 and 6 of this Report. The Report now considers additional matters raised by the mining sector and focuses on the benefits of mining to both the local Wimmera and wider Australian community.

A valuable precis of these benefits was incorporated in a submission by VCM. The major points raised in this submission are listed below.

1. Consideration of mineral sand mining in the Wimmera should not unduly influence the National Party's policy with respect to current proposals for legislative change. The Committee acknowledges this point but notes that many of the issues raised in the Wimmera can be equally applied to other areas of the minerals industry.

2. Mining has over time been responsible for accelerated population growth in Victoria particularly through immigration during the last century. It has also contributed to much of the basic infrastructure in the State. Many country towns which today act as a centre for agriculture and government services, started as mining communities.

3. A paper recently published by the Australian Mining Industry Council (and referred to at Nhill by Dr Bob Creelman) highlighted that mining activity contributed 48 per cent of Australia's merchandise export income and 7 per cent of its gross domestic product in 1988-1989. Agriculture contributed 37 per cent of export income and 5

per cent of GDP. Given that these two industries are the most important revenue earners in the country, they should work together in a coordinated and responsible fashion to maximise the benefits to all Australians.

4. Mining occupies an estimated 1500 square kilometres of land representing approximately 0.02 per cent of Australia's total land area. Agricultural activity occupies more than 60 per cent of Australia's land area.

5. Very little mining takes place on prime farming land. In Victoria, the VCM acknowledged only three areas where mining operations of any size occur on farmland. Two of these are gold mines, at Nagambie and Bendigo, and the third - and potentially the largest - is the trial mineral sands operation in the Wimmera, which is the subject of this Inquiry.

6. At the national level, Australia benefits from mining through export income where the minerals are exported, or through import replacement where minerals are used domestically.

7. In 1988/89 the mining industry paid $4.6 billion in royalties, excises, charges and taxes which were used to fund Government programmes. This amounted to $270 for every Australian.

8. The cost and benefits of the alternative land use which may be carried out in a given area must be considered, and any socioeconomic cost benefit analysis must be carried out in a consistent and impartial manner.

9. Mining is a land use which can provide a high return compared with other productive uses of land - even after taking account of the costs of restoring the land to its former environmental status or productivity. Examples illustrating the comparative returns offered by mining in the Wimmera when compared to farming, were presented and considered in Part 5.7 of this Report.

10. Much of the negative community perceptions with respect to mining is based on a historical context, and the operation of miners, particularly small gold prospectors who had less experience in managing environmental aspects of their operations. One hundred years ago environmental issues were scarcely considered in the rush for gold. It was emphasised that today the mining sector is far more experienced in environmental matters. The input of mining companies into research in restoration and rehabilitation was cited as an example of the commitment miners now have to the environment. Rehabilitation projects in various parts of Australia including New South Wales, Queensland (Fraser Island) and Western Australia were given as an example of the manner in which miners have developed their concern for responsible land use and preservation of the environment. Some examples are referred to in Part 5.2 of this Report.

11. The major part of land used on modern mining processes can be rehabilitated. Further, the VCM supports community input into the rehabilitation process, initially through the environmental effects statement, and VCM would also encourage consultation with landowners in the preparation of rehabilitation plans, and in their satisfactory completion.

12. The current Mines Act, and the time consuming and frustrating bureaucratic system governing mining in Victoria has totally frustrated investment in exploration and mine developments in Victoria in recent years. This has caused the State to miss opportunities in the past, particularly gold mining over the last decade. The recent

mineral sands discoveries in Victoria present another "window of opportunity" and it is imperative that this time the opportunity not be lost.

13. The VCM has supported changes to the Mines Act which increase compensation and protection for landowners, promote a clearer understanding of landowners' rights, and lessen the time taken to decide whether a mineral tenement will be granted.

8. CONCLUSION

A stated objective of this Report was to arrive at a sensible and realistic conclusion which takes account of the interests of all parties in the light of the existing Mines Act.

Under the Act, it is likely that the WIM mining project will proceed in the Wimmera district, providing that WIM satisfies the requirements under the Act.

The new Mineral Resources Development Bill, if enacted, can also be expected to allow the project to proceed, however, it will contain a number of different provisions, and is likely to be further amended in Parliament.

The requirements of legislation provide onerous conditions for miners and generally provide substantial public scrutiny, and a right to object to a mining proposal. In the case of the WIM project, further opportunities will be given during the various public processes, for objectors to state their case, and the value of this process to the community must not be underestimated.

This Inquiry has provided a means of allowing interested parties to voice their point of view directly to Members of Parliament to facilitate a more amicable resolution of disputes now and in the future, and to ensure protection of landowners and local communities.

The National Party acknowledges the valuable contribution made to Australia's economy and its export income by the mining industry, and recognises the fundamental dependence of a highly developed technological society on the raw materials obtained from mining.

In summary, the conclusion arrived at and recommendations made by the Committee are intended to help provide a fair and reasonable outcome for all those concerned.

RECOMMENDATIONS

Community uncertainty is a major issue in the Wimmera Industrial Minerals proposal to mine heavy mineral sands.

A full and detailed Environmental Effects Statement is required under legislation before mining can commence, and this process will be a critical phase in the project's future.

The Environmental Effects Statement must address public concerns satisfactorily, and answer in laymans terms the questions of the Wimmera community.

If and when mining proceeds, the Committee strongly recommends:

1. That before mining commences in any one of the proposed sites, a statement evaluating the worth of sustainable agriculture compared to the economic and social value of mining must be prepared and made publicly available.

2. That Wimmera Industrial Minerals (WIM) provide public consultation and the provision of information to local people, particularly on a face to face basis.
3. In order to reduce uncertainty, WIM make public its intended timetable for sand mining in the Wimmera region, at the earliest possible date, including:
   a. the time at which the Company expects to complete its research into the mineral sands separation process;
   b. the planned commencement date of
      (i) a pilot mining project; and
      (ii) full scale commercial mining;
   c. the likely commencement date of mining ore bodies already identified at WIM 50,100, 150, 200, and 250, and the year or years in which individual landowners properties will be mined.
4. WIM make available to the public regular progress reports on research into the mining and mineral separation methods which it may employ on the project.
5. WIM provide to the public details of any chemicals which may be used, or which may be discharged as waste during the mining process, together with details of the treatment of any waste materials resulting from the mining process, and the chemical content of these materials.

   This information must be in laymen's terms and be sufficient to enable the community to satisfactorily assess and understand the effects, if any, of these materials on local water supplies.

   The Committee understands that the Environment Effects Statement required prior to commencement of mining will contain such information, but it must be readily available to the public, in a form which can be understood in conformity with recommendation No. 2.
6. WIM conduct a test/demonstration project on a reasonable sized area, to demonstrate the standard at which rehabilitation will be achieved. It would be an advantage if this area were cropped or grazed immediately following completion of rehabilitation, and that productivity results be made available to the public. A full scale pilot mining project would be an appropriate means of achieving the desired objective.
7. Local Government be given a key role in formulating land rehabilitation plans, and full consultation concerning rehabilitation with affected landowners and community groups be carried out.
8 WIM provide details of the mineral content of ore bodies under each or any farmer's land upon request from the landowner.
9 WIM enter into a firm agreement with the Rural Water Commission, to finance the piping of water in the Wimmera-Mallee system, in order to save sufficient water from seepage loss to supply requirements from that source for mining operations.
10. WIM provide to the public details of the expected percentage (if any) of mined land that will not be adequately rehabilitated to productive farmland at the end of the mining operation.
11. WIM make publicly available the proposed location of its employees in the Wimmera area.

12. WIM undertake to assist and support local community clubs and facilities and organisations such as CFA, schools etc. if they are adversely affected by the mining operation from time to time.
13. WIM recognise public concern about the levels of radioactivity and radon gas emissions resulting from mining operations, and make publicly available specific research into this issue, together with adequate explanation in layman's terms.
14. WIM undertake to negotiate with local Municipal Councils to provide financial assistance, in addition to any rates which may be payable to the Council, as compensation for the additional burden placed on community resources, particularly local roads, due to mining operations.
15. WIM offer to purchase at market value, plus a solatium, any farming land it may intend to mine.
16. That WIM, during the Environmental Effects Statement process, assist interested local individuals or groups to fully understand the EES, in order to allay public concern.
17. WIM address the issue of the need to continue water reticulation via channels, regardless of altered land levels following rehabilitation, and ensure that no landowner be placed at a cost disadvantage in obtaining their normal supplies of water for domestic, stock or irrigation purposes.
18. Local Government, as a representative of the community should be involved in a continual monitoring of rehabilitation.

APPENDIX A

PERSONS AND ORGANISATIONS WHO MADE SUBMISSIONS

Shire of Dunmunkle, *Robin Webb*

Dunmunkle Land Protection Group, *Jim Starbuck*

Victorian Farmers Federation, Wimmera District Council, *David Matthews*

Victorian Farmers Federation, *Rupanyup Branch, Andrew Weidemann*

Avon Plains Landcare Group, *Carol Lamb and Fiona Burchall*

Shire of Lowan, *Bryce Simpson*

Diapur-Lawloit Landholders Group, *Errol Laverty*

Toolondo and District Survival Committee, *Robert McDonald, Richard Hobbs*

Arapiles Land Care Group, *John McQueen*

Wimmera Anglers Association, *Andrew Carine*

Australian Conservation Foundation, Wimmera Branch, *Barry Clugston*

Shire of Wannon, *G. J. Wallis*

Shire of Kowree, *John McKenry*

Victorian National Parks Association, *Jenny Barnett*

Denison Australia Pty Limited and Fidunu Mining Company, *Dr. Bob Creelman*

Victorian Chamber of Mines Inc, *John Reynolds, Duncan Bell, Terry Johanson*

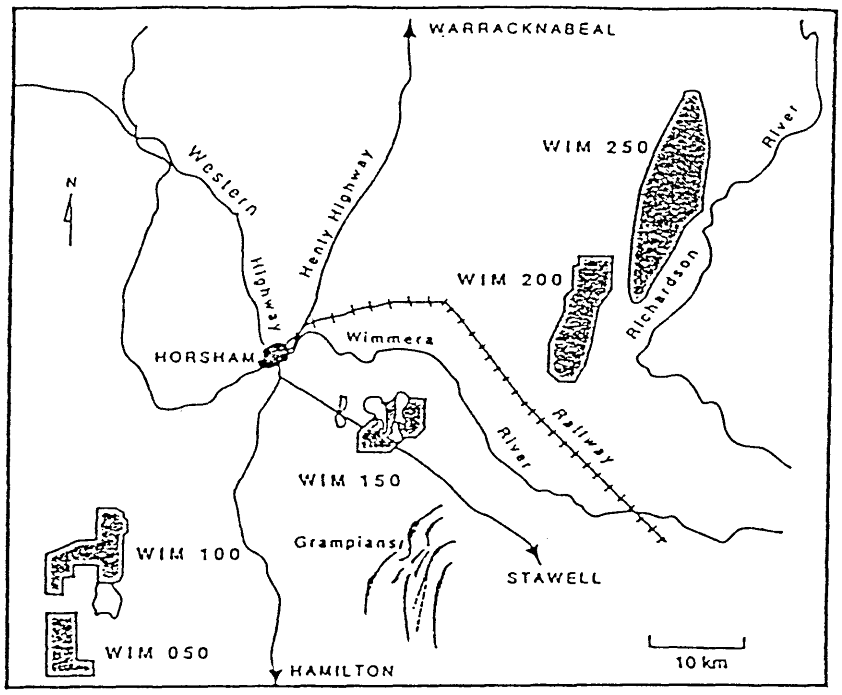
Wimmera Industrial Minerals Pty Limited, *Ian Goudie, Marshall Baillieu, Colin Bills*

CRA Limited, *Mike Bell*

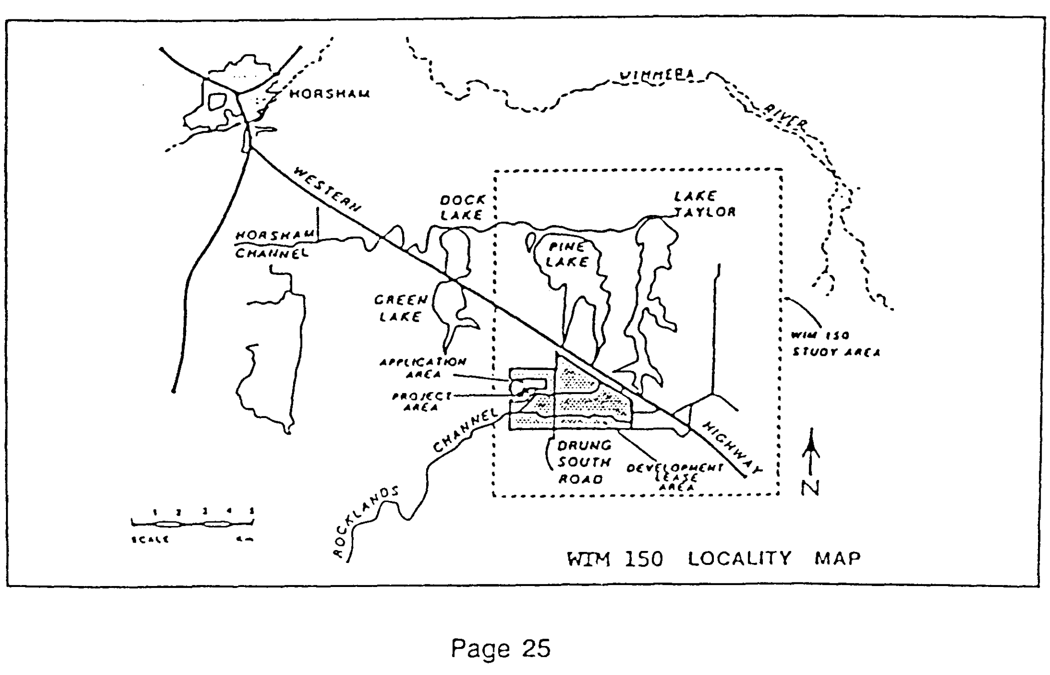
Allen Matthews, Jim Starbuck, Stewart Peters, Frank Drum, Ian Morgan, David Matthews, Michael Burchell, Jenny Holmes, Peter Funcke, Debbie Funcke, Stuart White, Doug McKenry, Clair McKenry, John McKenry, Guy Brook, John McQueen, George Bennett, Joan Bennett, Dr. R. Mck.Sutherland, Julie O'Brien, S. Jones, Peter French, Mary French, Gil Hopkins, Lorna Hounsell, A. E. Loats, Bert Loats, David Mudie, Dr. Michael Axtens

APPENDIX B

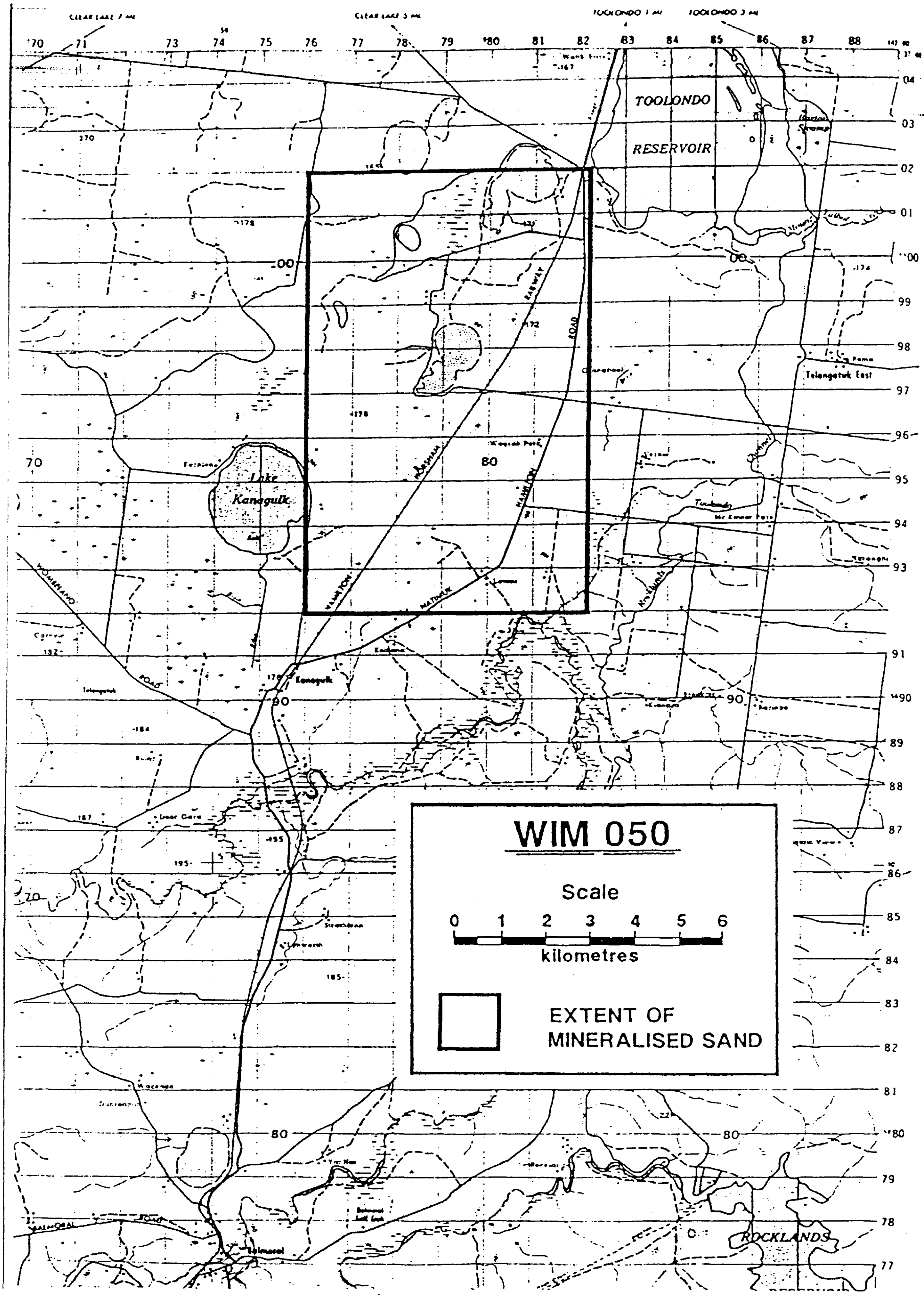
LOCATION OF THE MINERALS



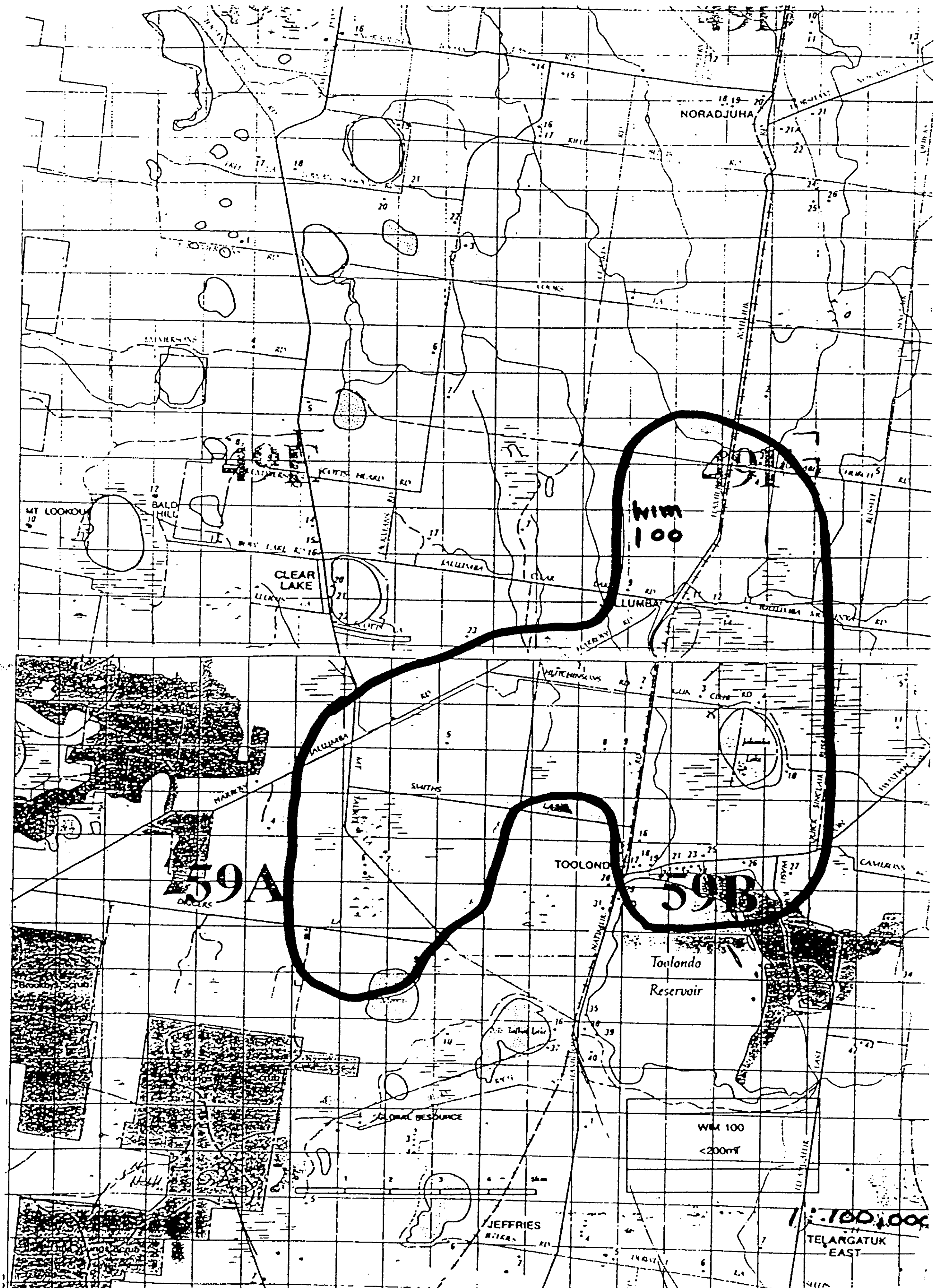
LOCALITY MAP - WIMMERA
MINERAL SAND RESOURCES



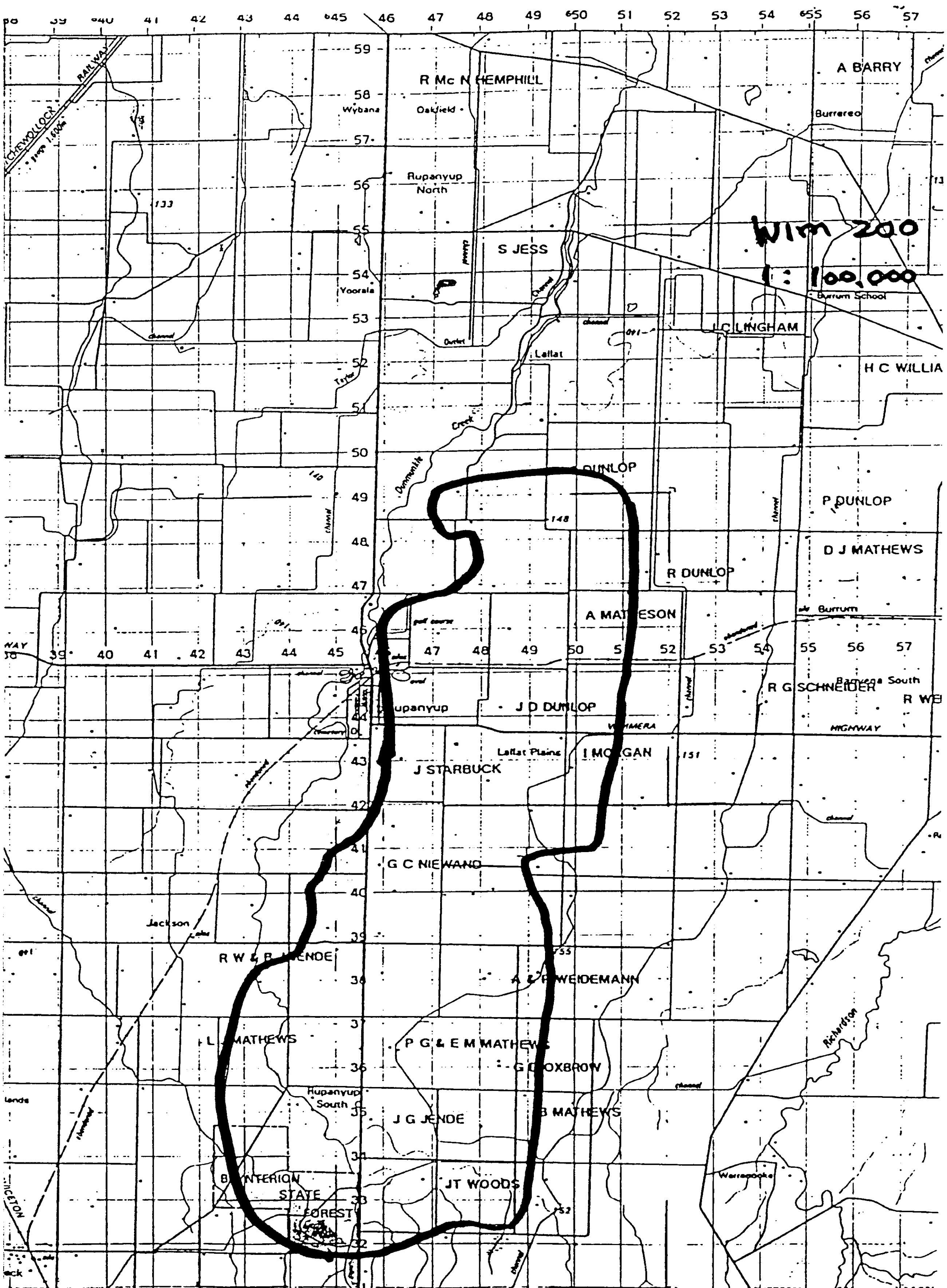
WIM 150 LOCALITY MAP



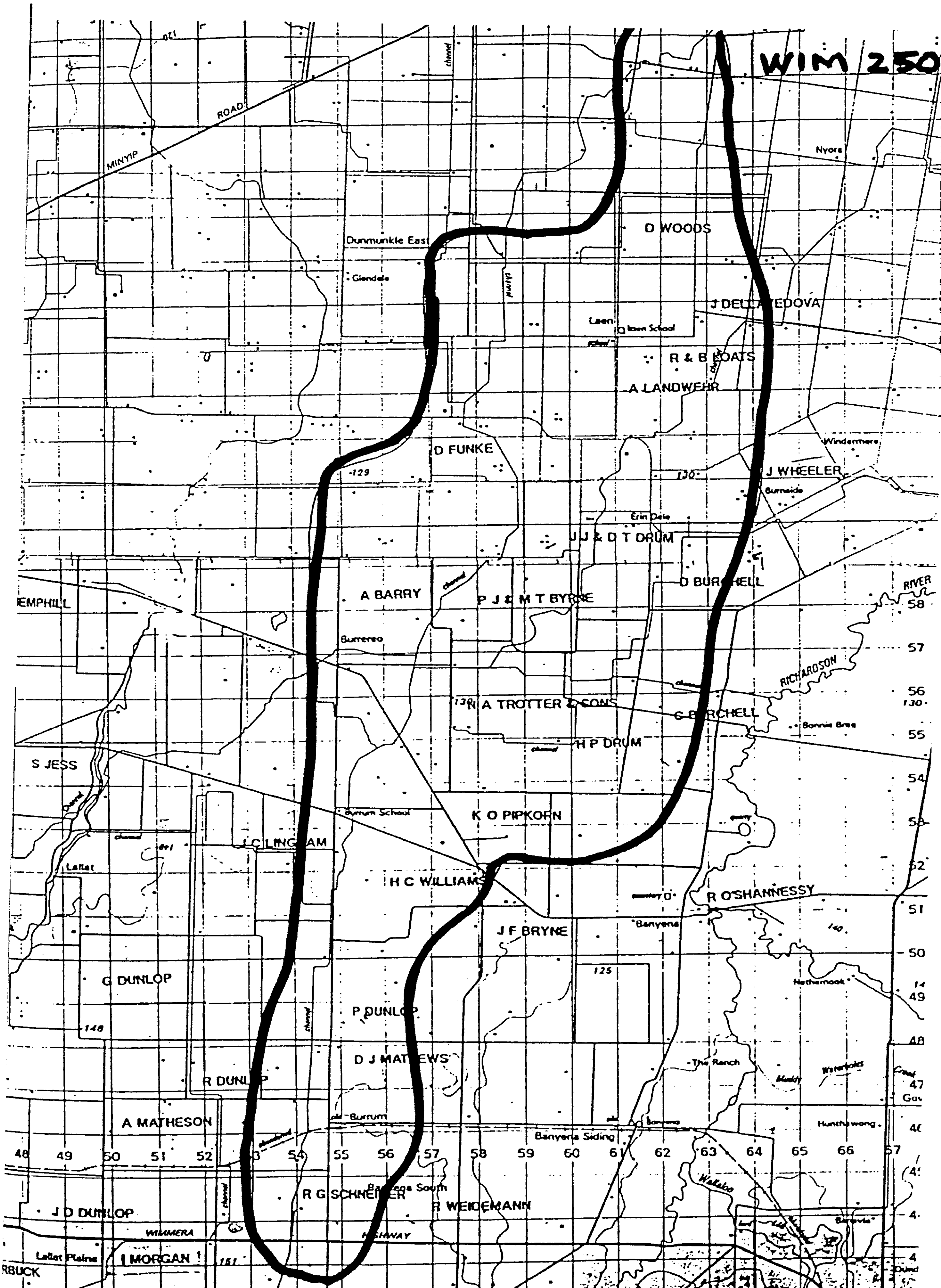
TOOLONDO
RESERVOIR
Lake Kanagulk
Kanagulk
ROCKLANDS
HAMILTON
RAILWAY
ROAD
WIM 050
Scale
0 1 2 3 4 5 6
kilometres
EXTENT OF
MINERALISED SAND



NORADJUHA
MT LOOKOUT
BALD HILL
CLEAR LAKE
WIM 100
59A
59B
59C
TOOLONDO
Toolondo Reservoir
GLOBAL RESOURCE
JEFFRIES
TELANGATUK EAST
WIM 100
<200mT
1:100,000



Wlm 200
1: 100,000
A BARRY
R Mc N HEMPHILL
Wybana
Oakfield
Rupanyup North
Burrereo
S JESS
Yoorala
Burrum School
I C LINGHAM
Lallat
H C WILLIA
DUNLOP
P DUNLOP
D J MATHEWS
R DUNLOP
A MATHESON
Burrum
R G SCHNEIDER
Banyena South
R WE
Rupanyup
J D DUNLOP
WIMMERA
HIGHWAY
Lallat Plains
I MORGAN
J STARBUCK
G C NIEWAND
Jackson
R W & B JENDE
A & P WEIDEMANN
L J MATHEWS
P G & E M MATHEWS
G OXBROW
Hupanyup South
J G JENDE
B MATHEWS
Richardson
Warracooke
BUNTERION STATE FOREST
JT WOODS
RAILWAY


WIM 250
MINYIP ROAD
Nyora
Dunmunkle East
Glendale
D WOODS
Laen
Laen School
A LANDWEHR
D FUNKE
Windermere
J WHEELER
Burnside
Erin Dale
A BARRY
P J & M T BYRNE
RIVER
Burrereo
RICHARDSON
Bonnie Brae
S JESS
K O PIPKORN
Burrum School
Lallat
H C WILLIAMS
R O'SHANNESSY
Banyena
J F BRYNE
G DUNLOP
The Ranch
A MATHESON
Burrum
Banyena Siding
Hunthawong
R WEIDEMANN
WIMMERA
HIGHWAY
Lallat Plains
I MORGAN
48 49 50 51 52 54 55 56 57 58 59 60 61 62 63 64 65 66

APPENDIX C

COMPARISON OF PROVISIONS IN THE EXISTING ACT AND THE PROPOSED BILL PROTECTING LANDOWNERS PREPARED BY THE VICTORIAN CHAMBER OF MINES

COMPARISON OF LANDOWNERS PROTECTION

Under the old and proposed mining legislation

Many good features of the existing Act are retained. The following refers to changes which generally favour landholders. There do not appear to be any changes which are adverse to landholders.

The mining industry believes the new conditions are more onerous to it than the old. It may be necessary to amend certain of them marked.

	OLD	MRD BILL
	Exist Mines Act 1958	Mineral Resources Development Bill Dec 1989 (Clause of MRD Bill)
Ownership of Minerals	Public	Public (9)
Consultations with landholder prior to for purposes of marking out	Not required	Required (20)
Consultation with landholder regarding rehabilitation in preparation of work plans	Not required	Required (79)
Notice of entry for commencement of work	Not required	21 days notice must be given (42)
Landowner's planned improvements on land subject of a licence application	Unclear situation	Bill clearly defies 'Planned Improvements' and landowners right to obtaincompensation for loss of opportunity to proceed with them as a consequence of licenceapplication (4,85)

	OLD	NEW
	Existing Mines Act 1958	Mineral Resources Development Bill Dec 1989 Clause of MRD Bill)
A security bond to be lodged prior to marking out	Not required	Required to protect land holder against injury or damage
Authority to enter for marking out must be shown to landowner	Not required	Required 20,21
Protection of dwellings and other sites	Provided	Minister may consent to explore in certain areas. Minister and landowner may grant consent to mine (45)
Compensation	Compensation payable for specified items of loss	Compensation payable for any loss with the items of compensation extended to conclude: - loss of amenity - loss of opportunity - reduction in market value Plus a solatium of up to 10% of the compensation agreed or determined. (85)
Disputes	The processes the magistrates Court are available	Landowner or licensee has right to take disputes to the Mining Warden (4,97)
Protection against costs of long term failure of rehabilitation works	Nil	Government agrees to pick up (84)

	OLD	NEW
	Existing Mines Act 1958	Mineral Resources Development Bill Dec 1989 (Clause of MRD Bill)
Time for government to determine applications for licences	No limit	90 days (removes long period of uncertainty) (26 (5)
Qualification of applicants for licences	No statutory requirement	'fit and proper' persons - genuine intent to work - financial resources (15(4)
Applicants to provide work programmes	Limited require -ment -Programme could be very general	Programme nec- essary (40)
Requirement to promptly provide government with	No constraints on applicants	Applicant must provide inform promptly or risk lapse of application. (15 (5)
Minister has discretion to grant or refuse a title a license	Yes (except for Miners Right Claims)	Yes (all titles) (25 (2)
Right of applicants to sell applications for mineral titles	Yes	No (therefore trading in applications will cease) (17)
Grounds for cancellation of licences or titles	Limited controls	Stricter conditions regarding: - regulations - codes - conditions - planning schemes - delay in providing information - delay in commencing work (38)

APPENDIX 5

Wimmera Catchment Authority (1998) Wimmera Catchment Region, Demographic and Socio-Economic Profile: A strategic review of the social and economic character of the Wimmera Catchment Region, TBA Planners Pty Ltd with SGS Consulting, McGuinness and Associates and Neil Clark and Associates, November 1998.

Appendix 5

From: Wimmera Catchment Region, Demographic and Socio-Economic Profile: A strategic review of the social and economic character of the Wimmera Catchment Region, TBA Planners Pty Ltd with SGS Consulting, McGuinness and Associates and Neil Clark and Associates, Wimmera Catchment Authority, November 1998.

Yarriambiack

People

Yarriambiack Shire covers an area of 7,159 sq. km, with a population of 8,754. Most of the Shire's population lives in the southern areas of Yarriambiack, while the population of the northern Mallee region has a smaller population centred on the town of Hopetoun.*

Similarly to the region as a whole, rural population decline is a feature of population change in Yarriambiack. While all the key urban centres of Warracknabeal, Rupanyup and Hopetoun have all experienced some population loss, this has been less significant than the decline experienced in their rural hinterland.

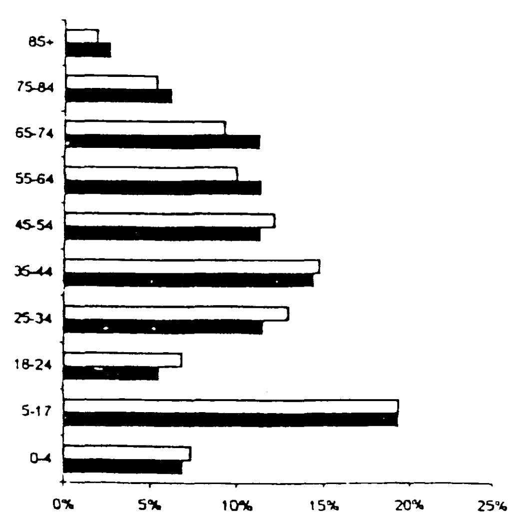
Population Change, 1986-1996

	1986	1991	1996	1986-96	1991-96	Avg. Annual
Hopetoun	750	704	670	-10.7%	-4.8%	-1.1%
Minyip	543	497	475	-12.5%	-4.4%	-1.3%
Murtoa	863	878	839	-2.8%	-4.4%	-0.3%
Rupanyup	446	422	407	-8.7%	-3.6%	-0.9%
Warracknabeal	2,689	2,689	2,493	-7.3%	-7.3%	-0.7%
Woomelang	275	221	217	-21.1%	-1.8%	-2.1%
Non-Urban	3,853	3,530	3,203	-16.9%	-9.3%	-1.7%
Yarriambiack (S)	9,419	8,941	8,304	-11.8%	-7.1%	-1.2%
Estimated Pop	9,883	9,466	3 831	-10.6%	-6.7%	-1.3%

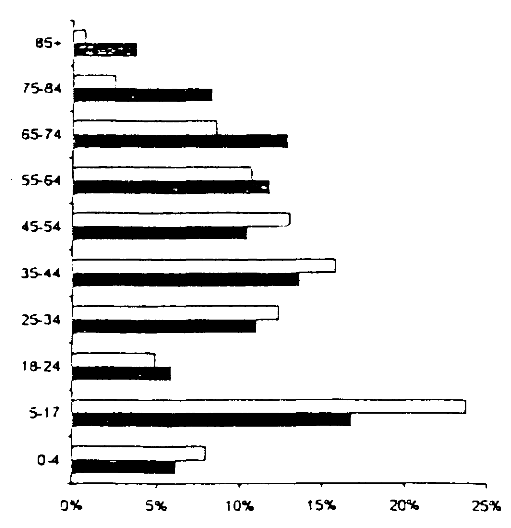
Source: ABS Enumerated and Estimated Populations

Converse to the patterns in the other municipalities in the Wimmera, Yarriambiack Shire has a younger rural population than the population of the urban areas. This has occurred despite a general pattern of ageing and population decline across the Shire as a whole.

Age Structure, 1996



Rural/Urban Age Structure, 1996



Source: ABS Enumerated Population

Age Structure, 1986-1996

	1986			1991			1996		
	Yarr'biack	*%*	*Region*	*Yarr'biack*	*%*	*Region*	*Yarr'biack*	*%*	*Region*
0-4	679	7.2%	7.4%	681	7.6%	7.5%	562	6.8%	7.3%
5-17	1,980	21.0%	21.6%	1,781	19.9%	20.2%	1,599	19.3%	19.3%
18-24	787	8.4%	9.6%	559	6.3%	8.0%	454	5.5%	6.8%
25-34	1,262	13.4%	14.1%	1,209	13.5%	14.5%	951	11.5%	13.0%
35-44	1,081	11.5%	12.5%	1,153	12.9%	13.9%	1,194	14.4%	14.8%
45-54	1,010	10.7%	10.5%	961	10.8%	10.9%	939	11.3%	12.2%
55-64	1,101	11.7%	10.7%	1,038	11.6%	10.2%	941	11.3%	10.0%
65-74	790	8.4%	7.6%	856	9.6%	8.2%	935	11.3%	9.3%
75-84	562	6.0%	4.7%	524	5.9%	5.2%	509	6.1%	5.4%
85+	161	1.7%	1.3%	173	1.9%	1.5%	216	2.6%	1.9%
	9,413	100.0%	100.0%	8,935	100.0%	100.0%	8,300	100.0%	100.0%

Source: ABS Enumerated Population

Compared to the region as a whole, Yarriambiack has a higher proportion of older people, although other age groups are represented at similar levels.

Workforce

Agriculture is the most significant component of Yarriambiack's labour force. Along with overall work force decline, this component is decreasing. Other sectors such as Education and Health Services, and Retailing are more significant components of the overall work force than they were in the past.

Industry of Employment, 1986-1996

	1986	*1991*	*1996*
Agriculture, Forestry & Fishing	40.6%	37.0%	36.1%
Mining	0.0%	0.1%	0.0%
Manufacturing	2.2%	2.3%	3.8%
Electricity, Gas & Water Supply	2.0%	1.7%	2.4%
Construction	4.1%	3.0%	2.0%
Wholesale & Retail Trade	14.4%	17.0%	19.9%
Transport & Storage	5.0%	4.2%	4.5%
Communication Services	1.3%	1.3%	1.3%
Finance & Insurance	3.1%	2.6%	2.2%
Property & Business Services	1.1%	1.3%	1.8%
Government Administration & Defence	4.0%	5.5%	4.6%
Education, Health & Community Health	17.1%	18.6%	18.6%
Cultural & Recreational Services	0.7%	0.8%	0.8%
Personal & Other Services	4.2%	4.5%	1.9%
Total Employed Population	***3,832***	***3,440***	***3,341***

Source: ABS Enumerated Population

Over 25% of the labour force is employed part time, although in the Shire's north this figure is closer to 20%. Work force participation is close to 45% in both areas.

Agriculture is a significant employers in the region, while other large employers include the Hospital and larger retailers.

Business Numbers and Employment Size, 1997

Industry	*Employees* N/A	*<5*	*5-9*	*10-19*	*20-49*	*50-99*	*100+*	*Total*
Agriculture, Forestry and Fishing	27	753	5	-	-	-	-	785
Mining	-	-	-	-	-	-	-	-
Manufacturing	-	8	6	3	-	-	-	17
Electricity, Gas and Water Supply	-	4	2	-	-	-	-	6
Construction	-	14	2	-	-	-	-	16
Wholesale and Retail Trade	-	82	33	7	1	-	-	123
Accommodation, Cafes and Restaurants	-	18	5	2	-	-	-	25
Transport and Storage	-	52	9	2	2	-	-	65
Communication Services	-	1	1	-	-	-	-	2
Finance and Insurance	-	6	4	2	1	-	-	13
Property and Business Services	-	11	2	1	-	-	-	14
Government Administration and Defence	-	5	4	1	3	-	-	13
Education	-	32	8	2	4	-	-	46
Health and Community Services	-	27	3	3	7	-	1	41
Cultural and Recreational Services	-	20	-	2	-	-	-	22
Personal and Other Services	-	37	-	-	-	-	-	37

Source: ABS Business Location Counts

Agriculture

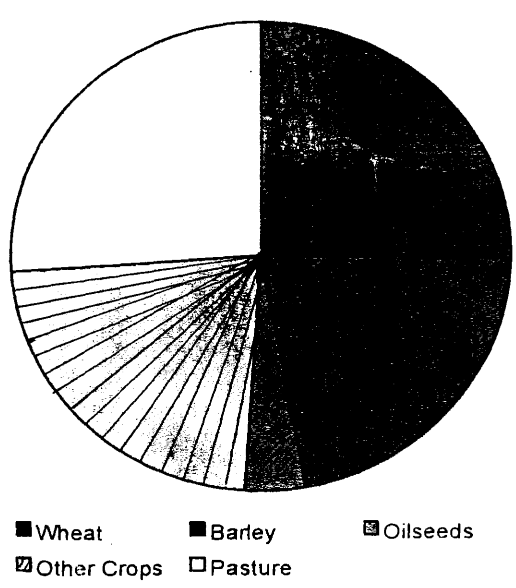
Yarriambiack Shire had a GVP for agriculture of $215,069,168 in 1995-96, the largest in the region, comprising 3.9% of the Victorian total. This is almost exclusively (89%) the product of cropping activity, particularly wheat, barley and chick peas. Wool ($9,891,891) and livestock production for meat ($11,970,575) together contributed less than 10% of the total GVP, although these contributions were not insignificant.

Gross Value of Production: Broadacre Crops, 1995-96

Canola	*$ 9,092,781*
Oilseeds	*$ 9,615,291*
Barley for grain	*$ 53,668,920*
Triticale for grain	*$ 2,195,758*
Wheat for grain	*$ 72,668,104*
Cereals for grain	*$130,101,680*
Cereal crops for hay	*$ 625,956*
Chick peas	*$ 28,739,976*
Faba beans	*$ 1,950,683*
Field peas for grain	*$ 13,700,398*
Pasture seed	*$ 318,606*
Other Crops	*$ 1,184,020*
TOTAL CROPS	*$193,105,424*
Wool	*$ 76,151,639*
Beef	*$ 9,729,401*
Sheep and Lamb Slaughterings	*$ 53,361,948*

Source: ABS

Agricultural Land Use, 1995-96

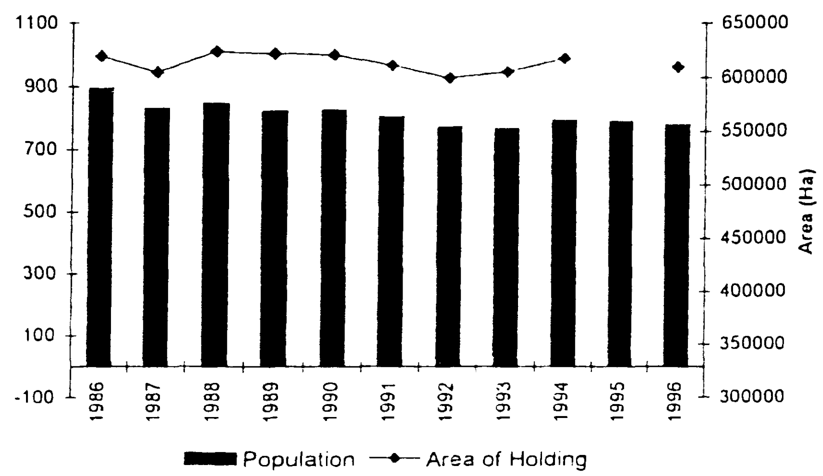


Crops, especially cereal crops and pulses, cover almost 75% of all agricultural land in Yarriambiack. Barley and wheat alone account for almost half of the land area.

Grazing land, including significant areas of native or naturalised (unimproved) pasture covered over a quarter of the Shire's agricultural land.

Importantly, during the same period the total area of Agricultural Holding has increased slightly. The declining role of Agriculture in labour force data would appear to reflect the emerging role of off-farm income in Yarriambiack, and in other municipalities in the region. Farm numbers have declined in Yarriambiack, although this trend is not too dramatic.

Total Area of Holding and Farming Population, 1986-1996



Source: ABS

Yarriambiack

Total enumerated population	8,304
less overseas visitors	3
equals **enumerated Australians**	8,301
Estimated Resident Population 1991	9,466
Estimated Resident Population 1996	8,832
Average annual growth 1991 to 1996	-1.38%
Total area (square kilometres)	7,159.8

Age structure

Age group	Persons No.	%	RVic%
0-4	562	6.8	7.4
5-17	1,599	19.3	20.7
18-24	454	5.5	8.7
25-34	951	11.5	13.5
35-49	1,694	20.4	22.3
50-59	895	10.8	10.0
60-69	976	11.8	8.2
70-84	951	11.5	8.0
85+	218	2.6	1.3
Total	8,302	100.0	100.0

Religion

	Persons No.	%	RVic%
Five top-ranking in Yarriambiack:			
Uniting Church	2,444	29.5	12.4
Catholic	1,508	18.2	25.9
Anglican	1,402	16.9	20.2
Lutheran	970	11.7	1.5
Presbyterian and Reformed	232	2.8	5.6
Total Christian	6,949	83.8	71.8
Total Non-Christian	0	0.0	0.7
No religion	762	9.2	18.0
Inad. described and not stated	581	7.0	9.5
Total	8,292	100.0	100.0

Household income

Gross weekly income	Households No.	%	RVic%
Negative and nil income	24	0.7	0.7
$1-$119	47	1.5	1.0
$120-$299	772	23.9	21.9
$300-$499	679	21.1	19.6
$500-$699	505	15.7	14.7
$700-$999	422	13.1	15.0
$1,000-$1,499	266	8.3	10.8
$1,500-$1,999	88	2.7	3.0
$2,000 and over	72	2.2	2.2
Not stated	349	10.8	11.2
Total	3,224	100.0	100.0

Individual income

Gross weekly income	Persons aged 15 years and over No.	%	RVic%
Negative income	38	0.6	0.8
Nil income	312	4.8	6.6
$1-$119	610	9.4	10.0
$120-$299	2,595	40.1	36.7
$300-$499	1,383	21.5	19.5
$500-$699	667	10.3	11.0
$700-$999	322	5.0	7.0
$1,000-$1,499	107	1.7	2.1
$1,500 and over	62	1.0	1.0
Not stated	366	5.7	6.3
Total	6,468	100.0	100.0

Household size

Persons per household	Households No.	%	RVic%
1 person	850	26.6	23.8
2 persons	1,120	35.0	33.3
3 persons	447	14.0	15.3
4 persons	399	12.5	15.8
5 persons	257	8.0	8.4
6 or more persons	125	3.9	3.5
Total	3,198	100.0	100.0

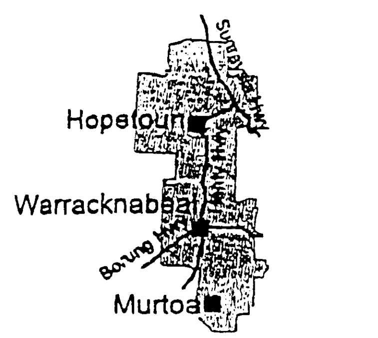
Household type

	Households No.	%	RVic%
One family			
Couple with children	1,104	34.5	36.0
Couple without children	970	30.3	25.0
One parent family	186	5.8	9.6
Other one family households	27	0.8	1.0
Total one family	2,237		
Two or more families	14	0.4	0.5
Lone person household	850	26.6	23.8
Group household	47	1.5	3.2
Total households	3,198	100.0	100.0

Dwellings

Dwelling type	Persons in occupied private dwellings No.	%	RVic%	Private dwellings Occupied	Un-occupied	All dwellings	Avg. household size This Area	RVic
Separate house	7,665	95.4	92.0	3,033	485	3,518	2.53	2.74
Semi-detached, row etc.	25	0.3	1.8	5	3	8	5.00	1.86
Flat, unit, apartment	90	1.1	3.5	85	12	97	1.06	1.52
Caravan, houseboat etc.	19	0.2	0.3	11	3	14	..	..
Attached shop/office etc.	76	0.9	0.6	28	8	36	..	..
Other and not stated	161	2.0	1.3	61	19	80	..	..
Total	8,036	100.0	100.0	3,223	530	3,753	2.49	2.61

The Shire of Yarriambiack is situated in north western Victoria, in the heart of the State's wheat belt. The major towns in the municipality are Warracknabeal and Hopetoun. Other centre are Patchewollock, Speed, Woomelang, Minyip and Rupanyup. The major physical feature of the Shire are the gently undulating Wimmera plains. Part of the Wyperfeld National Park is within the Shire boundaries.



Education

Highest qualification obtained	Persons 15 years and over No.	%	RVic%
Higher degree	8	0.1	0.6
Postgraduate diploma	70	1.1	1.3
Bachelor degree	206	3.2	5.1
Undergraduate diploma	180	2.8	3.4
Associate diploma	123	1.9	2.3
Vocational qualification	803	12.4	13.7
No qualifications	4,426	68.3	62.1
Inad. described and not stated	663	10.2	11.4
Total	6,479	100.0	100.0

Labour force

Age group Persons 15 years and over	Percentage employed or seeking work: Males %	Males RVic%	Females %	Females RVic%
15-19 years	41.2	45.9	34.1	45.3
20-24 years	91.5	84.8	70.5	72.5
25-34 years	94.4	89.7	82.3	81.8
35-44 years	92.5	89.7	73.8	89.7
45-54 years	88.4	85.0	69.0	65.9
55-64 years	68.0	58.5	39.6	29.4
65-69 years	33.8	19.2	18.1	8.3
70-74 years	19.8	11.4	5.7	4.2
75 years and over	10.8	6.1	1.8	1.7
Total all age groups	67.8	68.5	44.9	48.6

Occupation

Employment by occupation	Employed males No.	%	RVic%	Employed females No.	%	RVic%	Employed persons No.	%	RVic%
Managers and administrators	811	39.5	17.6	334	23.8	9.3	1,145	33.1	14.0
Professionals	124	6.0	11.1	229	16.3	18.3	353	10.2	14.2
Associate professionals	160	7.8	11.6	160	11.4	11.2	320	9.3	11.4
Tradespersons and related	334	16.3	21.2	43	3.1	3.6	377	10.9	13.7
Advanced clerical and service	16	0.8	0.7	77	5.5	6.6	93	2.7	3.2
Intermediate clerical, sales, service	88	4.3	8.2	266	18.9	22.0	354	10.2	13.0
Intermediate production and transport	192	9.4	13.3	28	2.0	3.5	220	6.4	9.1
Elementary clerical, sales, service	51	2.5	4.7	132	9.4	13.9	183	5.3	8.8
Labourers and related	222	10.8	10.8	97	6.9	9.0	318	9.2	10.0
Inad. described and not stated	53	2.6	3.0	40	2.8	2.6	83	2.7	2.8
Total	2,051	100.0	100.0	1,406	100.0	100.0	3,457	100.0	100.0

Industry

Employment by industry	Employed males No.	%	RVic%	Employed females No.	%	RVic%	Employed persons No.	%	RVic%
Agriculture, forestry and fishing	865	42.4	14.9	338	24.3	9.0	1,203	35.1	12.4
Mining	0	0.0	0.8	0	0.0	0.1	0	0.0	0.5
Manufacturing	89	4.4	17.6	45	3.2	8.1	134	3.9	13.5
Electricity, gas and water	36	1.8	2.1	0	0.0	0.4	36	1.1	1.4
Construction	101	5.0	8.1	12	0.9	1.7	113	3.3	5.9
Wholesale trade	167	8.2	6.1	35	2.5	2.8	202	5.9	4.7
Retail Trade	196	9.6	12.1	184	13.2	17.6	380	11.1	14.4
Accommodation, cafes, restaurants	28	1.4	3.2	53	3.8	6.3	81	2.4	4.5
Transport and Storage	133	6.5	4.7	18	1.3	1.5	151	4.4	3.3
Communication Services	24	1.2	1.8	15	1.1	1.2	39	1.1	1.5
Finance and Insurance	25	1.2	1.6	49	3.5	3.4	74	2.2	2.4
Property and business services	33	1.6	5.7	27	1.9	5.9	60	1.8	5.8
Govt. administration and defence	93	4.6	4.4	66	4.8	3.9	159	4.6	4.2
Education	87	4.3	4.8	178	12.8	11.2	265	7.7	7.5
Health and community services	61	3.0	3.5	295	21.2	18.5	356	10.4	9.8
Cultural and recreational services	17	0.8	1.5	3	0.2	2.0	20	0.6	1.7
Personal and other services	25	1.2	3.2	33	2.4	3.5	58	1.7	3.3
Non-classifiable and not stated	59	2.9	3.0	38	2.7	3.0	97	2.8	3.0
Total	2,039	100.0	100.0	1,389	100.0	100.0	3,428	100.0	100.0

APPENDIX 6

Reports by DLPG members on Visits to Other Mines

APPENDIX 6

Report prepared by Ian Morgan on the trip to other mines made by Ian Morgan and Jim Starbuck in October 1990

AREAS INSPECTED

Noraville, The Entrance, Tomago, Nabiac, Manning Point, Ovens Valley (Gold Mining).
All areas inspected were sand dune formations of varying shape and size.

INFORMATION RECEIVED FROM FOLLOWING PEOPLE:-

John Bell	Environmental Officer - Wyong Shire
Ned White	Understudy to John Bell
John Simpson	Environmental Officer - R.Z. Mines
Don McNair	Honorary Associate of Biology, Newcastle Uni.
Mrs. Bruce Smith and neighbouring farmers - Manning Point area	
Bill Downs	Officer with Hunter Water Board - Headworks Division at Tomago
Syd Dalbosco	Shire Councillor Bright Shire - Farmer

NORAVILLE
Long sand dunes near sea. Restoration was extremely poor, vegetation was short and contained a fair amount of introduced legume (species unknown).

THE ENTRANCE
17-18 years since mining. Again along sand dune near sea. Restoration was fair, mostly shorter shrubby species had been established. Only a fraction of total number of species originally growing now established. This area was badly infested with a South African species of plant called "Bitou Bush or Bone Seed". This was originally used as a dune stabilizer but is now hopelessly out of control. To the detriment of indigenous species this area will take many decades to even resemble original bushland.

TOMAGO
Restoration varies from good down to poor but it is at different stages due to mining still taking place. Small areas of existing vegetation are left intact to allow for natural seed dispersion - trees will disperse seed as far out horizontally as they are high. Again this area will take decades to resemble existing bushland and also as in other restoration areas only a fraction of the original species number are regenerated.

Other points of note made by John Simpson

1. It is now viable due to modern technology to re-mine areas that were mined 20 years ago. This being the case, restored areas would be destroyed in the process.
2. R.Z. Mines have their own plant nursery to produce plants for the restoration work.
3. A considerable amount of old vegetation was pushed aside pre-mining and replaced post-mining. This material contained a lot of plant seed and helped create a more nutritious environment for young plants.
4. Mining alters soil chemistry - more iron now in Newcastle water supply - this area being water catchment for part of the Newcastle water supply.

5. Water table now higher than since records were first recorded - in fact water table is now above the surface.
6. Small dredges that are operating in this area produce along with the initial separating plant, 5 tonnes of minerals per hour. Dredges of this size can mine 25 hectares per year.

NABIAC

Flat sand area, no restoration done as yet, one small area just ready to be sown down to pasture - the rest to be restored to bushland. Very untidy with old tree trunks and branches scattered everywhere.

MANNING POINT TO OLD BAR - 1978

Sand dune area near sea and approximately 1 kilometre back from sea. No restoration done to revert to bushland. Attempts made to establish pasture with species of grass cattle won't eat. Pasture cover poor, ugly water hole with eroding small sand dune left where dredge finished. Small areas of bushland were left around beach front and along creeks or swamps.

FARMERS COMMENTS

This area contains 8% minerals. Only 3% were first mined. There is now speculation that the area may be mined again. Water now goes straight through soil after mining because of altered soil structure. Pre mining oat crops would be normal height, post mining crops only 6 inches high.

DISCUSSIONS HELD WITH THE FOLLOWING PEOPLE

John Bell and Ned White both stated strongly the following points.

1. Re restoration - both felt there would be no chance of satisfactory restoration - particularly because of our soil structure.
2. Did not believe it possible to remove top soil totally by itself and then remove each clay layer and then replace without considerable mixing.
3. This would give no hope of farming again in present form.
4. Because of the disturbance factor, two situations relevant to water will arise - rainfall will dramatically disappear downwards through the soil - water tables on the other hand could significantly rise - big problems where underground water is saline.
5. Distribution of waste saline water from mining process would create problems - if disposed of underground, would upset existing aquifers - if disposed of above ground would increase surface salinity - question - where does it go?
6. If sands had to be kept wet during mining and processing, salinity would also increase.
7. Soil P.H. would be altered - stock piles of soil will become more acid - radioactivity has some effect here on altering P.H.
8. Servicing of mine - severe dust problem over summer.
9. Stockpiles of soil will be subject to severe erosion both summer and winter.
10. .3% of minerals is a viable mine.

DON McNAIR Honorary Associate of Biology, Newcastle University

Has done studies of plant populations in the Port Stevens - Tomaree Peninsula area and has established the following findings. (This includes the Tomago mining area near towns Raymond Terrance and Williamtown).

MINED AREAS

Plot A	1977	24 families	47 species
	1983	9	25
Plot B	1977	31	57
	1983	18	39

NON-MINED

Plot C	1977	41	108
	1983	41	108

COMMENTS

1. Seven years after mining eucalypts are becoming the dominant species (Developing a monoculture).
2. This is happening because of altered soil structure.
3. Dangers are occurring despite P.H. of soil remaining the same.
4. Water table has risen because of mining. (Destruction of large trees takes away natural water dispersion).
5. Water quality has declined - increased iron content.
6. Restoration of soil structure impossible - physical nature altered - farming in present form impossible.
7. Salinity - altering any natural water flows of any sort is a tremendous danger - should not tamper with aquifers in any way.
8. Demand huge bond in place to cover restoration.
9. Approach Universities to see if any students interested in doing thesis on vital issues.
10. Follow up every possible lead that may help because mining companies "Rape and Run".
11. When quoting - quote reliable authors and sources.

BILL DOWNS - Hunter Water Board

COMMENTS

1. Water Board has had problems with dissolved iron in water supply - Water Board has treatment plant to reduce iron content.
2. Believes restoration good but more difficult when soil mined second time due to nutrients in topsoil being further reduced.

SYD DALBOSCO - Shire Councillor Bright Shire - Farmer

COMMENTS (All relate to Gold mining which finished around 1954)

1. Ovens Valley - in poor condition where mined, overgrown with blackberries and weeds - native species not established. Due to altered soil structure, mined and unmined areas obvious.
2. Evidence of tailings heaps all along valley floor.
3. Areas unmined provide green pastures all year. Mined areas have reduced feed quality and die out over summer.

4. Our soil will be totally different after mining and we will not be able to retain moisture vital to crops.
5. Water tables will be altered - should not tamper with natural flows of underground water.
6. Mined ground in valley is higher.
7. Mined areas will only satisfactorily grow pine trees.
8. Attempts to re-mine in late 1980's stopped because company went broke but Shire put severe restrictions on them through planning scheme.
9. Come summer difference between mined and unmined areas on Dalbosco's property obvious.

<u>SUMMARY</u>

1. Our opinion has for some time indicated that it will be impossible for C.R.A. to totally restore our soil. Expert opinion that we now have from Mr. John Bell and Mr. Don McNair have substantiated this. Along with the opinion of farmers from Manning Point (Taree) area in N.S.W. it is becoming more and more evident that this type of mining destroys the soils various horizons that are so vital to the growing of all the indigenous plants of any nominated area and to the successful growing of pastures and crops.
2. The non retention of useable rainfall in the upper clays will seriously affect the amount of moisture available to crops and pasture and it would be expected that they will suffer serious moisture deficiencies when grown on mined soil.
3. Water tables have also been disturbed in forest areas in the Raymond Terrace, Williamtown district (in fact they are the highest ever recorded). The water table is at present above the surface. It would be expected that our area could have water table problems too due to increased permeability after mining. These problems would most likely be in the eastern portion of our Shire where high water tables and salinity are already a problem.
4. Further to the above factors the removal of the topsoil from the clay subsoil cannot be done effectively and this will add to the reduction in quality of the soil post mining.
5. A casual visit to BHP-UTAH sandmining separation plant at Tea Gardens also reinforces the thought that companies tend to distract the public from their operations by leaving areas of bush bordering the mined areas creating a typical out of sight out of mind scenario. In these situations mined dunes are hard to detect until experienced. It is also clear that restoration is only practiced to the level of public outcry against them - no outcry - no restoration. In the case of the farmers at Manning Point they were too few in numbers and too poor financially to oppose the company so restoration was minimal.
6. Restoration is clearly a level of public acceptance, our level must be total restoration in all aspects of mining operation. If our trip to the sand mining areas showed us nothing else it clearly showed us this and we must leave no stone unturned in our efforts to achieve this.
7. It is now our carefully considered opinion that we should now be prepared to allow WIM to establish a demonstration, restoration site in our area. This would -

   1. Allow for sustentation or otherwise of opinion before us.
   2. Indicate whether WIM is genuine in their belief that they can restore the soil to its original state.

APPENDIX 7

Meycheck Paddock Report, 1994, Rupanyup, Department of Agriculture.

Group Summary Notes

The summary is for your group only. It summarises the information received in the Meycheck paddock booklets from 1994.
Each paddock code refers to one paddock. Growers who returned books have also received a paddock report.

WUE % This is an estimation of the efficiency of the crop to convert growing season rainfall into grain. Different crop types have varying degrees of efficiency in converting water to grain.
Unfortunately, in a dry season the calculation is not always reliable as it is difficult to measure stored soil moisture.

ROTATION Each number refers to a particular rotation as shown in the following table. The numbers are from left to right, the crop grown in '94, '93, '92 and 1991.

No.	Rotation	No.	Rotation
1	Wheat	9	Safflower
2	Barley	10	Triticale
3	Oats	11	Chem. Fallow
4	Lupins	12	Mech. Fallow
5	Chick Peas	13	Pasture Grass
6	Field Peas	14	Pasture Legume
7	Faba Beans	15	Vetch
8	Canola	16	Mixed Pasture

GROWING SEASON RAINFALL As supplied by the grower, or in some cases records from a near neighbour or the Bureau of Meteorology are used.

N APPLICATION The nitrogen applied in fertilisers during 1994 in kg per hectare.

N BALANCE The estimated nitrogen balance after calculation of Nitrogen removal in grain and stubble.

P APPLICATION The phosphorus applied in fertilisers during 1994 in kg per hectare.

P BALANCE The estimated phosphorus balance after calculation of Phosphorus removal in grain and stubble.

CULTIVATION METHOD This is an indication of the amount of cultivation involved in producing the crop. The codes are: DD= direct drill; MT= minimum tillage; CT=conventional cultivation. We have attempted to categorize cultivation methods as MT or CT by the number of cultivations completed.

GROSS MARGIN This accounts for all variable costs associated with the production of the crop, such as fertiliser, herbicide, seed, fuel and machinery repairs but not overhead costs such as ownership costs associated with machinery, shire rates etc.

TopCrop Australia Group Summary 1994

MeyCheck

Group name: Rupanyup
Group Coordinator: Robert Christie

Paddock Code	Variety	WUE %	* Rotation	Yield t/HA	Growing Season Rainfall	Time of Sowing	N Application	N Balance	P Application	P Balance	% Screenings	Hectolitre weight	Plant Density Sqr M	% Protein / Oil	Cultivation Method	Herbi Costs $/HA	Fert Costs $/HA	Total Costs $/HA	Gross Margin $/HA	Comment
	Wheat																			
335200	Kellalac	225	1,11,6,1,-	3.00	157	30-Jun	55	-13	21	12			189	14.80	FT	24	233	294	337	
335223	Rosella	222	1,15,15,1,-	3.69	169	13-Jun	0	-84	19	9			117	12.00	FT	47	176	262	475	
335215	Meering	222	1,11,5,16,-	3.60	173	20-Apr	0	-82	13	3				10.00	MT	16	28	79	582	
335221	Meering	209	1,12,6,1,-	3.02	148	3-Jun	50	-18	9	1			200	13.25	FT	26	47	107	511	
335225	Kellalac	205	1,12,5,1,-	3.32	173	14-Jun	0	-76	13	3				11.00	MT	8	28	69	601	
335224	Rosella	198	1,12,6,-,-	3.20	172	15-Jun	0	-73	13	4				11.00	MT	8	28	54	591	
335209	Rosella	173	1,7,1,5,-	2.80	173	9-May	59	-4	10	2			157	12.00	DD	17	59	103	450	
335202	Kellalac	155	1,7,1,13,-	2.07	157	14-Jun	38	-9	18	13			150	12.70	DD	12	50	94	318	
335232	Kellalac	150	1,5,11,16,-	2.00	157	3-Jun	51	5	21	16	0	0	196	12.40	DD	44	63	137	262	
335204	Rosella	93	1,6,2,11,-	1.25	157	4-Jul	56	27	21	17			164	15.90	DD	11	66	110	151	
335220	Rosella	68	1,6,8,11,-	1.25	163	9-Jun	36	8	15	11	0	0	136	13.50	DD	24	57	92	157	
335226	Lowan	45	1,11,13,13,-	.60	157	8-Jul	8	-5	17	16			144	12.80	MT	27	28	90	29	
335216	Rosella	38	1,6,14,6,-	.60	166	2-Jun	36	23	12	10			177	.00	DD	48	47	126	2	
335212	Rosella	25	1,5,9,6,-	.40	137	11-Jun	34	25	10	9	0	0	143	14.00	DD	48	45	118	-37	
	Barley																			
335203	Arapiles	97	2,6,2,12,-	1.56	157	5-Jul	58	27	22	17			132	15.80	DD	11	69	110	172	
	Chick Peas																			
335227	Dooen	53	5,1,11,1,-	.57	157	13-Jun	0	-19	15	13			50	.00	MT	22	32	128	167	
335206	Dooen	38	5,1,12,7,1	.25	143	9-Jun	0	-8	11	10			42	.00	MT	23	25	56		
335218	Dooen	31	5,2,5,11,6	.40	166	13-Jun	0	-13	9	7			38	.00	UN	21	16	91	112	
335211	Kaniva	29	5,-,-,-,-	.38	137	2-Jul	0	-13	9	7			43	.00	UN	38	16	64	285	
335217	Kaniva	27	5,1,12,14,-	.35	166	11-Jun	0	-12	9	7			19	.00	DD	34	16	126	197	
335210	Dooen	20	5,1,11,16,-	.22	157	9-Jul	0	-7	18	17			39	.00	DD	27	40	137	-22	
335231	Narayen	8	5,1,12,5,-	.09	157	12-Jul	0	-3	15	14			27	.00	MT	35	33	186	-114	
	Field Peas																			
335213	Alma	86	6,2,1,6,-	1.00	142	23-Jun	0	-41	0	-3	0	0	67	.00	MT	20		70	169	
335229	Dun	39	6,2,12,5,-	.42	157	15-Jul	0	-17	17	15			61	.00	DD	47	37	132	-19	
335214	Alma	17	6,1,6,2,-	.20	143	17-Jun							75	.00	MT	20		68	-20	
	Faba Beans																			
335230	Fiord	45	7,1,13,13,-	.48	157	9-Jun	0	-19	14	11			29	.00	DD	27	198	276	-153	
	Canola																			
335205	Oscar	221	8,11,13,13,-	1.19	143	1-Jun	51	2	10	1			83	41.00	FT	16	138	188	270	

11/05/95

TopCrop Australia Group Summary 1994

MeyCheck

Group name: Rupanyup
Group Coordinator: Robert Christie

Paddock Code	Variety	WUE %	* Rotation	Yield t/HA	Growing Season Rainfall	Time of Sowing	N Appli-cation	N Bal-ance	P Appli-cation	P Bal-ance	% Scree-nings	Hecto-litre weight	Plant Density Sqr M	% Protein / Oil	Culti-vation Method	Herbi Costs $/HA	Fert Costs $/HA	Total Costs $/HA	Gross Margin $/HA	Comment
335201	Dunkeld	187	8,11,7,1,-	1.67	157	22-Jun	54	-13	23	11			96	40.00	FT	31	236	311	314	
335238	Oscar	164	8,12,2,15,1	1.90	138	24-May	73	-4	12	-1				42.00	FT	24	137	209	512	
335239	Dunkeld	144	8,12,14,14,6	1.60	169	2-Jun	27	-10	21	32			67	44.00	FT	12	58	275	332	
335243	Dunkeld	144	8,12,14,14,6	1.60	169	2-Jun	27	-10	21	32			67	44.00	FT	12	120	275	332	
335233	Dunkeld	128	8,11,6,2,12	1.35	166	20-May	46	-9	11	2			60	46.90	FT	14	126	188	360	
335219	Dunkeld	110	8,11,2,6,-	1.34	163	3-Jun	53	-1	15	6			89	46.00	MT	23	79	140	371	
335208	Oscar	101	8,1,14,1,-	.90	157	22-Jun	73	36	20	13			64	35.30	FT	40	244	326	-12	
335240	Dunkeld	90	8,13,13,16,16	.80	117	28-May	62	29	21	15			30	41.00	FT	48	158	294	-6	
335242	Dunkeld	77	8,12,6,5,1	.74	147	1-Jun	46	15	7	2			103	.00	FT	5	94	148	132	
335241	Oscar	71	8,16,16,16,16	1.20	214	1-Jun	0	-49	27	18			176	41.80	FT	41	120	211	252	
335207	Dunkeld	64	8,16,16,14,-	.57	157	11-Jun	46	23	24	20			75	42.60	MT	12	231	278	-54	
335237	Dunkeld	59	8,5,1,6,12	.72	163	2-Jun	49	20	15	10			95	46.50	MT	31	82	148	112	
335234	Oscar	54	8,7,11,14,14	.66	163	30-May	58	31	18	13			70	38.00	MT	26	91	151	46	
335236	Dunkeld	28	8,5,5,1,12	.35	163	1-Jun	51	37	16	14			60	43.00	MT	34	79	145	-24	

Topcrop Australia 94

MeyCheck

Report page 1 - Paddock performance

Group Name: Rupanyup
Group Coordinator: Robert Christie

Paddock No: 335240
Paddock Name: H No 6

Area under crop (HA): 36.00

Paddock and Crop Details

Current Season Crop: **Canola**

Variety: **Dunkeld**

Cultivation method: **Full Till**

Price received $/tonne: **360.00**

- Crop Rotation and Previous Gross Margin -

		$
Previous season:	**Pasture Grass**	
2 Years prior:	**Pasture Grass**	
3 Years prior:	**Mixed Pasture**	
4 Years Prior:	**Mixed Pasture**	

Crop Performance

Yield t/HA **0.80**

Time of Sowing: **28-May**

Screenings %

Protein: **41.0** %

Plant Density: **30** Sqr M

Hectolitre weight: kg/HL

Crop Water Use

Growing Season Rainfall **117** *mm (GSR Apr-Oct inclusive)*

Water Use efficiency **9.0** *(Kg yield per mm per HA)*

Net Water use by crop **83** *mm (GSR - Crop Evaporation)*

Crop Potential WUE **10.0** *(Kg yield per mm per HA)*

Water Use Efficiency 90 **% of potential**

Income, Costs and Gross Margin *

Topcrop Regional Benchmark

Income	
Yield T/Ha	.80
Price/Tonne ($)	360.00

Expenses	
Seed and Fertiliser costs:	170.64
Herbicide costs:	48.11
Fungicide & Insecticide costs:	11.90
Fuel and Oil Costs:	8.98
Machinery costs:	1.00
Maintenance costs:	11.77
Contractor Costs:	51.20

Total Income $/HA 288.00

Total Costs $/HA **$303.59**

Gross Margin $/HA **-$15.59**

Notes:

11/05/95 Version 1.06 5/4/95

Topcrop Australia 94

Report page 2 - Plant and Soil Results

Group Name: Rupanyup
Group Coordinator: Robert Christie

Paddock No: 335240
Paddock Name: H No 6

Area under crop (HA): 36.00

Paddock and Crop Details

Current Season Crop: **Canola**
Variety: **Dunkeld**
Cultivation method: **Full Till**

Soil Test

Soil test date

Organic Carbon	Manganese	P.R.I
Phosphorus	Aluminium	Reactive Iron
Potassium	Nitrate Nitrogen	Ammonium N
Salt EC ms/cm	Zinc	pH Calc
Magnesium	Sulphur	pH H20
Fizz test	Copper	

Plant Tissue Nutrient Levels

	Actual	Optimum	Rating	TopCrop Regional Benchmark
N03 (ppm)	5000			
Phosphorus %	.59			
Potassium %	4.90			
Sulphur %	.56			
Zinc (ppm)	57.40			
Copper (ppm)	6.20			
Manganese (ppm)	51.00			

Nutrient Balance Sheet

	N	P	S	Zn (grams)
nput from fertilisers kg/HA	62	21	410	2.90
Output from crop kg/HA	32	5	8	32.00
Nutrient Balance kg/HA	29	15	402	-29.10

Notes:

Topcrop Australia 94

Report page 3 - Herbicides and Weeds

Group Name: Rupanyup
Group Coordinator: Robert Christie

Paddock No: 335240
Paddock Name: H No 6

Area under crop (HA): 36.00

Paddock and Crop Details

Current Season Crop: **Canola**
Variety: **Dunkeld**
Cultivation method: **Full Till**

Weeds Observed

Date	Weed Description	No: Sqr/M
1/07/94	Ryegrass ; Perennial	7
1/07/94	Hogweed (Tree)	3
1/07/94	Erodium (Storksbill ; Corkscrew ; C	6
1/07/94	Medic (All Types)	6
1/07/94	Capeweed	1
1/07/94	Wild Oats	5
1/07/94	Ryegrass ; Annual (Wimmera)	1
1/07/94	Nettle (Dead Nettle)	1
1/07/94	Ox Tongue (Bristly Ox Tongue)	2
1/07/94	Mustard	1

Herbicides Applied

Date	Herbicide Name	Group	Rate	Cost $
1/10/93	Round-up	*M*	1.00	10.50
1/10/93	2,4 D Ester	*I*	0.30	2.98
13/05/94	Trifluralin (Treflan)	*D*	1.50	8.85
1/08/94	Verdict	*A*	0.50	16.25
1/08/94	Lontrel	*I*	0.20	9.52

Total $48.10

Herbicide Resistance Potential:

		Group A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*
*Pre 1991 Total applications										
1991	**Mixed Pasture**	-	-	-	-	-	-	-	-	-
1992	**Pasture Grass**	-	-	-	-	-	-	-	-	-
1993	**Pasture Grass**	-	-	-	-	-	-	-	-	-
1994	**Canola**	X	-	-	X	-	-	-	-	X
**Average No: of applications										
***Lowest No: of applications										
'Shots' left										

A=Fops,Dims
B=Sulfonylureas,Imidazolino
C=Ureas, Triazines, Triazino
D=Dinitroanilines, Thiocarbama
E=Amides,Carbamat
F=Nicotinanilides
G=Diphenyl Ethers,Oxadiaz
H=Thiocarbamate
I=Benzoic,Phenoxyalkanoic,Pyrdinecarbolic acids

* Enter data from previous years
** Ave No: of applications before resistance detected
*** Lowest No: of applications before resistance detect

Paddock disease potential:

Notes:

TopCrop Australia Group Summary 1994

MeyCheck

Group name: Rupanyup
Group Coordinator: Robert Christie

Paddock Code	Variety	WUE %*	* Rotation	Yield t/HA	Growing Season Rainfall	Time of Sowing	N Application	N Balance	P Application	P Balance	% Screenings	Hectolitre weight	Plant Density Sqr M	% Protein / Oil	Cultivation Method	Herbi Costs $/HA	Fert Costs $/HA	Total Costs $/HA	Gross Margin $/HA	Comment
	Wheat																			
335200	Kellalac	225	1,11,6,1,-	3.00	157	30-Jun	55	-13	21	12			189	14.80	FT	24	233	294	337	
335223	Rosella	222	1,15,15,1,-	3.69	169	13-Jun	0	-84	19	9			117	12.00	FT	47	176	262	475	
335215	Meering	222	1,11,5,16,-	3.60	173	20-Apr	0	-82	13	3				10.00	MT	16	28	79	582	
335221	Meering	209	1,12,6,1,-	3.02	148	3-Jun	50	-18	9	1			200	13.25	FT	26	47	107	511	
335225	Kellalac	205	1,12,5,1,-	3.32	173	14-Jun	0	-76	13	3				11.00	MT	8	28	69	601	
335224	Rosella	198	1,12,6,-,-	3.20	172	15-Jun	0	-73	13	4				11.00	MT	8	28	54	591	
335209	Rosella	173	1,7,1,5,-	2.80	173	9-May	59	-4	10	2			157	12.00	DD	17	59	103	450	
335202	Kellalac	155	1,7,1,13,-	2.07	157	14-Jun	38	-9	18	13			150	12.70	DD	12	50	94	318	
335232	Kellalac	150	1,5,11,16,-	2.00	157	3-Jun	51	5	21	16	0	0	196	12.40	DD	44	63	137	262	
335204	Rosella	93	1,6,2,11,-	1.25	157	4-Jul	56	27	21	17			164	15.90	DD	11	66	110	151	
335220	Rosella	68	1,6,8,11,-	1.25	163	9-Jun	36	8	15	11	0	0	136	13.50	DD	24	57	92	157	
335226	Lowan	45	1,11,13,13,-	.60	157	8-Jul	8	-5	17	16			144	12.80	MT	27	28	90	29	
335216	Rosella	38	1,6,14,6,-	.60	166	2-Jun	36	23	12	10			177	.00	DD	48	47	126	2	
335212	Rosella	25	1,5,9,6,-	.40	137	11-Jun	34	25	10	9	0	0	143	14.00	DD	48	45	118	-37	
	Barley																			
335203	Arapiles	97	2,6,2,12,-	1.56	157	5-Jul	58	27	22	17			132	15.80	DD	11	69	110	172	
	Chick Peas																			
335227	Dooen	53	5,1,11,1,-	.57	157	13-Jun	0	-19	15	13			50	.00	MT	22	32	128	167	
335206	Dooen	38	5,1,12,7,1	.25	143	9-Jun	0	-8	11	10			42	.00	MT	23	25	56		
335218	Dooen	31	5,2,5,11,6	.40	166	13-Jun	0	-13	9	7			38	.00	UN	21	16	91	112	
335211	Kaniva	29	5,-,-,-,-	.38	137	2-Jul	0	-13	9	7			43	.00	UN	38	16	64	285	
335217	Kaniva	27	5,1,12,14,-	.35	166	11-Jun	0	-12	9	7			19	.00	DD	34	16	126	197	
335210	Dooen	20	5,1,11,16,-	.22	157	9-Jul	0	-7	18	17			39	.00	DD	27	40	137	-22	
335231	Narayen	8	5,1,12,5,-	.09	157	12-Jul	0	-3	15	14			27	.00	MT	35	33	186	-114	
	Field Peas																			
335213	Alma	86	6,2,1,6,-	1.00	142	23-Jun	0	-41	0	-3	0	0	67	.00	MT	20		70	169	
335229	Dun	39	6,2,12,5,-	.42	157	15-Jul	0	-17	17	15			61	.00	DD	47	37	132	-19	
335214	Alma	17	6,1,6,2,-	.20	143	17-Jun							75	.00	MT	20		68	-20	
	Faba Beans																			
335230	Fiord	45	7,1,13,13,-	.48	157	9-Jun	0	-19	14	11			29	.00	DD	27	198	276	-153	
335228	Fiord		7,5,1,12,-		157	1-Jul	0		16				29	.00	DD	41	36	105		
	Canola																			

19/04/95

TopCrop Australia Group Summary 1994

MeyCheck

Group name: Rupanyup
Group Coordinator: Robert Christie

Paddock Code	Variety	WUE %	* Rotation	Yield t/HA	Growing Season Rainfall	Time of Sowing	N Application	N Balance	P Application	P Balance	% Screenings	Hectolitre weight	Plant Density Sqr M	% Protein / Oil	Cultivation Method	Herbi Costs $/HA	Fert Costs $/HA	Total Costs $/HA	Gross Margin $/HA	Comment
335205	Oscar	221	8,11,13,13,-	1.19	143	1-Jun	51	2	10	1			83	41.00	FT	16	138	188	270	
335201	Dunkeld	187	8,11,7,1,-	1.67	157	22-Jun	54	-13	23	11			96	40.00	FT	31	236	311	314	
335238	Oscar	164	8,12,2,15,1	1.90	138	24-May	73	-4	12	-1				42.00	FT	24	137	209	512	
335239	Dunkeld	144	8,12,14,14,6	1.60	169	2-Jun	27	-38	21	10			67	44.00	FT	12	58	105	502	
335233	Dunkeld	128	8,11,6,2,12	1.35	166	20-May	46	-9	11	2			60	46.90	FT	14	126	188	360	
335219	Dunkeld	110	8,11,2,6,-	1.34	163	3-Jun	53	-1	15	6			89	46.00	MT	23	79	140	371	
335208	Oscar	101	8,1,14,1,-	.90	157	22-Jun	73	36	20	13			64	35.30	FT	40	244	326	-12	
335207	Dunkeld	64	8,16,16,14,-	.57	157	11-Jun	46	23	24	20			75	42.60	MT	12	231	278	-54	
335237	Dunkeld	59	8,5,1,6,12	.72	163	2-Jun	49	20	15	10			95	46.50	MT	31	82	148	112	
335234	Oscar	54	8,7,11,14,14	.66	163	30-May	58	31	18	13			70	38.00	MT	26	91	151	46	
335236	Dunkeld	28	8,5,5,1,12	.35	163	1-Jun	51	37	16	14			60	43.00	MT	34	79	145	-24	

Topcrop Australia Group Data Summary

3352 Rupanyup

	Paddock Code	Variety	Previous crop	Gross Margin $/HA	WUE Kg/mm H2O use	WUE Rank	Yield t/HA	Growing Season Rainfall	Time of Sowing	N Appli-cation	N Bal-ance	P Appli-cation	P Bal-ance	% Scree-nings	Hecto-litre weight	Plant Density Sqr M	% Protein / Oil	Culti-vation Method	Herbi Costs $/HA	Fert Costs $/HA	Total Costs $/HA
	Wheat																				
1	337,763	Rosella	Canola	1128	21	1	6.00	391	8/05/95	57	-81	12.12	-4.68	3.0	85	176	11.00	Dir	21	53	102
2	337,767	Meering	Chick Peas	957	18	3	5.14	391	30/05/95	0	0	.00	.00			156	9.50	Dir	0	0	29
3	337,766	Meering	Canola	926	18	2	5.21	391	19/05/95	11	-109	12.12	-2.47	0.2	83	203	9.30	Ful	54	21	116
4	337,762	Meering	Canola	853	17	4	4.85	391	12/05/95	11	-101	12.12	-1.46	1.0	85	164	9.00	Dir	21	21	69
5	337,730	Rosella	Field Peas	769	16	5	4.38	379	16/05/95	28	-73	10.92	-1.34	1.0		150	9.20	Dir	38	37	107
6	335,214	Meering	Field Peas	732	14	6	4.30	422	12/05/95	32	-67	.00	-12.04				9.30	Min	13	22	72
7	335,213	Meering	Field Peas	683	13	7	4.10	422	18/05/95	37	-58	.00	-11.48				9.00	Min	19	25	84
	Barley																				
1	337,759	Arapiles	Field Peas	821	14	1	4.40	391	29/05/95	64	-24	10.10	-3.10			107	10.20	Ful	41	55	125
2	337,760	Schooner	Chick Peas	621	12	2	3.62	391	16/06/95	55	-17	10.10	-.76	4.0		111	9.60	Dir	30	49	103
3	337,732	Weeah	Chick Peas	618	11	4	3.50	389	1/06/95	14	-57	11.70	1.20				9.20	Min	22	29	82
4	335,211	Schooner	Chick Peas	479	12	3	3.46	379	16/06/95	53	-16	10.08	-.30			139	.00	Dir	62	53	143
	Chick Peas																				
1	335,217	Kaniva	Chick Peas	2607	10	2	2.68	391	15/06/95	0	-88	4.50	-4.34			31	.00	Dir	20	8	140
2	337,761	Kaniva	Wheat	2073	9	6	2.33	391	17/05/95	0	-77	4.50	-3.19			32	.00	Dir	44	8	163
3	335,233	Kaniva	Canola	2073	9	7	2.33	391	22/05/95	0	-77	4.50	-3.19			28	.00	Dir	44	8	164
4	337,757	Dooen	Barley	780	10	1	2.80	391	4/06/95	0	-92	4.50	-4.74			48	.00	Dir	35	8	93
5	337,768	Dooen	Wheat	705	9	4	2.52	391	16/06/95	0	-83	4.50	-3.82			59	.00	Dir	24	8	81
6	337,728	Dooen	Unspecified	670	10	3	2.60	393	22/05/95	5	-81	10.90	2.32			63	.00	Min	39	18	123
7	335,221	Dooen	Wheat	667	9	5	2.50	393	23/05/95	5	-78	10.90	2.65			63	.00	Min	12	18	96
8	335,216	Dooen	Wheat	633	9	8	2.30	391	31/05/95	0	-76	4.50	-3.09			51	.00	Dir	27	8	85
	Canola																				
1	337,758	Oscar	Mechanical F	556	8	1	2.23	391	5/05/95	69	-23	20.20	4.59			87	44.20	Ful	43	126	198
2	337,765	Rainbow	Chemical Fall	486	6	2	1.86	391	7/05/95	70	-7	16.16	3.14			62	45.80	Ful	43	136	208
3	337,764	Oscar	Chemical Fall	480	6	3	1.86	391	6/05/95	70	-7	16.16	3.14			67	45.80	Ful	49	136	214
4	335,212	Dunkeld	Wheat	422	6	4	1.58	379	12/05/95	55	-10	10.92	-.14			74	48.00	Dir	43	56	128
5	337,731	Dunkeld	Chemical Fall	234	4	5	1.00	389	10/05/95	13	-28	11.05	4.05			20	48.50	Min	42	27	102

APPENDIX 8

Raw data from Australian Bureau of Statistics, on Area by Commodity, 1992 – 1994. Rupanyup Shire (former boundary). Summary of Statistical Data, Area by Commodity, 1961 - 1994.

APPENDIX 8

Australian
Bureau of
Statistics

Area Sown by Crop (Ha), Five Year Average, 1961 – 1994, Dunmunkle

(Source ABS)

	ave wheat	ave barley	ave oats	ave triticale	ave peas	ave beans	ave lupins	ave chick pea	ave canola	ave safflower
61-65	39482	357	4188							
66-70	40496	1848	4575							
71-75	38920	2280	5740							
76-80	39800	6089	2550							
81-85	40664	7368	2157	38	8415		60	119	259	162
86-90	30720	8904	2813	128	13876	1288	59	3016	790	683
91-94	23786	14055	2004	35	11298	4498	333	16099	3142	945

Area Sown by Crop (Ha), 1961 – 1994, Dunmunkle.

(Source: ABS)

	farmed total area	wheat	barley	oats	triticale	peas	beans	lupins	chick peas	canola	safflower
1961	154025	38318	595	3419							
1962	154031	41198	460	4670							
1963	145973	38862	355	4113							
1964	146038	39150	189	5189							
1965	145941	39885	188	3548							
1966	147610	41447	310	3465							
1967	152022	41807	563	2468							
1968	148048	51603	1409	4598							
1969	147443	41731	2437	4158							
1970	148832	25892	4520	8186							
1971	146288	34654	3960	7033							
1972	149717	37292	3571	4191							
1973	151043	39647	3361	4081							
1974	149227	36624	4787	2725							
1975	147198	35701	7492	4251							
1976	142702	35175	6665	2616							
1977	143801	37891	7688	2654							
1978	146278	40936	6272	3003							
1979	144583	41956	5247	2254							
1980	147882	43044	4571	2225							
1981	148685	36827	5798	2074							
1982	143286	37172	4003	2367	20	4345				33	10
1983	145310	47269	8576	3202	4	5719		12		6	117
1984	149259	41255	10689	1611	8	9677		156		96	267
1985	143401	40799	7772	1529	120	13918		12	119	899	252
1986	140454	35630	4935	2334	142	17815	34	8	432	808	557
1987	144248	29592	9608	3351	166	19038	218	36	660		907
1988	145582	28380	9148	2713	214	14824	723	70	1422	1011	785
1989	140512	30932	9701	3738		10956	1793	20	3170	978	619
1990	139548	29064	11130	1928	4	10686	2417	109	6812	382	421
1991	137992	19770	13769	2404	20	12477	3758		13360	1570	1069
1992	135326	26168	16195	2539	49	10374	5895	258	12861	1213	802
1993	142986	22424	17377	1676		11703	4765	408	15415	2623	1348
1994	142000	21503	11805	1471		10637	3572		22759	7160	562

EXPLANATORY NOTES

INTRODUCTION

1 This publication contains detailed statistics on crops, livestock and livestock products and characteristics of farms. Also included is summary information on the financial performance of agricultural industries, the value of agricultural commodities produced (VACP) and apparent consumption of foodstuffs.

SCOPE AND COVERAGE

2 The statistics on crops (including horticulture), livestock numbers, structure of agricultural industries, land management and farm inputs in this publication are derived from the annual Agricultural Census conducted throughout Australia at 31 March. The Agricultural Census collects data from establishments with agricultural activity.

3 The scope of the 1995–96 Census was establishments with an estimated value of agricultural operations (EVAO) of $5,000 or more. The scope of the Census for earlier years was set at different levels. The table below indicates the change in scope of the Agricultural Census over the past ten years based on the EVAO of establishments.

Year	EVAO cut-off level $
1985–86	2 500
1986–87	20 000
1987–88	20 000
1988–89	20 000
1989–90	20 000
1990–91	20 000
1991–92	22 500
1992–93	22 500
1993–94	5 000
1994–95	5 000
1995–96	5 000

4 In addition to the Census, some basic data has been previously collected via an Activity Collection for a limited range of commodities from those establishments having an EVAO of between $5,000 and $22,499. These data can be used together with census data to derive estimates of totals for selected commodities for all establishments having an EVAO greater than $5,000. Results for 1993–94 to 1995–96 based on $22,500 EVAO for crops (including fruit and vegetables) are available on request.

AUSTRALIAN BUREAU OF STATISTICS						
AGRICULTURE CENSUS DATA. 1994-95						
Dunmunkle (S)						
Selected crops						
SLA Code	**Region**	**Commodity**	**Amount**	**Unit**	**Population**	**Respondents**
225102480	Dunmunkle (S)	WHEAT FOR GRAIN - AREA	21503.2	HA	240	197
225102480	Dunmunkle (S)	WHEAT FOR GRAIN - PRODUCTION	34196.4	Tonnes	240	197
225102480	Dunmunkle (S)	OATS FOR GRAIN - AREA	1471	HA	240	39
225102480	Dunmunkle (S)	OATS FOR GRAIN - PRODUCTION	1494.5	Tonnes	240	39
225102480	Dunmunkle (S)	BARLEY FOR GRAIN - AREA	11805	HA	240	151
225102480	Dunmunkle (S)	BARLEY FOR GRAIN - PRODUCTION	12053.2	Tonnes	240	151
225102480	Dunmunkle (S)	FIELD PEAS FOR GRAIN - AREA	10636.8	HA	240	138
225102480	Dunmunkle (S)	FIELD PEAS FOR GRAIN - PRODUCTION	5076.1	Tonnes	240	138
225102480	Dunmunkle (S)	CHICK PEAS - AREA	22758.6	HA	240	174
225102480	Dunmunkle (S)	CHICK PEAS - PRODUCTION	7376.9	Tonnes	240	174
225102480	Dunmunkle (S)	CANOLA/RAPESEED (CLEAN SEED) - AREA	7159.6	HA	240	95
225102480	Dunmunkle (S)	CANOLA/RAPESEED (CLEAN SEED) - PRODUCTION	5556.9	Tonnes	240	95
225102480	Dunmunkle (S)	SAFFLOWER - AREA	561.7	HA	240	12
225102480	Dunmunkle (S)	SAFFLOWER - PRODUCTION (CLEAN SEED)	346.6	Tonnes	240	12
225102480	Dunmunkle (S)	FABA, TICK AND HORSE BEANS - AREA	3571.5	HA	240	54
225102480	Dunmunkle (S)	FABA, TICK AND HORSE BEANS - PRODUCTION	1023.9	Tonnes	240	54

AUSTRALIAN BUREAU OF STATISTICS						
AGRICULTURE CENSUS DATA. 1995-96						
Yarriambiack (S) - South						
Selected crops						
SLA Code	**Region**	**Commodity**	**Amount**	**Unit**	**Population**	**Respondents**
225107632	Yarriambiack (S) - South	Wheat for grain - area	56847.8	HA	471	395
225107632	Yarriambiack (S) - South	Wheat for grain - production	155170.4	Tonnes	471	395
225107632	Yarriambiack (S) - South	Oats for grain - area	3066	HA	471	65
225107632	Yarriambiack (S) - South	Oats for grain - production	6897.8	Tonnes	471	65
225107632	Yarriambiack (S) - South	Barley for grain - area	43279	HA	471	371
225107632	Yarriambiack (S) - South	Barley for grain - production	108170.4	Tonnes	471	371
225107632	Yarriambiack (S) - South	Field peas for grain - area	13947.6	HA	471	211
225107632	Yarriambiack (S) - South	Field peas for grain - production	26675.1	Tonnes	471	211
225107632	Yarriambiack (S) - South	Chick peas - area	33874.3	HA	471	301
225107632	Yarriambiack (S) - South	Chick peas - production	60327.8	Tonnes	471	301
225107632	Yarriambiack (S) - South	Canola - area	13619.9	HA	471	160
225107632	Yarriambiack (S) - South	Canola - production (clean seed)	20506.3	Tonnes	471	160
225107632	Yarriambiack (S) - South	Safflower - area	1420	HA	471	28
225107632	Yarriambiack (S) - South	Safflower - production (clean seed)	1258.8	Tonnes	471	28
225107632	Yarriambiack (S) - South	Faba beans (incl tick and horse) - area	2912	HA	471	51
225107632	Yarriambiack (S) - South	Faba beans (incl tick and horse) - production	6448.7	Tonnes	471	51

AUSTRALIAN BUREAU OF STATISTICS						
AGRICULTURE CENSUS DATA. 1996-97						
Yarriambiack (S) - South						
Selected crops						
SLA Code	Area	Commodities	Amount	Unit	Population	Respondents
225107632	Yarriambiack (S) - South	Wheat for grain - Area	65203.7	HA	498	430
225107632	Yarriambiack (S) - South	Wheat for grain - Production	212580.3	Tonnes	498	430
225107632	Yarriambiack (S) - South	Oats for grain - Area	1697.3	HA	498	48
225107632	Yarriambiack (S) - South	Oats for grain - Production	3495.1	Tonnes	498	48
225107632	Yarriambiack (S) - South	Barley for grain - Area	45651.8	HA	498	392
225107632	Yarriambiack (S) - South	Barley for grain - Production	120170.8	Tonnes	498	392
225107632	Yarriambiack (S) - South	Field peas for grain - Area	14309.8	HA	498	187
225107632	Yarriambiack (S) - South	Field peas for grain - Production	23696.8	Tonnes	498	187
225107632	Yarriambiack (S) - South	Chick peas - Area	39987.5	HA	498	349
225107632	Yarriambiack (S) - South	Chick peas - Production	55972.6	Tonnes	498	349
225107632	Yarriambiack (S) - South	Canola - Area	16319.8	HA	498	184
225107632	Yarriambiack (S) - South	Canola - Production (clean seed)	26630.9	Tonnes	498	184
225107632	Yarriambiack (S) - South	Safflower - Area	967.4	HA	498	20
225107632	Yarriambiack (S) - South	Safflower - Production (clean seed)	522.3	Tonnes	498	20
225107632	Yarriambiack (S) - South	Faba beans (incl tick and horse) - Area	3933.4	HA	498	78
225107632	Yarriambiack (S) - South	Faba beans (incl tick and horse) - Production	8181.8	Tonnes	498	78

AUSTRALIAN BUREAU OF STATISTICS
AGRICULTURAL CENSUS 1992-93
Area by Commodity
VICTORIA-Continued

AREA		COMMODITY	UNIT OF QUANTITY	QUANTITY	NUMBER OF RESPONDENTS
225102360 Donald (S)					
	8007001	EGGS PRODUCED FOR HUMAN CONSUMPTION - DOZEN	D	216,118	2
	8701001	SUSTAINABLE LAND USE INFORMATION - OTHER LAND HOLDERS	N	81	81
	8701501	SUSTAINABLE LAND USE INFORMATION - MEDIA(NEWSPAPERSTV)	N	54	54
	8702001	SUSTAINABLE LAND USE INFORMATION - GOVERNMENT OR COUNCIL	N	21	21
	8702501	SUSTAINABLE LAND USE INFORMATION - RESEARCH AGENCIES	N	26	26
	8703001	SUSTAINABLE LAND USE INFORMATION - OTHER	N	7	7
225102480 Dunmunkle (S)					
	0100101	TOTAL AREA OF HOLDING	H	135,326	229
	0100351	PASTURES AND GRASSES - TOTAL AREA CROPPED	H	3,570	64
	0108011	CROPS AND PASTURES FOR HAY - TOTAL AREA	H	3,815	74
	0108012	CROPS AND PASTURES FOR HAY - TOTAL PRODUCTION	T	8,908	74
	0108211	CROPS EXCLUDING PASTURES AND GRASSES - TOTAL AREA	H	78,201	220
	0108411	CROPS AND PASTURES - TOTAL AREA	H	81,770	221
	0108501	AREA OF LAND AFFECTED BY EROSION - WIND OR WATER AT 31 MARCH	H	2,256	7
	0108601	AREA OF LAND AFFECTED BY SOIL SALINITY -DRY LAND AT 31 MARCH	H	363	8
	0108701	AREA OF LAND AFFECTED BY SOIL SALINITY-IRRIGATION 31 MARCH	H	3	1
	0108801	AREA OF LAND AFFECTED BY OTHER DEGRADATION - AT 31 MARCH	H	1,040	8
	1000501	PURE LUCERNE AT 31 MARCH - AREA	H	94	6
	1001201	PASTURE LEGUMES EXCLUDING PURE LUCERNE AT 31 MARCH - AREA	H	1,964	24
	1001301	SOWN GRASSES AT 31 MARCH - AREA	H	2,736	32
	1001401	MIXTURE OF GRASSES AND LEGUMES AT 31 MARCH - AREA	H	19,626	97
	1001701	OTHER PASTURES - NATIVE AND NATURALISED - AREA	H	11,391	90
	1002501	SOWN PASTURE EXCLUDINC PURE LUCERNE AT 31 MARCH - AREA	H	24,326	137
	1002751	SOWN PASTURES AND GRASSES AT 31 MARCH - TOTAL AREA	H	24,420	137
	1005101	PURE LUCERNE PASTURES CUT FOR HAY - AREA	H	61	3
	1005102	PURE LUCERNE PASTURES CUT FOR HAY - PRODUCTION	T	209	3
	1008101	PASTURES EXCL PURE LUCERNE, CUT FOR HAY - AREA	H	3,299	63
	1008102	PASTURES EXCL PURE LUCERNE, CUT FOR HAY - PRODUCTION	T	7,695	63
	1008701	PASTURES CUT FOR HAY - AREA	H	3,360	63
	1008702	PASTURES CUT FOR HAY - PRODUCTION	T	7,904	63
	1100601	PASTURE SEED - AREA	H	210	5
	1100602	PASTURE SEED - PRODUCTION	K	35,250	5
	1500101	WHEAT FOR GRAIN - AREA	H	26,168	204
	1500102	WHEAT FOR GRAIN - PRODUCTION	T	81,002	204
	1500801	OATS FOR GRAIN - AREA	H	2,539	54
	1500802	OATS FOR GRAIN - PRODUCTION	T	5,949	54
	1500901	OATS FOR HAY - AREA	H	292	10
	1500902	OATS FOR HAY - PRODUCTION	T	434	10
	1501701	BARLEY FOR GRAIN - AREA	H	16,195	169

AUSTRALIAN BUREAU OF STATISTICS
AGRICULTURAL CENSUS 1992-93
Area by Commodity
VICTORIA-Continued

AREA	COMMODITY		UNIT OF QUANTITY	QUANTITY	NUMBER OF RESPONDENTS
225102480 Dunmunkle (S)					
	1501702	BARLEY FOR GRAIN - PRODUCTION	T	35,878	169
	1505401	MAIZE FED OFF OR CUT FOR GREEN FEED OR SILAGE - AREA	H	10	1
	1508801	TRITICALE FOR GRAIN - AREA	H	49	2
	1508802	TRITICALE FOR GRAIN - PRODUCTION	T	155	2
	1509211	CEREAL CROPS FOR GRAIN - TOTAL AREA	H	44,951	217
	1509212	CEREAL CROPS FOR GRAIN - TOTAL PRODUCTION	T	122,984	215
	1509301	CEREAL CROPS CUT FOR HAY - AREA	H	327	14
	1509302	CEREAL CROPS CUT FOR HAY - PRODUCTION	T	507	14
	1509401	CEREAL CROPS FED OFF OR CUT FOR GREEN FEED OR SILAGE - AREA	H	60	2
	1509701	CEREAL CROPS EXCLUDING OATS, CUT FOR HAY - AREA	H	35	5
	1509702	CEREAL CROPS EXCLUDING OATS, CUT FOR HAY - PRODUCTION	T	73	5
	1510001	CEREAL CROPS EXCL MAIZE, FED OFF/CUT FOR GN FEED/SILAGE-AREA	H	50	1
	1800801	DRY EDIBLE BEANS EXCLUDING MUNG - AREA	H	60	1
	1800802	DRY EDIBLE BEANS EXCLUDING MUNG - PRODUCTION	T	115	1
	1801701	SOYBEANS - AREA	H	17	1
	1801702	SOYBEANS - PRODUCTION	T	45	1
	1806911	TOTAL OILSEEDS - AREA	H	2,032	28
	1806912	TOTAL OILSEEDS - PRODUCTION	T	2,803	28
	1807001	WHITE OR YELLOW LUPINS FOR GRAIN - AREA	H	258	3
	1807002	WHITE OR YELLOW LUPINS FOR GRAIN - PRODUCTION	T	479	3
	1809011	LEGUMES FOR GRAIN - TOTAL AREA	H	30,347	187
	1809012	LEGUMES FOR GRAIN - TOTAL PRODUCTION	T	58,338	186
	1809101	FIELD PEAS FOR GRAIN - AREA	H	10,374	140
	1809102	FIELD PEAS FOR GRAIN - PRODUCTION	T	22,937	140
	1809451	COW AND FIELD PEAS FOR GRAIN - TOTAL AREA	H	10,374	140
	1809452	COW AND FIELD PEAS FOR GRAIN - TOTAL PRODUCTION	T	22,937	139
	1900301	CHICK PEAS - AREA	H	12,861	125
	1900302	CHICK PEAS - PRODUCTION	T	24,644	125
	1900901	CANOLA/RAPESEED - AREA	H	1,213	16
	1900902	CANOLA/RAPESEED (CLEAN SEED) - PRODUCTION	T	1,965	16
	1901401	SAFFLOWER - AREA	H	802	13
	1901402	SAFFLOWER - PRODUCTION (CLEAN SEED)	T	793	13
	1901951	CROPS FED OFF OR CUT FOR GREEN FEED OR SILAGE - TOTAL AREA	H	136	3
	1904801	VETCHES FOR SEED - AREA	H	819	12
	1904802	VETCHES FOR SEED - PRODUCTION	K	712,636	12
	1905111	CROPS FOR HAY - TOTAL AREA	H	455	17
	1905112	CROPS FOR HAY - TOTAL PRODUCTION	T	1,004	17
	1905201	LENTILS - AREA	H	80	1
	1905202	LENTILS - PRODUCTION	T	80	1

AUSTRALIAN BUREAU OF STATISTICS
AGRICULTURAL CENSUS 1992-93
Area by Commodity
VICTORIA-Continued

AREA	COMMODITY	UNIT OF QUANTITY	QUANTITY	NUMBER OF RESPONDENTS
225102480 Dunmunkle (S)				
1907601	TICK, HORSE AND FABA BEANS - AREA	H	5,895	76
1907602	TICK, HORSE AND FABA BEANS - PRODUCTION	T	9,371	76
1909001	CROPS EXCL CEREALS & FORAGE SORGHUM, CUT FOR HAY - AREA	H	128	3
1909002	CROPS EXCL CEREALS & FORAGE SORGHUM, CUT FOR HAY - PRODN	T	497	3
1909101	CROPS EXCL CEREALS & FORAGE SORG-FO/CUT FOR GR FEED/SIL-AREA	H	76	1
1909801	NON CEREAL CROPS NEC - AREA	H	280	1
3300501	WHEAT SOWN OR INTENDED TO BE SOWN IN 1993 - AREA	H	22,065	182
3300801	OATS SOWN OR INTENDED TO BE SOWN IN 1993 - AREA	H	2,763	52
3301101	BARLEY SOWN OR INTENDED TO BE SOWN IN 1993 - AREA	H	17,566	172
3301501	FIELD PEAS SOWN OR INTENDED TO BE SOWN IN 1993 - AREA	H	13,505	147
3301801	LUPINS FOR CROP SOWN OR INTENDED TO BE SOWN IN 1993 - AREA	H	838	8
3302801	WHEAT HELD ON HOLDING AT 31 MARCH	T	10,726	159
3303201	OATS HELD ON HOLDING AT 31 MARCH	T	4,412	62
3303601	BARLEY HELD ON HOLDING AT 31 MARCH	T	3,532	123
3307101	HAY HELD ON HOLDING AT 31 MARCH	T	17,827	135
3307201	HAY SOLD DURING YEAR ENDED 31 MARCH	T	1,446	22
5608901	ARTIFICIAL FERTILISERS USED - AREA	H	60,971	182
5608902	ARTIFICIAL FERTILISERS USED - QUANTITY	T	8,380	182
5609301	SOIL CONDITIONERS USED - AREA	H	7,894	82
5609302	SOIL CONDITIONERS - TONNES	T	15,395	82
5700501	PASTURES IRRIGATED - AREA	H	203	17
5700601	CEREAL CROPS IRRIGATED - AREA	H	95	2
5701501	CROPS NEC IRRIGATED - AREA	H	110	2
5708955	CROPS AND PASTURES IRRIGATED - TOTAL AREA	H	408	19
6000101	RAMS ONE YEAR AND OVER - NUMBER	N	1,560	116
6000201	BREED EWES 1 YR & OVER, INCL MAIDEN EWES INTEND FOR BREED-NO	N	62,796	141
6000301	NON-BREEDING EWES ONE YEAR AND OVER - NUMBER	N	9,070	42
6000401	WETHERS ONE YEAR AND OVER-NUMBER	N	48,243	108
6000501	LAMBS AND HOGGETS UNDER ONE YEAR - NUMBER	N	42,884	120
6000601	SHEEP & LAMBS - TOTAL NUMBER	N	164,553	172
6000751	SHEEP EXCLUDING LAMBS - TOTAL NUMBER	N	121,669	171
6300101	SHEEP SHORN - NUMBER	N	135,762	149
6300102	SHEEP WOOL (INCLUDING LOCKS, PIECES & BELLIES) - PRODUCTION	K	751,935	149
6300201	LAMBS SHORN - NUMBER	N	35,256	92
6300202	LAMBS WOOL (INCLUDING LOCKS, PIECES & BELLIES) - PRODUCTION	K	54,942	92
6300302	CRUTCHINGS, ETC - PRODUCTION	K	22,472	82
6300401	SHEEP AND LAMBS SHORN - TOTAL NUMBER	N	171,018	151
6300402	WOOL - TOTAL PRODUCTION	K	829,349	151
6400101	LAMBS MARKED - NUMBER	N	45,787	122

AUSTRALIAN BUREAU OF STATISTICS
AGRICULTURAL CENSUS 1992-93
Area by Commodity
VICTORIA-Continued

AREA		COMMODITY	UNIT OF QUANTITY	QUANTITY	NUMBER OF RESPONDENTS
225102480 Dunmunkle (S)					
	6400201	EWES MATED - CURRENT LAMBING - NUMBER	N	55,214	122
	6415101	EWES TO BE MATED TO MERINO RAMS TO LAMB IN YR TO 31/3/94-NO	N	32,576	64
	6418201	INT MATINGS & MATINGS OF EWES TO OTHER RAMS - TOTAL NUMBER	N	27,621	87
	6418601	EWES TO BE MATED TO LAMB IN YEAR ENDING 31/3/94 - NUMBER	N	60,197	128
	7002001	MILK COWS, IN MILK AND DRY (EXCLUDING HOUSE COWS) - NUMBER	N	28	4
	7003101	MILK HEIFERS AND HEIFER CALVES (EXCLUDING HOUSE COWS)-NUMBER	N	2	1
	7004751	MILK CATTLE INCLUDING BULLS (EXCL HOUSE COWS) - TOTAL NUMBER	N	30	4
	7004811	MILK COWS, HEIFERS & HEIFER CALVES (EXCL HOUSE COWS) - NO	N	30	4
	7006101	BEEF BREED BULLS & BULL CALVES USED/INTENDED FOR SERVICE- NO	N	52	24
	7006801	MEAT COWS AND HEIFERS 1 YEAR AND OVER - NUMBER	N	719	24
	7007201	COWS AND HEIFERS 1 YEAR AND OVER-FOR BEEF HERD REPLACEMENT	N	570	21
	7007301	COWS AND HEIFERS 1 YEAR AND OVER-OTHER (EG GROWING ETC)	N	149	10
	7007601	MEAT CALVES UNDER 1 YR, EXCL BULL CALVES INT FOR SERVICE- NO	N	442	23
	7008701	MEAT CATTLE NEC (STEERS,BULLOCKS,SPAY COWS) 1 YEAR & OVER-NO	N	440	18
	7009751	MEAT CATTLE EXCLUDING BULLS & CALVES FOR SERVICE - NUMBER	N	1,601	32
	7009851	MEAT CATTLE - TOTAL NUMBER	N	1,653	33
	7010101	CATTLE FOR ALL PURPOSES EXCLUDING HOUSE COWS - TOTAL NUMBER	N	1,683	33
	7500101	PIGS - BOARS - NUMBER	N	30	11
	7500601	PIGS-BREEDING SOWS AND GILTS INTENDED FOR BREEDING - NUMBER	N	408	11
	7508801	PIGS NEC INCLUDING SUCKERS, WEANERS, GROWERS ETC - NUMBER	N	2,439	11
	7508901	PIGS-TOTAL-NUMBER	N	2,877	11
	7603201	GOATS KEPT FOR FIBRE - NUMBER	N	104	2
	7603711	GOATS EXCLUDING FERAL - TOTAL NUMBER	N	104	2
	7605801	STUD HORSES - NUMBER	N	39	3
	7605901	HORSES EXCLUDING STUD - NUMBER	N	65	23
	7606051	HORSES - TOTAL NUMBER	N	104	24
	7607501	EMUS - NUMBERS	N	10	1
	7700501	SALES OF SHEEP - NUMBER	N	29,591	95
	7700901	SALES OF LAMBS - NUMBER	N	25,171	81
	7701001	SALES OF SHEEP AND LAMBS - NUMBER	N	54,762	118
	7702001	SALES OF DAIRY BULLS 1 YEAR AND OVER FOR BREEDING - NUMBER	N	4	1
	7702201	SALES OF BEEF BULLS 1 YEAR AND OVER FOR BREEDING - NUMBER	N	3	3
	7703101	SALES OF CATTLE AND CALVES, EXCL BULLS SOLD FOR BREEDING-NO	N	414	21
	7704551	SALES OF CATTLE AND CALVES - TOTAL NUMBER	N	421	21
	7704801	SALES OF GRAIN FED CATTLE- NUMBER	N	133	4
	7705501	SALES OF PIGS - NUMBER	N	3,328	13
	7706001	SALES OF GOATS EXCLUDING FERAL - NUMBER	N	24	2
	7706601	SALES OF HORSES - TOTAL NUMBER	N	7	2
	7803601	DEATHS ON HOLDING OF SHEEP & LAMBS (EXCL UNMARKED LAMBS)- NO	N	6,167	139

AUSTRALIAN BUREAU OF STATISTICS
AGRICULTURAL CENSUS 1992-93
Area by Commodity
VICTORIA-Continued

AREA		COMMODITY	UNIT OF QUANTITY	QUANTITY	NUMBER OF RESPONDENTS
225102480 Dunmunkle (S)					
	8002501	EGG STRAIN HENS & PULLETS FOR EGGS FOR HUMAN CONS-NO ON HLD	N	2,520	2
	8002502	EGG STRAIN HENS & PULLETS FOR EGGS FOR HUMAN CONS - NO DISP	N	940	2
	8005001	LIVE DUCKS - NUMBER ON HOLDING	N	6,000	1
	8006001	LIVE POULTRY NEC INCL GEESE, GAME BIRDS, ETC - NO ON HOLDING	N	700	1
	8006002	LIVE POULTRY NEC INCL GEESE, GAME BIRDS, ETC- NO DISPOSED OF	N	2,350	1
	8007001	EGGS PRODUCED FOR HUMAN CONSUMPTION - DOZEN	D	65,884	2
	8701001	SUSTAINABLE LAND USE INFORMATION - OTHER LAND HOLDERS	N	73	73
	8701501	SUSTAINABLE LAND USE INFORMATION - MEDIA(NEWSPAPERSTV)	N	82	82
	8702001	SUSTAINABLE LAND USE INFORMATION - GOVERNMENT OR COUNCIL	N	20	20
	8702501	SUSTAINABLE LAND USE INFORMATION - RESEARCH AGENCIES	N	29	29
	8703001	SUSTAINABLE LAND USE INFORMATION - OTHER	N	5	5
225103560 Kaniva (S)					
	0100101	TOTAL AREA OF HOLDING	H	196,437	192
	0100351	PASTURES AND GRASSES - TOTAL AREA CROPPED	H	4,871	102
	0108011	CROPS AND PASTURES FOR HAY - TOTAL AREA	H	4,497	105
	0108012	CROPS AND PASTURES FOR HAY - TOTAL PRODUCTION	T	13,584	103
	0108211	CROPS EXCLUDING PASTURES AND GRASSES - TOTAL AREA	H	52,928	170
	0108411	CROPS AND PASTURES - TOTAL AREA	H	57,799	173
	0108501	AREA OF LAND AFFECTED BY EROSION - WIND OR WATER AT 31 MARCH	H	825	33
	0108601	AREA OF LAND AFFECTED BY SOIL SALINITY -DRY LAND AT 31 MARCH	H	37	8
	0108701	AREA OF LAND AFFECTED BY SOIL SALINITY-IRRIGATION 31 MARCH	H	20	1
	0108801	AREA OF LAND AFFECTED BY OTHER DEGRADATION - AT 31 MARCH	H	1,184	11
	1000501	PURE LUCERNE AT 31 MARCH - AREA	H	1,424	9
	1001201	PASTURE LEGUMES EXCLUDING PURE LUCERNE AT 31 MARCH - AREA	H	7,327	17
	1001301	SOWN GRASSES AT 31 MARCH - AREA	H	6,471	18
	1001401	MIXTURE OF GRASSES AND LEGUMES AT 31 MARCH - AREA	H	76,690	126
	1001701	OTHER PASTURES - NATIVE AND NATURALISED - AREA	H	26,846	66
	1002501	SOWN PASTURE EXCLUDING PURE LUCERNE AT 31 MARCH - AREA	H	90,488	152
	1002751	SOWN PASTURES AND GRASSES AT 31 MARCH - TOTAL AREA	H	91,912	152
	1005101	PURE LUCERNE PASTURES CUT FOR HAY - AREA	H	48	2
	1005102	PURE LUCERNE PASTURES CUT FOR HAY - PRODUCTION	T	98	2
	1008101	PASTURES EXCL PURE LUCERNE, CUT FOR HAY - AREA	H	3,924	94
	1008102	PASTURES EXCL PURE LUCERNE, CUT FOR HAY - PRODUCTION	T	10,096	94
	1008401	PASTURES EXCL PURE LUCERNE, CUT FOR GREEN FEED/SILAGE - AREA	H	429	6
	1008701	PASTURES CUT FOR HAY - AREA	H	3,972	95
	1008702	PASTURES CUT FOR HAY - PRODUCTION	T	10,194	93
	1008901	PASTURES CUT FOR GREEN FEED OR SILAGE - AREA	H	429	6
	1100601	PASTURE SEED - AREA	H	470	13
	1100602	PASTURE SEED - PRODUCTION	K	129,187	13

AUSTRALIAN BUREAU OF STATISTICS
AGRICULTURAL CENSUS 1993-94
Area by Commodity
VICTORIA-Continued

AREA		COMMODITY	UNIT OF QUANTITY	QUANTITY	NUMBER OF RESPONDENTS
225102360 Donald (S)					
	8003952	MEAT CHICKENS - TOTAL NUMBER DISPOSED OF	N	980,000	2
	8005301	LIVE TURKEYS - NUMBER ON HOLDING	N	25,700	2
	8005302	LIVE TURKEYS - NUMBER DISPOSED OF	N	28,604	4
	8006001	LIVE POULTRY NEC INCL GEESE, GAME BIRDS, ETC - NO ON HOLDING	N	140	1
	8006658	POULTRY SLAUGHTERED - TOTAL	N	1,008,604	6
	8007001	EGGS PRODUCED FOR HUMAN CONSUMPTION - DOZEN	D	214,960	2
	8500101	HIVES FROM WHICH HONEY WAS TAKEN (INC POLN HIVES ROBBED) - NO	N	250	1
	8500301	HIVES KEPT FOR HONEY PROD FROM WHICH NO HONEY WAS TAKEN - NO	N	50	1
	8500701	HIVES KEPT - TOTAL NUMBER	N	300	1
	8504701	HONEY EXTRACTED (INCL HONEY COMB PRODUCED FOR SALE) - PROD	K	8,880	1
	8504901	BEESWAX OBTAINED - PRODUCTION	K	296	1
	8703501	ENOUGH INFORMATION AVAILABLE ON ORGANIC PRACTICES? - YES	N	30	30
	8703502	ENOUGH INFORMATION AVAILABLE ON ORGANIC PRACTICES? - NO	N	31	31
	8704001	HAVE YOU BEEN CERTIFIED AS AN ORGANIC PRODUCER? - YES	N	3	3
	8704002	HAVE YOU BEEN CERTIFIED AS AN ORGANIC PRODUCER? - NO	N	60	60
	8704501	ARE YOU SEEKING CERTIFICATION AS AN ORGANIC PRODUCER? - YES	N	1	1
	8704502	ARE YOU SEEKING CERTIFICATION AS AN ORGANIC PRODUCER? - NO	N	62	62
	8800101	ESTIMATED TIME TAKEN TO FILL IN FORM - MINUTES	M	6,093	119
	8800301	ESTIMATED TIME TAKEN TO FILL IN FORM - BEEKEEPING- MINUTES	M	15	1
225102480 Dunmunkle (S)					
	0100101	TOTAL AREA OF HOLDING	H	142,986	239
	0100351	PASTURES AND GRASSES - TOTAL AREA CROPPED	H	2,012	46
	0103601	NATIVE VEGETATION PROTECTED FROM DOMESTICATED ANIMALS - AREA	H	621	29
	0105501	SALT AFFECTED LAND - IRRIGATED - AREA	H	3	1
	0105502	SALT AFFECTED - DRY LAND -AREA	H	187	4
	0108011	CROPS AND PASTURES FOR HAY - TOTAL AREA	H	2,376	57
	0108012	CROPS AND PASTURES FOR HAY - TOTAL PRODUCTION	T	5,347	57
	0108211	CROPS EXCLUDING PASTURES AND GRASSES - TOTAL AREA	H	78,814	224
	0108411	CROPS AND PASTURES - TOTAL AREA	H	80,826	224
	0700101	TOTAL NUMBER OF TREES PLANTEDAT 31 MARCH	N	10,662	61
	1000401	MIXTURE OF LUCERNE AND OTHER PASTURE SPECIES - 31/3 - AREA	H	3,670	20
	1000402	MIXTURE OF LUCERNE AND OTHER PAST SOWN/RESOWN - AREA	H	96	2
	1000501	PURE LUCERNE AT 31 MARCH - AREA	H	142	6
	1001201	PASTURE LEGUMES EXCLUDING PURE LUCERNE AT 31 MARCH - AREA	H	3,140	29
	1001202	PASTURE LEGUMES EXCL PURE LUC SOWN/RESOWN IN SEASON - AREA	H	1,078	19
	1001301	SOWN GRASSES AT 31 MARCH - AREA	H	5,976	41
	1001302	SOWN GRASSES SOWN/RESOWN DURING SEASON - AREA	H	16	1
	1001401	MIXTURE OF GRASSES AND LEGUMES AT 31 MARCH - AREA	H	22,755	94
	1001402	MIXTURE OF GRASSES & LEGUMES SOWN/RESOWN DURING SEASON -AREA	H	1,502	11

AUSTRALIAN BUREAU OF STATISTICS
AGRICULTURAL CENSUS 1993-94
Area by Commodity
VICTORIA-Continued

AREA		COMMODITY	UNIT OF QUANTITY	QUANTITY	NUMBER OF RESPONDENTS
225102480 Dunmunkle (S)					
	1001701	OTHER PASTURES - NATIVE AND NATURALISED - AREA	H	7,266	83
	1002101	MIXTURE OF PERENNIAL GRASSES AND LEGUMES AT 31 MARCH - AREA	H	7,135	25
	1002102	MIXTURE OF PERENNIAL GRASSES AND LEGUMES -SOWN/RESOWN - AREA	H	50	1
	1002201	MIXTURE OF ANNUAL GRASSES AND LEGUMES AT 31 MARCH - AREA	H	11,950	57
	1002202	MIXTURE OF ANNUAL GRASSES - SOWN/RESOWN - AREA	H	1,356	8
	1002501	SOWN PASTURE EXCLUDING PURE LUCERNE AT 31 MARCH - AREA	H	31,871	151
	1002502	SOWN PASTURE EXCL PURE LUCERNE SOWN/RESOWN IN SEASON - AREA	H	2,596	27
	1002751	SOWN PASTURES AND GRASSES AT 31 MARCH - TOTAL AREA	H	32,013	151
	1005101	PURE LUCERNE PASTURES CUT FOR HAY - AREA	H	5	1
	1005102	PURE LUCERNE PASTURES CUT FOR HAY - PRODUCTION	T	6	1
	1008101	PASTURES EXCL PURE LUCERNE, CUT FOR HAY - AREA	H	1,943	45
	1008102	PASTURES EXCL PURE LUCERNE, CUT FOR HAY - PRODUCTION	T	4,499	45
	1008401	PASTURES EXCL PURE LUCERNE, CUT FOR GREEN FEED/SILAGE - AREA	H	64	1
	1008701	PASTURES CUT FOR HAY - AREA	H	1,948	45
	1008702	PASTURES CUT FOR HAY - PRODUCTION	T	4,505	45
	1008901	PASTURES CUT FOR GREEN FEED OR SILAGE - AREA	H	64	1
	1500101	WHEAT FOR GRAIN - AREA	H	22,424	194
	1500102	WHEAT FOR GRAIN - PRODUCTION	T	71,756	194
	1500801	OATS FOR GRAIN - AREA	H	1,676	40
	1500802	OATS FOR GRAIN - PRODUCTION	T	3,301	40
	1500901	OATS FOR HAY - AREA	H	236	11
	1500902	OATS FOR HAY - PRODUCTION	T	585	11
	1501701	BARLEY FOR GRAIN - AREA	H	17,377	182
	1501702	BARLEY FOR GRAIN - PRODUCTION	T	48,212	182
	1502301	CEREAL RYE FOR GRAIN - AREA	H	92	2
	1502302	CEREAL RYE FOR GRAIN - PRODUCTION	T	73	2
	1509211	CEREAL CROPS FOR GRAIN - TOTAL AREA	H	41,569	220
	1509212	CEREAL CROPS FOR GRAIN - TOTAL PRODUCTION	T	123,341	219
	1509301	CEREAL CROPS CUT FOR HAY - AREA	H	238	12
	1509302	CEREAL CROPS CUT FOR HAY - PRODUCTION	T	590	12
	1509401	CEREAL CROPS FED OFF OR CUT FOR GREEN FEED OR SILAGE - AREA	H	20	1
	1509701	CEREAL CROPS EXCLUDING OATS, CUT FOR HAY - AREA	H	2	1
	1509702	CEREAL CROPS EXCLUDING OATS, CUT FOR HAY - PRODUCTION	T	5	1
	1510001	CEREAL CROPS EXCL MAIZE, FED OFF/CUT FOR GN FEED/SILAGE-AREA	H	20	1
	1801701	SOYBEANS - AREA	H	40	1
	1801702	SOYBEANS - PRODUCTION	T	10	1
	1806701	LINSEED/LINOLA - AREA	H	10	1
	1806702	LINSEED/LINOLA (CLEAN SEED) - PRODUCTION	T	6	1
	1806911	TOTAL OILSEEDS - AREA	H	4,021	61

AUSTRALIAN BUREAU OF STATISTICS
AGRICULTURAL CENSUS 1993-94
Area by Commodity
VICTORIA-Continued

AREA		COMMODITY	UNIT OF QUANTITY	QUANTITY	NUMBER OF RESPONDENTS
225102480 Dunmunkle (S)					
	1806912	TOTAL OILSEEDS - PRODUCTION	T	6,259	61
	1807001	WHITE OR YELLOW LUPINS FOR GRAIN - AREA	H	408	8
	1807002	WHITE OR YELLOW LUPINS FOR GRAIN - PRODUCTION	T	565	8
	1809011	LEGUMES FOR GRAIN - TOTAL AREA	H	32,704	194
	1809012	LEGUMES FOR GRAIN - TOTAL PRODUCTION	T	53,670	192
	1809101	FIELD PEAS FOR GRAIN - AREA	H	11,703	147
	1809102	FIELD PEAS FOR GRAIN - PRODUCTION	T	21,993	147
	1809451	COW AND FIELD PEAS FOR GRAIN - TOTAL AREA	H	11,703	147
	1809452	COW AND FIELD PEAS FOR GRAIN - TOTAL PRODUCTION	T	21,993	147
	1900301	CHICK PEAS - AREA	H	15,415	136
	1900302	CHICK PEAS - PRODUCTION	T	23,462	136
	1900901	CANOLA/RAPESEED (CLEAN SEED) - AREA	H	2,623	41
	1900902	CANOLA/RAPESEED (CLEAN SEED) - PRODUCTION	T	4,981	41
	1901401	SAFFLOWER - AREA	H	1,348	23
	1901402	SAFFLOWER - PRODUCTION (CLEAN SEED)	T	1,262	23
	1901951	CROPS FED OFF OR CUT FOR GREEN FEED OR SILAGE - TOTAL AREA	H	35	2
	1904801	VETCHES FOR SEED - AREA	H	142	3
	1904802	VETCHES FOR SEED - PRODUCTION	K	198,000	3
	1905111	CROPS FOR HAY - TOTAL AREA	H	428	16
	1905112	CROPS FOR HAY - TOTAL PRODUCTION	T	842	16
	1905201	LENTILS - AREA	H	270	3
	1905202	LENTILS - PRODUCTION	T	301	3
	1907601	TICK, HORSE AND FABA BEANS - AREA	H	4,765	78
	1907602	TICK, HORSE AND FABA BEANS - PRODUCTION	T	7,151	78
	1909001	CROPS EXCL CEREALS & FORAGE SORGHUM, CUT FOR HAY - AREA	H	190	4
	1909002	CROPS EXCL CEREALS & FORAGE SORGHUM, CUT FOR HAY - PRODN	T	252	4
	1909101	CROPS EXCL CEREALS & FORAGE SORG-FO/CUT FOR GR FEED/SIL-AREA	H	15	1
	1909801	NON CEREAL CROPS NEC - AREA	H	57	1
	3300501	WHEAT SOWN OR INTENDED TO BE SOWN IN 1994 - AREA	H	21,600	192
	3300801	OATS SOWN OR INTENDED TO BE SOWN IN 1994 - AREA	H	1,928	45
	3301101	BARLEY SOWN OR INTENDED TO BE SOWN IN 1994 - AREA	H	11,864	155
	3301501	FIELD PEAS SOWN OR INTENDED TO BE SOWN IN 1994 - AREA	H	12,687	150
	3301801	LUPINS FOR CROP SOWN OR INTENDED TO BE SOWN IN 1994 - AREA	H	1,036	15
	3302801	WHEAT HELD ON HOLDING AT 31 MARCH	T	7,031	145
	3303201	OATS HELD ON HOLDING AT 31 MARCH	T	2,385	51
	3303601	BARLEY HELD ON HOLDING AT 31 MARCH	T	7,857	131
	3307101	HAY HELD ON HOLDING AT 31 MARCH	T	12,781	101
	3307201	HAY SOLD DURING YEAR ENDED 31 MARCH	T	1,266	16
	5608901	ARTIFICIAL FERTILISERS USED - AREA	H	58,523	168

AUSTRALIAN BUREAU OF STATISTICS
AGRICULTURAL CENSUS 1993-94
Area by Commodity
VICTORIA-Continued

AREA		COMMODITY	UNIT OF QUANTITY	QUANTITY	NUMBER OF RESPONDENTS
225102480 Dunmunkle (S)					
	5608902	ARTIFICIAL FERTILISERS USED - QUANTITY	T	6,046	168
	5609301	SOIL CONDITIONERS USED - AREA	H	7,277	93
	5609302	SOIL CONDITIONERS - TONNES	T	16,953	93
	5700501	PASTURES IRRIGATED - AREA	H	178	20
	5700601	CEREAL CROPS IRRIGATED - AREA	H	137	1
	5701501	CROPS NEC IRRIGATED - AREA	H	14	1
	5708955	CROPS AND PASTURES IRRIGATED - TOTAL AREA	H	329	22
	5709201	HOLDING FLOOD IRRIGATED - AREA	H	162	18
	5800601	IRR BY CHANNEL FROM SURFACE WATER IN STATE IRR SCHEME - AREA	H	327	21
	5801001	IRRIGATED DIRECT FROM UNREGULATED STREAMS - AREA	H	2	1
	5803055	IRRIGATED LAND - AREA	H	329	22
	6000101	RAMS ONE YEAR AND OVER - NUMBER	N	1,540	121
	6000201	BREED EWES 1 YR & OVER, INCL MAIDEN EWES INTEND FOR BREED-NO	N	59,400	138
	6000301	NON-BREEDING EWES ONE YEAR AND OVER - NUMBER	N	9,184	44
	6000401	WETHERS ONE YEAR AND OVER-NUMBER	N	37,250	105
	6000501	LAMBS AND HOGGETS UNDER ONE YEAR - NUMBER	N	51,916	136
	6000601	SHEEP & LAMBS - TOTAL NUMBER	N	159,290	173
	6000751	SHEEP EXCLUDING LAMBS - TOTAL NUMBER	N	107,374	169
	6300101	SHEEP SHORN - NUMBER	N	123,894	161
	6300102	SHEEP WOOL (INCLUDING LOCKS, PIECES & BELLIES) - PRODUCTION	K	708,865	161
	6300201	LAMBS SHORN - NUMBER	N	40,008	110
	6300202	LAMBS WOOL (INCLUDING LOCKS, PIECES & BELLIES) - PRODUCTION	K	60,045	110
	6300302	CRUTCHINGS, ETC - PRODUCTION	K	23,444	84
	6300401	SHEEP AND LAMBS SHORN - TOTAL NUMBER	N	163,902	162
	6300402	WOOL - TOTAL PRODUCTION	K	792,354	162
	6400101	LAMBS MARKED - NUMBER	N	47,727	132
	6400201	EWES MATED - CURRENT LAMBING - NUMBER	N	55,495	132
	6415101	EWES TO BE MATED TO MERINO RAMS TO LAMB IN YR TO 31/3/95-NO	N	28,486	59
	6418201	INT MATINGS & MATINGS OF EWES TO OTHER RAMS - TOTAL NUMBER	N	25,886	93
	6418601	EWES TO BE MATED TO LAMB IN YEAR ENDING 31/3/95 - NUMBER	N	54,372	125
	7002001	MILK COWS, IN MILK AND DRY (EXCLUDING HOUSE COWS) - NUMBER	N	9	4
	7003101	MILK HEIFERS AND HEIFER CALVES (EXCLUDING HOUSE COWS)-NUMBER	N	3	2
	7004751	MILK CATTLE INCLUDING BULLS (EXCL HOUSE COWS) - TOTAL NUMBER	N	12	4
	7004811	MILK COWS, HEIFERS & HEIFER CALVES (EXCL HOUSE COWS) - NO	N	12	4
	7006101	BEEF BREED BULLS & BULL CALVES USED/INTENDED FOR SERVICE- NO	N	59	27
	7006801	MEAT COWS AND HEIFERS 1 YEAR AND OVER - NUMBER	N	728	30
	7007201	COWS AND HEIFERS 1 YEAR AND OVER-FOR BEEF HERD REPLACEMENT	N	624	26
	7007301	COWS AND HEIFERS 1 YEAR AND OVER-OTHER (EG GROWING ETC)	N	104	7
	7007601	MEAT CALVES UNDER 1 YR, EXCL BULL CALVES INT FOR SERVICE- NO	N	577	28

AUSTRALIAN BUREAU OF STATISTICS
AGRICULTURAL CENSUS 1993-94
Area by Commodity
VICTORIA-Continued

AREA		COMMODITY	UNIT OF QUANTITY	QUANTITY	NUMBER OF RESPONDENTS
225102480 Dunmunkle (S)					
	7008701	MEAT CATTLE NEC (STEERS,BULLOCKS,SPAY COWS) 1 YEAR & OVER-NO	N	308	15
	7009751	MEAT CATTLE EXCLUDING BULLS & CALVES FOR SERVICE - NUMBER	N	1,613	33
	7009851	MEAT CATTLE - TOTAL NUMBER	N	1,672	35
	7010101	CATTLE FOR ALL PURPOSES EXCLUDING HOUSE COWS - TOTAL NUMBER	N	1,684	36
	7500101	PIGS - BOARS - NUMBER	N	39	12
	7500601	PIGS-BREEDING SOWS AND GILTS INTENDED FOR BREEDING - NUMBER	N	555	12
	7508801	PIGS NEC INCLUDING SUCKERS, WEANERS & GROWERS ETC - NUMBER	N	3,004	14
	7508901	PIGS - TOTAL NUMBER	N	3,598	14
	7602001	DONKEYS - NUMBER	N	2	2
	7603201	GOATS KEPT FOR FIBRE - NUMBER	N	138	3
	7603711	GOATS EXCLUDING FERAL - TOTAL NUMBER	N	138	3
	7605801	STUD HORSES - NUMBER	N	21	2
	7605901	HORSES EXCLUDING STUD - NUMBER	N	66	22
	7606051	HORSES - TOTAL NUMBER	N	87	23
	7607501	EMUS - NUMBERS	N	180	9
	7700501	SALES OF SHEEP - NUMBER	N	45,263	114
	7700901	SALES OF LAMBS - NUMBER	N	27,437	98
	7701001	SALES OF SHEEP AND LAMBS - NUMBER	N	72,700	138
	7702001	SALES OF DAIRY BULLS 1 YEAR AND OVER FOR BREEDING - NUMBER	N	8	2
	7702201	SALES OF BEEF BULLS 1 YEAR AND OVER FOR BREEDING - NUMBER	N	15	6
	7703101	SALES OF CATTLE AND CALVES, EXCL BULLS SOLD FOR BREEDING-NO	N	1,197	23
	7704551	SALES OF CATTLE AND CALVES - TOTAL NUMBER	N	1,220	24
	7705501	SALES OF PIGS - NUMBER	N	4,639	13
	7706601	SALES OF HORSES - TOTAL NUMBER	N	8	3
	7707101	SALES OF EMUS - NUMBER	N	7	1
	7803601	DEATHS ON HOLDING OF SHEEP & LAMBS (EXCL UNMARKED LAMBS)- NO	N	5,375	149
	8002501	LAYERS - HENS & PULLETS FOR EGGS FOR HUMAN CONS-NO ON HLD	N	1,320	2
	8002502	LAYERS - HENS & PULLETS FOR EGGS FOR HUMAN CONS - NO DISP	N	2,040	2
	8002601	LAYERS - REPLACEMENT STOCK - NUMBER ON HOLDING	N	1,480	2
	8003501	MEAT CHICKENS GROWN ON CONTRACT - NUMBER ON HOLDING	N	46,000	1
	8003951	MEAT CHICKENS - TOTAL NUMBER ON HOLDING	N	46,000	1
	8007001	EGGS PRODUCED FOR HUMAN CONSUMPTION - DOZEN	D	45,800	2
	8703501	ENOUGH INFORMATION AVAILABLE ON ORGANIC PRACTICES? - YES	N	41	41
	8703502	ENOUGH INFORMATION AVAILABLE ON ORGANIC PRACTICES? - NO	N	56	56
	8704001	HAVE YOU BEEN CERTIFIED AS AN ORGANIC PRODUCER? - YES	N	2	2
	8704002	HAVE YOU BEEN CERTIFIED AS AN ORGANIC PRODUCER? - NO	N	94	94
	8704501	ARE YOU SEEKING CERTIFICATION AS AN ORGANIC PRODUCER? - YES	N	3	3
	8704502	ARE YOU SEEKING CERTIFICATION AS AN ORGANIC PRODUCER? - NO	N	92	92
	8800101	ESTIMATED TIME TAKEN TO FILL IN FORM - MINUTES	M	8,251	146

APPENDIX 9

Preliminary Study of Soils Associated with the WIM 200 and WIM 250 Mining Sites in The Yarriambiack Shire (1999), Prepared for the Dunmulkle Land Protection Group, by Alan Bedggood, Victorian Institute of Dryland Agriculture, DNRE, Horsham.

PRELIMINARY STUDY OF SOILS ASSOCIATED WITH THE WIM 200 AND WIM 250 MINING SITES IN THE YARRIAMBIACK SHIRE

Prepared for the Dunmunkle Land Protection Group

By Alan Bedggood
Landcare Support Officer
Agriculture Victoria
Victorian Institute for Dryland Agriculture
Horsham.

ACKNOWLEDGEMENTS

The Department of Manufacturing and Industry Development made this study possible by the donation of funds.

Derek Dykstra, Department of Agriculture, Victoria, began preliminary work on this project and set objectives for the soil related activities.

Dr Graham Ford was instrumental in presenting the results to the farming community with the results at the soil pit sites and resulting discussions and interpretations. His comments and editing have been a major contribution to this manuscript.

The patience and understanding of the Dunmunkle Land Protection Group, of Jim Starbuck and Ian Morgan in particular, is greatly appreciated.

CONTENTS

PRELIMINARY STUDY OF SOILS ASSOCIATED WITH THE WIM 200 AND WIM 250 MINING SITES IN THE YARRIAMBIACK SHIRE

INTRODUCTION

Wimmera Industrial Mining, a subsidiary of CRA, has identified two sites (mining leases WIM 200 and WIM 250) in the Yarriambiack shire (previously, the Dunmunkle shire) as having potential for the extraction of titanium and zirconium bearing minerals (illminite, rutile and zircons) from the subterranean sand deposits. A considerable amount of overburden has to be removed to extract these sands, which vary from 3 to 20 metres below the surface.

The two sites are located between the Dunmunkle Creek and the Richardson river to the east of Rupanyup (see map). The majority of the area encompassed by these two sites is highly productive agricultural land that has been farmed for over 120 years. Excavation to the depth of these mineral sands layers will necessarily completely disrupt this agricultural area. Even if the soils are returned in some semblance of the order in which they were removed, there is considerable concern that the inevitable mixing of the soil material from various depths will adversely affect post-mining productivity. Raising soil material, which is sodic, highly alkaline and possibly saline, as well as possible adverse biological changes in the topsoil, are all possible outcomes of extractive mining activities.

1. AIMS

The purpose of this study was to obtain preliminary information on the soils in these two mining sites and to identify their agricultural significance. Points of particular interest were the fertility of the topsoil, which has been developed by farm management practices over many years, and the possible impact of the soil properties on the rooting depth of crops growing in these soils.

The soil properties that impact on the rooting depth of the crops will create implications on the procedure for sand mining and for the rehabilitation of the area after mining.

2. METHODS

a) Site selection

The best available information on the soils of this area is in two Department of Agriculture reports "Agricultural Management and Productivity Information System (AMPIS) (Dykstra, unpublished) and "Soils of the Eastern Wimmera" (Badawy, 1984). These were used to determine the variability and occurrence of the soils in the mining site areas. The predominant soils identified in these reports were grey clays with small occurrences of red duplex soils associated with rising ground and some smaller areas of `watercourse' land. The soil association maps of Badawy (1984) were used to select sites for soil pits within both mining lease areas which were representative of the major soils identified in his survey. Each of the eight sites chosen was also selected to be in a crop phase of rotation as information on the distribution of crop roots within each soil profile was required.

b) Soil pits

The pits were excavated in November 1993. At each site, a soil pit approximately 1.5 m wide and 1.5 m deep was excavated by a backhoe. The floor of the pit sloped to the surface to allow easy access. The face of the pit was chipped away to remove marks left by the backhoe and leave the natural structure of the soil visible. The depth of the crop roots was ascertained and marked by tapes; yellow indicating the lower level of the majority of roots, red indicating the lower level of the longest visible root. A photographic record was also made of the pit face.

The main horizons of the soil profile were identified and profile samples were taken for analysis. A topsoil (0 - 10 cm) sample was taken from the pit face. Soil samples were taken from each horizon as sections of soil 10 cm wide and 10 cm deep taken over the full depth of each; 4 to 6 samples being taken for each pit. The samples were air dried at 38^0C and gently crushed to pass through a 2 mm sieve before being sent to Richland Laboratories, Tatura 3616, for detailed analyses.

After the crop was harvested, a series of soil cores to approximately 1.5 m deep were taken from across the paddock to indicate how representative the soil pit was of the whole paddock. These cores were placed side by side and photographed.

c) Soil tests - nutrients

The soil tests undertaken were mostly chemical analyses to assess the available nutrient status of the soil and to gain an appreciation of the potential soil structure. Fertiliser recommendations are based, to some extent, on the results of such tests but more often on other considerations. It is necessary, therefore, to distinguish between those factors that represent technical data and those that are interpretive judgements. The soil tests performed on the pit samples can be divided into two classes: *nutritional* and *structural*, with the subsoils receiving only the structural tests.

The *nutritional* tests measure :

i. the acidity or the alkalinity of the soil **(pH)**. This is measured in a 1:5 soil suspension using either water (pH_{water}) or in a dilute (0.01 M) suspension of calcium chloride (pH_{CaCl2}). This gives an indication of the potential availability of many of the nutrients. Most crop plants perform best in the pH_{water} range of 6.5 to 8 (bear in mind that a pH of 5 is 10 times more acid than pH of 6).

ii. the **Salinity** of the soil. This will indicate any potential problems with plant vigour. In saline soils, the high levels of soluble salts increase the osmotic potential for plants and restrict uptake of water and nutrient. The salinity of the soil may also affect the soil structure. The salinity level is measured from the electrical conductivity of a 1:5 soil:water suspension and is recorded as E.C. units (dS/m).

iii. the **Total Nitrogen** content (%N) of the soil measures all of the nitrogen stored in the soil organic matter.

iv. the **Nitrate Nitrogen** measures the nitrogen that is in a plant available (water soluble) form, whether from mineralisation (decomposition) of organic matter or from fertiliser applications. It is recorded as mg N / kg soil, numerically equivalent to ppm.

v. the **Organic Carbon** (%C) is a measure of the total organic matter in the soil. Soil organic matter is an important source of many nutrients, and contributes to stabilising soil aggregates.

vi. the available **Phosphorus** levels in the soil is a measure of its general fertility,; Australian soils are naturally low in phosphorus. This nutrient is necessary to develop a good root system in plants especially during the early development of most crops. Phosphorus is chemically altered ("fixed") in the soil into forms that are not available to plants. Note that this soil test (using the Colwell method) indicates the potential phosphate status of the soil, not necessarily the ability to supply phosphate to plants. However, it allows soils to be compared on the basis of potential phosphate status.

d) Soil tests - structure

Three major types of soil structure are identified, *single-grained* (unattached), *massive* (large and massive blocks) and *aggregated* (intermediate, with small clods or aggregates). The soils encountered in this study are of the aggregated type and it is the stability of the soil aggregates that determines the degree of soil structure and affects management decisions to maintain and or improve soil aggregate stability. The formation and stability of soil aggregates is dependent largely upon the quantity and mineralogy of the clay fraction and upon the presence of various forms of organic matter.

Flocculation
Flocculation of soil clay is a necessary condition for aggregate formation, although this alone does not form aggregates. Various cementing agents impart stability to soil aggregates such as dehydrated colloids of iron and aluminium oxides, calcium carbonate and especially stable organic complexes ("humus") resulting from the decomposition of plant and animal residues.

When the clay is deflocculated, as under the influence of exchangeable sodium, the soil aggregates generally collapse. Aggregates are also vulnerable to the effects of water (swelling and shrinking, raindrop action, ice formation, scouring), excessive tillage and compaction. The development and maintenance of a desirable soil structure, optimal for plant growth, is a perpetual requirement in agricultural soil management (Hillel, 1971).

Sodicity and sodic soils
A sodic soil is one which has a high ratio of soluble (or exchangeable) sodium compared to the sum of the calcium, magnesium and potassium components (Sodium Adsorption Ratio (SAR) in a 1:5 soil water extract greater than 3). When this occurs, the soluble sodium repels the negatively charged clay particles from the aggregates into the soil solution, *dispersing* the clay and breaking down the soil aggregates. The presence of high levels of total soluble salts (EC) will neutralise this effect. Hence, SAR and E.C. indicate the tendency for a soil to disperse (have poor structure).
The Sodium Adsorption Ratio is defined as:

$$\mathbf{SAR = [(Exchangeable\ Na^{+})/5]\ /\ [(Exchangeable\ Ca^{++} + Mg^{++})/10]^{1/2}}$$

where [ ] refers to concentrations in me/kg.

Another measure of soil sodicity is the Exchangeable Sodium Percentage (ESP). This is the percentage of exchangeable sodium of the total of exchangeable calcium, magnesium, sodium and potassium components of the soil. If the ESP is greater than 6 then the soil is classed as sodic.

The Exchangeable Sodium Percentage (ESP) is defined as:

$$\mathbf{ESP} = \frac{\mathbf{(100 * Exchangeable\ Na)}}{\mathbf{\Sigma(Exchangeable\ Ca+Mg+K+Na)}}$$

When using ESP as a measure of soil sodicity, the presence of sodium salts in the soil causes problems as the sum of the cations is used as the denominator. Thus, SAR is better used to describe soil sodicity when a saline condition occurs (Sumner, 1995).

Soil structure is also affected by the ratio of calcium to magnesium in the soil. If the magnesium level in the soil rises to greater than half that of the calcium (ie a calcium: magnesium ration of 2 or less) then this compounds the problems of sodicity in soil. Many Wimmera clays have high levels of calcium as limestone in the profile and so are less influenced by the magnesium levels.

Sodic surface soils will degrade when wet and form a smooth surface which crusts when dry. This restricts further water entry and the emergence of seedlings. Sodic subsoils will become more compacted after periods of wetting as the dispersed particles fill remaining spaces within the soil. These soils restrict the further movement of plant roots and moisture through the soil profile.

Slaking

A lump or small clod of soil is made up of a whole lot of smaller aggregates held together by various binding agents. These binding agents include the products of the breakdown of organic matter (resins, etc), the exudates from worms and snails, the growth of bacterial and fungal bodies in the soil and the effects of the myriad of insects and their larvae in the soil. These lumps also contain air spaces within their structure.

When placed in water or during heavy rain, water enters the clod of soil and displaces the air. In doing so, the air forces apart the soil aggregates making up the clod and it will break apart. This makes the soil surface flatter and can cause some surface crusting. However, the crusting caused in this way is less severe but will contribute to soil structure problems, especially if the soil is also dispersive (sodic).

Gypsum

Gypsum dissolved in water works to improve soil structure. Therefore, the finer the gypsum, the more surface area available to dissolve with water. Lumpy or crystal gypsum is of poorer quality for soil structure reclamation.

Gypsum improves soil structure in two ways, by initially raising the electrolyte level in the soil in the short term and by reducing the exchangeable sodium level on the clays in the long term. Electrolytes are soluble salts (not necessarily toxic salts). Gypsum in solution is an electrolyte and negates the repulsive effect of the sodium atoms on the clay particles (dispersion). Gypsum in solution forms Ca^{++} and SO_4^{--} ions. The larger Ca^{++} ions displace the Na^{+} ions on the clay. Chemically, the calcium binds the clay particles more closely together and reduces dispersion.

The *structural* tests measure :

i. the **pH** also. Soils with high levels of sodium will tend to disperse more if the pH level is high (>8; alkaline sodic soils). The concentrations of carbonates and bicarbonates in the soil increase due to evaporation, causing soluble calcium and magnesium to become low in the soil due to precipitation and soluble sodium levels increase in the soil solution (Rengasamy and Olsson, 1991).

ii. the **Salinity** also. Saline soils tend not to disperse, but can create management problems, particularly with germination and plant establishment.

iii. the exchangeable **Sodium** cations in the soil; high levels indicate a sodic soil condition with its associated management problems such as surface crusting or the formation of hardpans (Ford, *et al.* 1993).

iv. the soluble **Potassium, Calcium and Magnesium** cations in a 1 : 5 soil : water extract are used in the assessment of soil sodicity.

v. the Sodium Adsorption Ratio (**SAR**) indicates the likely effect of the relative proportions of soluble sodium, calcium and magnesium on the swelling and dispersion of the clay, and thus, on soil behaviour (eg infiltration versus run-off of water). A value or three or more is considered to indicate potential problems.

vi. the Total Cation Concentration (**TCC**). This is estimated from the soil E.C. and is used to interpret the likely effects of the SAR on soil stability, and to predict the probable gypsum requirement of each soil layer, especially the surface soil (Ford, *et al*. 1993).

viii. the **ratio** of exchangeable Calcium to Magnesium in the 1:5 soil:water extract. A ratio of 2 or greater is considered beneficial in heavier soils.

ix. the **Clay Dispersion**. This is a measure's the stability of soil aggregates when gently shaken in 1:5 soil:water suspension. A value of less than 1 % dispersed clay is preferable for surface soils and for subsoils, the lower the value the better. In the soil, unstable aggregates break apart and release clay particles which are carried by water into the soil profile. These block the natural channels in the soil, thus restricting water movement and oxygen exchange. Several soil properties (eg, pH, EC, sodium content, organic matter) affect aggregate stability and hence clay dispersion. Management (eg cultivation) also plays a major role in maintaining aggregate stability.

3. RESULTS

Soils Associations.

At the scale of mapping used by Badawy (1984), the distribution of the various soil types is described using larger units referred to as **soil associations**. A soil association is a group of adjoining soil types which occur in a pattern that may be repeated in different parts of the area. Each of these soil groups usually occupy a particular and often distinctive part of the landscape.

Six soil associations have been mapped in the WIM 200 and WIM 250 sites. Each of these associations have been given the name of its principal soil type. Table 1 lists the soil associations and the approximate percentage of the total area of the mining sites.

The eight soil pits were numbered sequentially from the southern to the northern most site. The pits are located on soils that make up the major soil associations in the mining site areas. The results of the soil tests and associated comments are grouped into these soil classifications, the order being that of the largest occurrence to the smallest.

Table 1. The percentage of each soil association (Badawy, 1984) making up the WIM 200 and WIM 250 mining sites

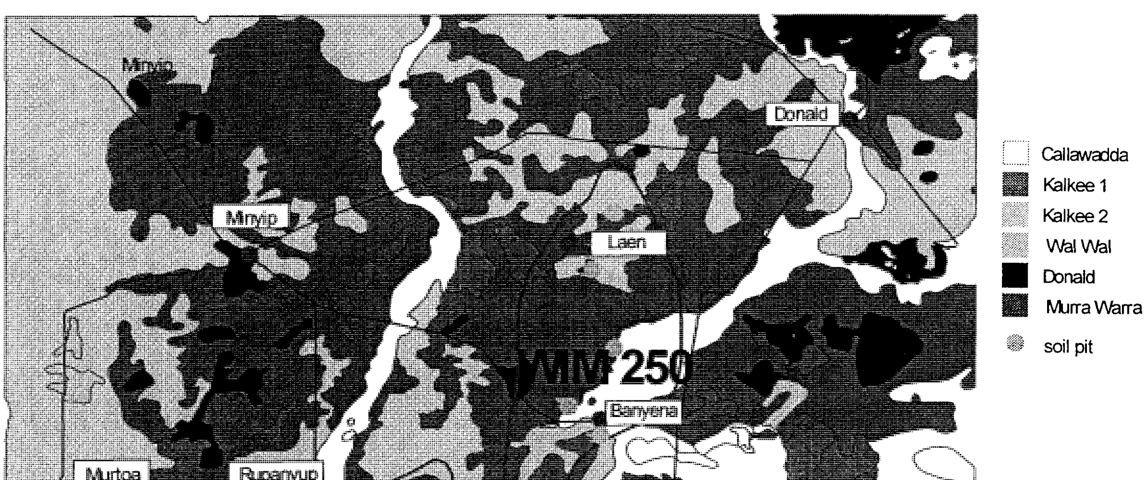
	Percentage of the area that is covered by the soil association		
Soil Association	**WIM 200**	**WIM 250**	**Total**
Murra Warra	25.0	64.0	51.5
Kalkee - Unit 2	57.5	16.5	29.6
Kalkee - Unit 1	0	17.0	11.5
Callawadda	11.3	0	3.6
Donald	4.3	2.5	3.2
Wal Wal	1.9	0	0.6

Table 2. Descriptions of soils in the soil associations found in the WIM 200 and WIM 250 mining sites (Badawy, 1984)

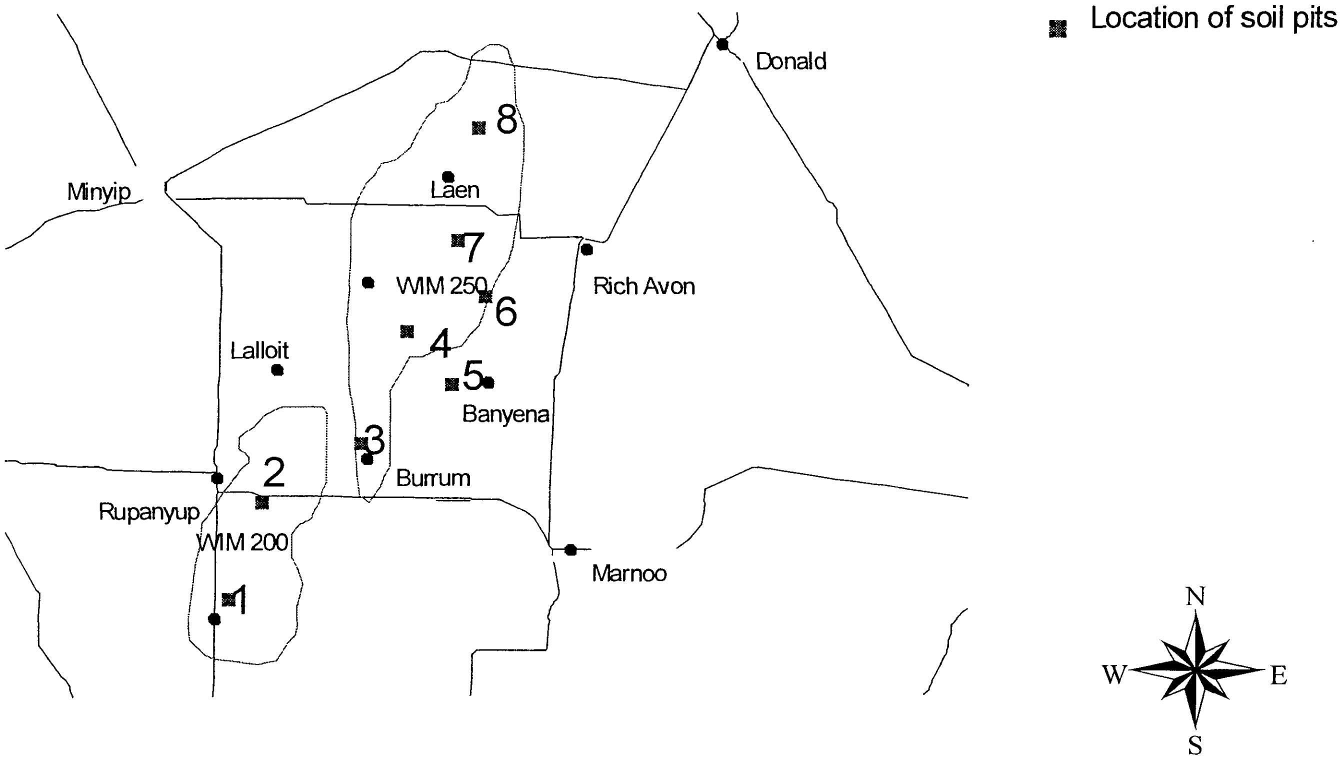
	Location in the landscape and the main soils of the association	Dominant Soils
Murra Warra	*moderately and gently undulating plains, clustered lake lunette systems and lower outwash slopes* Brown (& red) self-mulching cracking clays and the hard alkaline red duplex soils. The sub-dominant soils include grey (& dark grey) self-mulching cracking clays.	Murra Warra group Charlton series Donald sandy clay loam
Kalkee - Unit 1	*gently undulating plains and flood plains* Mostly grey (& dark grey) self-mulching cracking clays. Brown self-mulching cracking clays are of minor occurrence (less than 10% by area)	Kalkee group

Kalkee - Unit 2	*gently undulating plains, river plood plains and drainage lines* Similar to Kalkee - Unit 1, the main distinction being an increase in the proportion of brown (& red) cracking self-mulching clays to 10 to 40 % of the soil association area.	Kalkee group
Callawadda	*river flood plains, flood plains with channel networks, drainage lines, lake flood plains and gently undulating plains* Hard red, yellow and mottled-yellow duplex soils. Other soils include hard alkaline brown and neutral mottled-yellow duplex soils and cracking clays.	Callawadda series Brim fine sandy clay loam Bunguluke series Stratford clay loam
Donald	*lake lunette systems and lake flood plains* Hard alkaline red and mottled-yellow duplex soils and non-friable cracking grey clays. Also, sandy alkaline yellow duplex soils, cracking red clays and cracking clays with bleached subsoils.	Donald series Bunguluke series Charlton series
Wal Wal	*plains with prior streams and gently undulating plains.* Cracking clays with bleached subsoils and hard alkaline red and yellow duplex soils. Other soils include friable and non-friable grey and brown cracking clays.	Wal Wal clay Brim fine sandy clay loam Callawadda loam Donald fine sandy loam

Figure 1. Map of soil types (after Badawy 1984), location of mining sites and of soil pits.



WIM 200 and WIM 250 mining sites with the location of the soil pits identified.



BANYENA
red rise

SITE 6 BANYENA (red rise)

PHOTOGRAPH 1

This pit was 1.4 m deep in a red duplex soil typical of many of the red rises in the area. The surrounding wheat crop was more advanced in maturity than at the other pit sites, mostly attributable to the lack of moisture available to it. The red sandy clay subsoil continued to about 60 cm where the free carbonates occurred in a diffuse nodular form. The carbonate nodules were most abundant between 60 and 110 cm and sparse below 110 cm.

The majority of the crop roots were down to 75 cm (indicated by the yellow tape). The blocky nature of the subsoils allowed the crop roots to penetrate between the block interfaces, some penetrating to 1.3 m (red tape).

PHOTOGRAPH 2

The lighter topsoil was over heavier subsoil indicating a duplex soil type. The subsoil is subject to compaction and may cause a hard pan, reducing root and moisture penetration. A hard pan is indicated at this site by the horizontal segments falling apart in the top left of the photograph. Some worm holes and old tree roots were evident, with some crop roots following these pathways to below 1.0 m.

PHOTOGRAPH 3

Soil cores were taken after harvest, at equal intervals of about 80 m across the paddock, to indicate possible variations in the soil profile. The left-most core was taken 80 m from the pit site and the others sequentially across the paddock in a north-westerly direction. The cores indicate a uniform paddock of grey clay with lighter grey subsoils, particularly further across the paddock. The third core was placed into an area of deep grey soil with no sign of any carbonate deposits occurring.
The red rise that the soil pit was placed on continued to the west and did not extend into the paddock to any degree.

PHOTOGRAPH 4

View north-west in the direction of the soil core sampling, with the sampling rig preparing for the first core. The eastern extremity of the red rise can be seen in the foreground, the soil pit being placed just to the right of the photograph and was previously sown to Meering wheat. The rise extending to the west was planted to saltbush and was fenced off to control stock grazing. The soil surface across the remainder of the paddock was very flat and of a uniform grey colour.

a) <u>THE MURRA WARRA ASSOCIATION</u>

The dominant soil association in both mining site areas is the Murra Warra association. This is particularly so on the WIM 250 site. This association consists of brown and red self-mulching cracking clays and hard alkaline red duplex soils. To a lesser extent, cracking grey clays also occur.

Two soil pits were located in these soils - pits 6 and 7.

i. SITE 6 BANYENA (red rise)

This pit was on the property of Mr Gerald Drum, situated about 5 kilometres north of Banyena on the Glenorchy - Donald Road. The pit was placed towards the base of a red rise, typical of so many in the area. The pit was in the south east corner of the paddock on the rise which fell away to the north (region 17 fire map reference 42D, 633 556). The red soil petered out about 50 metres north of the pit and was replaced by self-mulching grey clay. The paddock had been sown to wheat and the crop had turned colour with the grain at the dough stage.

The soil profile represented the red soil that makes up the rises in the area and corresponded to the hard alkaline red duplex soil described by Badawy (1984). The topsoil has poor structure and is readily broken down into slurry by heavy rainfall. This slurry then sets and crusts, restricting plant emergence and subsequent water penetration. The wet soil is also prone to compaction by traffic of animals and vehicles. Cultivation when the soil is very wet will also break down soil structure and cause crop emergence and development problems. A very compacted band was evident in the profile just below the cultivation depth of about 15 cm.

Deposits of carbonate were present in a layer between 55 cm and 100 cm with occasional nodules lower down. The lower soil layers had increased proportions of sand and were more open. The majority of the crop roots (wheat) were down to 75 cm (yellow tape) with the longest root going down to 1.3 m. These lower roots followed cracks in the blocky structure of the soil. These cracks often had dark iron deposits in very thin layers.

Soil cores were taken 80 to 100 m apart, heading in a north-north-west direction from the soil pit. The cores show a range of soils across the paddock, the later 3 cores show free carbonate coming very close to the soil surface.

For testing, the profile was sampled at the following depths:

0 - 10 cm	topsoil
10 - 30 cm	red brown soil, blocky in structure
30 - 60 cm	red brown soil with increased amounts of sand
60 - 110 cm	limestone nodule deposits
110 - 140 cm	layer with reduced limestone, more sand in texture.

The 0 - 10 cm sample was tested for nutritional as well as structural properties. The subsurface samples were tested for structural properties only.

soil test results

Topsoil

Nutrition		Structure			
pH water	6.9	Texture; Fine sandy clay loam			
pH CaCl2	6.3	Sodium (me/kg)	1.2	ESP	14.6
E.C. (dS/m)	0.08	Potassium (me/kg)	0.4	SAR	0.3
Total Nitrogen (%N)	0.04	Calcium (me/kg)	5.0	TCC (me/L)	0.91
Nitrate Nitrogen (mg N/kg)	8.2	Magnesium (me/kg)	1.6	Ca/Mg	3.13
Organic Carbon (%C)	0.6			Clay Dispersion %	3.0
Phosphate (mg P/kg)	20.0				

The pH of the topsoil is practically neutral, very satisfactory for plant growth as most nutrients are soluble and available at this pH. The salinity level is very low and is of no toxicity concern for plant growth. However, nutrients are included in the Total Cation Concentration (TCC) measurement and the low level (< 1.0) in this soil may indicate reduced nutrient levels. The total nitrogen and organic carbon values are extremely low for this soil type. Stubble retention and reduced tillage practices should be adopted to raise these levels as this supplies much of the nutrients utilised by plants. The nitrate nitrogen level is low although this is expected at this late stage of the development of a wheat crop. The phosphate level is average for this soil type.

The soil surface at this site is hard setting, very prone to degradation by rainfall and mechanical disturbance. These observations are supported by the soil tests. The soil has a moderately high level of sodicity (ESP greater than 6) with very low levels of soluble salts (EC < 0.1 dS/m). With low levels of organic matter to help "bind" the soil together and the sodic nature of the clays, this soil will be quite dispersive.

Retention of stubble on the soil surface will reduce the impact damage to soil clods caused by raindrops. Low organic levels indicate a reduced level of microbial activity and hence more slaking. Reduced slaking with this soil type will reduce the incidence of dispersion.

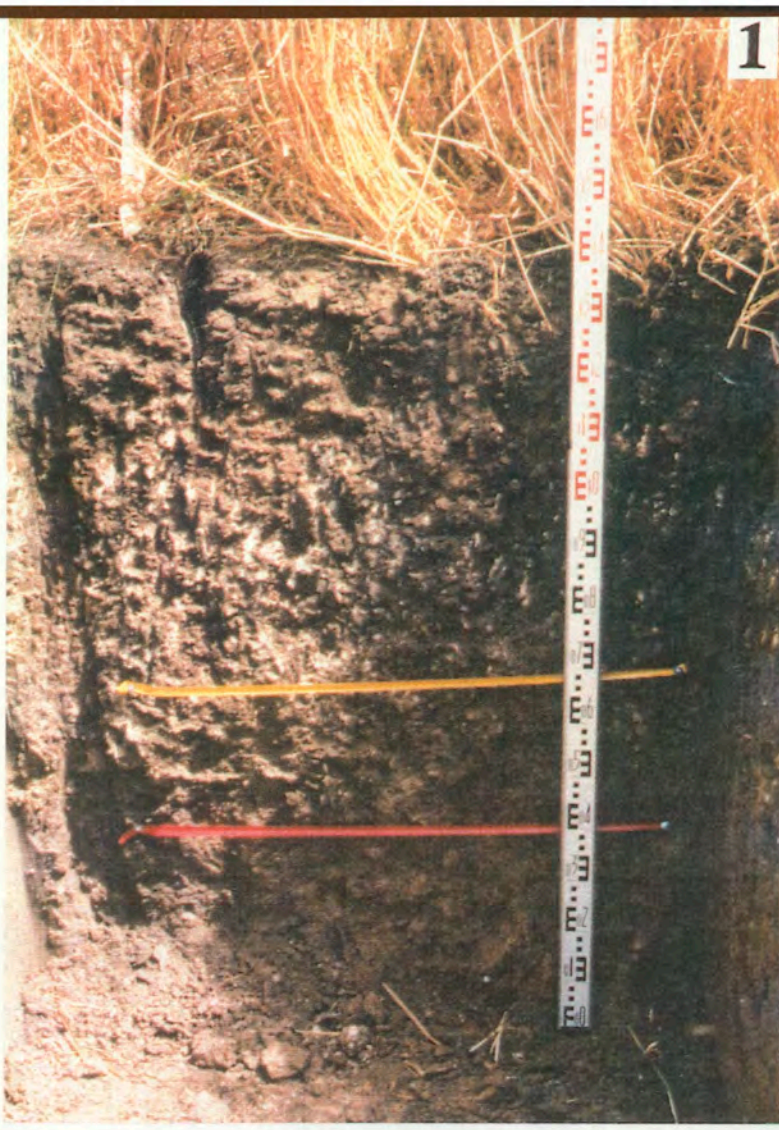
Subsoil

	10 - 30	30 - 60	60 - 110	110 - 140
pH_{water}	7.2	8.6	9.0	9.3
pH_{CaCl2}	6.6	7.7	7.9	8.0
E.C. (dS/m)	0.12	0.20	0.23	0.29
Sodium (me/kg)	2.6	6.4	9.9	14.3
Potassium (me/kg)	0.3	0.3	0.4	0.6
Calcium (me/kg)	3.4	3.4	6.2	5.2
Magnesium (me/kg)	1.6	1.4	3.1	4.0
ESP	32.9	55.7	50.5	59.1
SAR	0.7	1.9	2.1	3.0
TCC (me/L)	1.29	2.06	2.35	2.93
Ca/Mg	2.1	2.4	2.0	1.3
Clay Dispersion (%)	<1	4.5	8.5	10.5

The pH of the 10 - 30 cm layer is still close to neutral and should allow adequate nutrients to remain available to the crop. The increase in pH with depth parallels the soluble sodium levels, indicating the influence of sodium carbonate and sodium bicarbonate on the pH. The low salinity levels (E.C.) will have little negative influence on root development.

The ESP levels are disproportionably high in this soil as the overall electrolyte levels are quite low (TCC). Although the test show the soil to be extremely sodic, the actual dispersive nature of the soil will be less so because of the low total cations (TCC). The subsoils are still substantially sodic and dispersive, as indicated by the high clay dispersion tests. The clay dispersion value at 10 - 30 cm is questionable, considering the horizons immediately above and below are high.

The high dispersion values in the subsoil reflect that the soluble salt levels (E.C. and TCC) are too low to flocculate the clays at these sodicity levels (ESP much greater than 6).



LAEN SOUTH

SITE 7 LAEN SOUTH

PHOTOGRAPH 1

This pit was 1.4 m deep within a very well grown Schooner barley crop. The soils consisted of cracking grey clay over areas with substantial deposits of free carbonates, in both powder and nodule form. This free carbonate area was in one section of the pit (see photograph 1) but did not continue into the other walls of the pit. Other parts of the subsoils contained diffuse areas of carbonate nodules. Below the carbonate area (>90 cm), the clay was a yellow grey colour and quite damp.

The crop roots penetrated this soil very well, with a uniform and extensive fibrous root system down to 75 cm, as indicated by the yellow tape. There were no wormholes or old root cavities indicating preferential pathways for crop roots. However, some roots continued to 100 cm, as indicated by the red tape.

PHOTOGRAPH 2

The large accumulation of free carbonates in powder and nodule form did not seriously impede crop roots. Many fibrous roots continued through this area to 75 cm (yellow tape). The grey clay topsoil showed evidence of cracking, with lighter infill to 25 cm within the darker subsoil.

PHOTOGRAPH 3

Soil cores were taken after harvest, at equal intervals of about 80 m across the paddock, to indicate possible variations in the soil profile. The left-most core was taken 80 m from the pit site and the others sequentially across the paddock in a west-south-west direction. The cores indicate a variable paddock, with various coloured subsoils and carbonate nodules at times close to the surface while absent at other locations. The lighter surface soils could not be readily seen as the paddock was covered with ash from the burnt stubble (photograph 4).

PHOTOGRAPH 4

View west from the soil pit area over the ash-covered paddock at the time of core sampling. The terrain was quite flat but did contain some small rises, possible of gilgai formation.

ii. SITE 7 LAEN SOUTH

This site was on the property of Mr Damien Drum on M Burchills Road, midway between Banyena and Laen. This was on self-mulching grey clay that was sown to barley. The pit was on the north east of the paddock which was quite flat (region 17 fire map 42D 617 596).

This soil is a sub-dominant component of the Murra Warra soil association of Badawy (1984). The soil profile showed the typical cracking clay, with infill down to 30 cm. Below this level, the soil became lighter and had numerous nodule deposits of carbonate which continued down to about 65 cm. The barley plants had a good fibrous root system down to about 75 cm (yellow tape) with some roots going down to 100 cm (red tape). The soil below the root zone became a yellow grey colour and looked dispersive.

Cores were taken from the paddock after removal of surface stubble (photograph 4); there were no major colour changes in the surface soil across the paddock. Only the first core (left in picture 3) contained carbonate deposits; the others had colour variations within the deeper subsoil (yellow grey clay) but had no free carbonate nodules. The depth of the cracking grey clay varied across the paddock (to 50 cm).

For testing, the profile was sampled at the following depths:

0 - 10 cm	topsoil
10 - 30 cm	cracking grey clay
30 - 60 cm	grey soil with carbonate deposits
60 - 90 cm	yellow/grey clay with carbonate deposits
90 - 140 cm	yellow/grey clay without carbonate deposits

soil test results

Topsoil.

Nutrition		Structure				
pH_{water}	8.1	Texture:	Loamy medium clay.			
pH_{CaCl2}	7.4	Sodium	(me/kg)	3.0	ESP	25.6
E.C. (dS/m)	0.17	Potassium	(me/kg)	1.5	SAR	0.7
Total Nitrogen (% N)	0.11	Calcium	(me/kg)	5.9	TCC (me/L)	1.77
Nitrate Nitrogen (mg N/kg)	9.2	Magnesium	(me/kg)	1.3	Ca/Mg	4.9
Organic Carbon (% C)	1.3				Clay Dispersion %	3.0
Phosphate (mg P/kg)	38.8					

The pH of the topsoil is alkaline, with a level typical of calcareous self-mulching grey clays. The salinity of this area is quite low and is not of concern. The total nitrogen and organic carbon levels are average for this soil type but could be improved. The nitrate level is low but this is to be expected at this late stage of the development of a barley crop. The phosphate level is high and indicates a good history of phosphate fertiliser application.

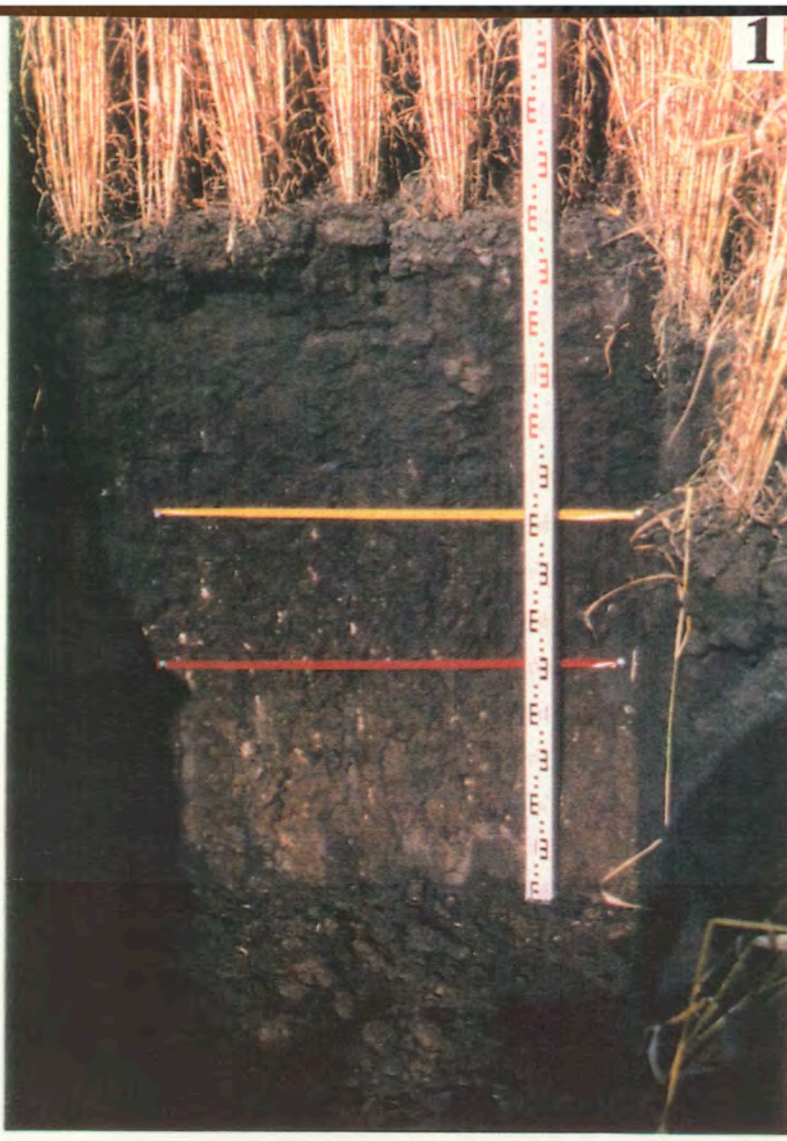
The ESP levels are disproportionably high in this soil and indicate an abundance of sodium, probably a residual amount raised by capillary action from the saline subsoils. The high ESP indicates a tendency to disperse when wet (as supported by the clay dispersion test) but not as severe as the very high ESP would suggest. The low SAR result supports the high saline aspect and indicates a lower tendency to disperse. The level of organic matter at this site indicates a reasonable amount of soil structure improvement if maintained by sound management practices.

Subsoil

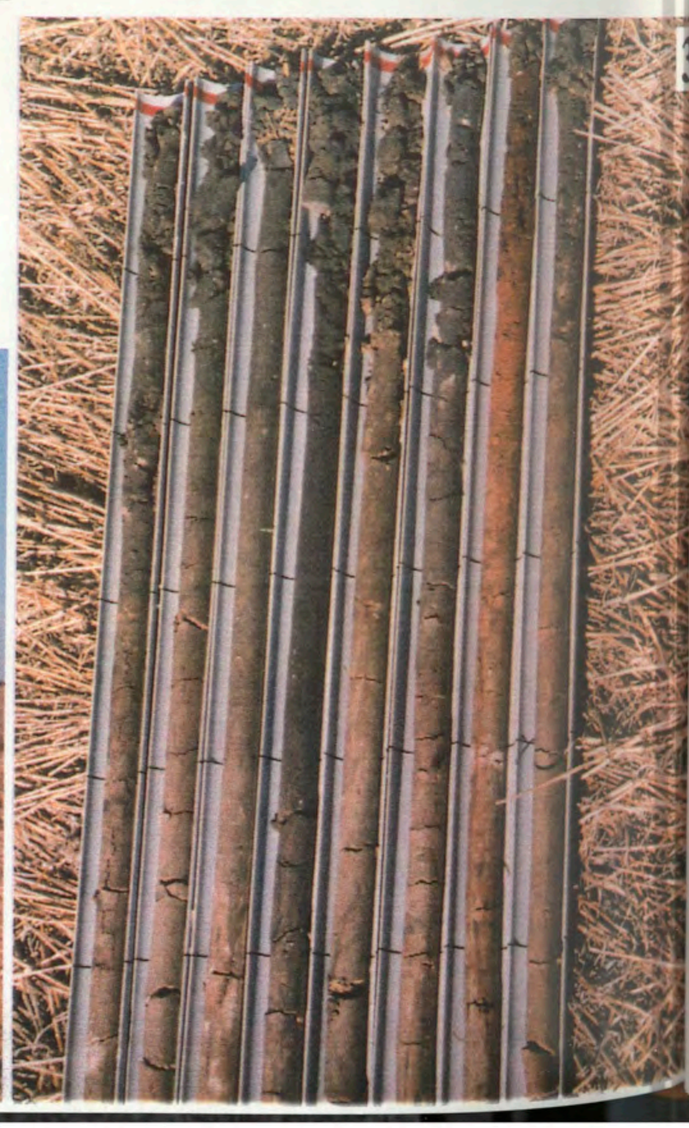
	10 - 30	30 - 60	60 - 90	90 - 140
pH_{water}	8.4	9.1	9.1	9.1
pH_{CaCl2}	7.6	8.0	8.2	8.3
E.C. (dS/m)	0.21	0.46	0.88	1.16
Sodium (me/kg)	6.6	21.3	41.6	58.2
Potassium (me/kg)	0.4	0.3	0.3	0.3
Calcium (me/kg)	6.0	6.2	2.1	1.9
Magnesium (me/kg)	1.6	4.0	1.1	1.4
SAR	1.5	4.2	14.7	20.3
TCC (me/L)	2.16	4.56	8.60	11.30
Ca/Mg	3.8	1.6	1.9	1.4
Clay Dispersion (%)	3.0	9.7	10.1	9.2

The pH of the subsurface layers increase due to the influence of sodium carbonate and or sodium bicarbonate (pH above 8.4). The increase in sodium is also indicated by the higher exchangeable sodium levels. The E.C. increases at depth, with the level below 60 cm becoming too high for optimum plant growth. The increasing salinity, along with the decreasing availability of nutrients would contribute to the apparent absence of roots below 75 cm.

The subsoil at this site deteriorates with depth, mostly due to salinity. However, if the salinity was removed the subsoils would be very dispersive and tight. The subsoil clays are sodic and dispersive (high clay dispersion) but this is masked to some degree by the high levels of sodium as soluble salts (high E.C. and TCC). This inhospitable sodic subsoil contributes to the lack of plant root and moisture movement below 75 cm.



RUPANYUP SOUTH



SITE 1 RUPANYUP SOUTH

PHOTOGRAPH 1

This pit was 1.4 m deep and consists of deep cracking clays with free carbonate nodules at depth. The light subsoils contained a lot of moisture which was inaccessible to the crop roots. The yellow tape indicates the depth of the majority of the wheat roots (60 cm). The red tape indicates the depth of the longest wheat root found (90 cm), there being only a couple of roots visible to this depth.

The white areas signify the presence of free carbonates, including limestone. These were in nodule form scattered throughout the lower layers of the soil profile (diffuse) rather than occurring as a concentrated layer or band.

PHOTOGRAPH 2

View southwards over the Meering wheat crop indicating an apparently healthy crop with a good yield potential. The terrain was quite flat with no visible variation in crop growth or health. Some wild oats occurred where herbicide application was not complete (middle distance).

PHOTOGRAPH 3

Soil cores were taken after harvest, at equal intervals of about 60 m across the paddock, to indicate possible variations in the soil profile. The left-most core was taken 60 m from the pit site and the others sequentially across the paddock.

The depth of the dark topsoil and the presence of free carbonate nodules varied across the paddock. The area where the red subsoil was located showed no visible variation in the topsoil or marked difference in crop residue density.

PHOTOGRAPH 4

View south-east in the direction of travel for taking the soil cores, overlooking the soil pit site, with soil sampling rig in the distance. This paddock is of a flat terrain with no obvious undulations but having a very slight rise in the direction of travel.

b) KALKEE ASSOCIATION - UNIT 2

This is the second major soil association in the mining site areas, particularly on the WIM 200 site. This association consists of predominantly grey self-mulching cracking clays, with a complex pattern of brown and red self-mulching cracking clays. Badawy (1984) estimated that the brown and red clays comprised 10 - 40 % (by area) of this association.

Three soil pits were located in these soil; pits 1,2 and 3 (all are in the WIM 200 site area).

i. SITE 1 RUPANYUP SOUTH

This site was on the property of Steve Lingham on Linghams Road at Rupanyup South. The soil was a self-mulching grey clay which was sown to wheat. The pit was on the north-west corner of a paddock with a slight fall to the west fence (region 17 fire map reference 52B, 473 347). The pit area would lay water after periods of high rainfall, due to surface run-off form higher parts of the paddock.

The surface soil was very friable and the soil profile showed a considerable depth of grey clay with a lighter infill to about 45 cm depth. The majority of the crop roots were restricted to 60 cm of the profile (as indicated by the yellow tape). Some roots were found down to 95 cm (red tape), but these were few in number and appeared to follow old root or worm channels to these depths.

Lumps or pockets of free carbonate were visible below 50 cm and continued sporadically to the base of the pit. The soil below 60 cm was quite damp indicating that this moisture was not exploited by the crop, presumably because root growth was restricted.

Soil cores were taken across the paddock, the left core being nearest the pit (photograph 3). There was an obvious variation of the depth of the darker grey clay above the lighter subsoil. Carbonate was found at various depths through the cores. Towards the upper end of the paddock (the eastern side), an area of red clay soil was sampled which had a shallow covering of grey clay.

For testing, the profile was sampled at the following depths:

0 - 10 cm	topsoil
10 - 50 cm	grey clay, with obvious infill
50 - 70 cm	grey clay with some carbonate deposits
70 - 100 cm	lighter grey clay with carbonate deposits
100 - 140 cm	lighter clay with carbonate deposits.

soil test results

Topsoil

Nutrition		Structure				
pH $_{water}$	8.1	Texture: Loamy medium clay				
pH_{CaCl2}	7.4	Sodium (me/kg)	1.9	ESP		22.9
EC (dS/m)	0.13	Potassium (me/kg)	0.5	SAR		0.5
Total Nitrogen (% N)	0.07	Calcium (me/kg)	4.7	TCC	(me/L)	1.10
Nitrate Nitrogen (mg N/kg)	4.8	Magnesium (me/kg)	1.2	Ca/Mg		3.9
Organic Carbon (% C)	0.8			Clay Dispersion (%)		<1
Phosphate (mg P/kg)	22.1					

Whilst the soil pH is alkaline, this is normal for a cracking grey clay soil. The salinity of the soil is quite low. Total nitrogen and organic carbon levels are low for this soil type and could be improve with management practices. The nitrate level is low but this is to be expected at the latter phase of a crop year. The phosphate level is average for this soil type and is adequate for plant growth.

This soil tests appears to give conflicting indications about the soil structure. Although the ESP is very high and TCC values are low indicating that the soil may potentially disperse, the dispersion test results indicate that aggregate stability is in fact satisfactory. This indicates that sodium salts influence the ESP and that the SAR should be checked. The low SAR indicates that the soil structure is chemically sound and not likely to disperse, as supported by the low clay dispersion level.

Subsoil

The soil becomes less hospitable to plant growth with increasing depth. With pH levels getting so high (greater than 9), most nutrients will become available to plants. Although the salinity levels (EC) are increasing with depth, the levels are relatively low and are of no concern as a toxicity problem.

Soil structural stability deteriorates at depth with the dispersive nature of the soil becoming increasingly evident. The increasing SAR value with increasing depth indicates a bigger influence of the sodium on the clays and a deteriorating soil structure. The decreasing Ca\Mg will be contributing to this deteriorating soil structure with depth and this is confirmed with the high clay dispersion values. The subsoil at 10 - 50 cm has a relatively low tendency to disperse, supported by a raised Ca\Mg (greater than 2). However, a lower Ca\Mg, coupled with a rising SAR and the high ESP, indicate that the subsoils below 50 cm will begin to be dispersive and, as such, would restrict moisture and root movement.

	10 - 50 cm	50 - 70 cm	70 - 100 cm	100 - 140 cm
pH_{water}	8.3	8.8	9.1	9.2
pH_{CaCl2}	0.14	0.21	0.33	0.47
EC (dS/m)	0.14	0.21	0.33	0.47
Sodium (me/kg)	3.4	9.4	18.1	21.8
Potassium (me/kg)	0.3	0.4	0.5	0.6
Calcium (me/kg)	3.8	5.3	5.9	5.1
Magnesium (me/kg)	1.2	2.5	4.2	4.0
SAR	1.0	2.0	3.6	4.6
TCC (me/L)	1.49	2.06	3.31	4.66
Ca/Mg	3.2	2.1	1.4	1.3
Clay Dispersion %	2.4	6.7	9.4	9.3

ii. SITE 2 RUPANYUP

This site was on the property of Jim Starbuck, south east of Rupanyup. The soil was a grey self-mulching clay which was sown to wheat. The pit was on the north side of a flat paddock (region 17 fire map reference 41F, 476 427). A gentle rise off to the east may have some bearing on water flow in excessively wet years.

The soil profile was surprising in the shallow depth of the grey topsoil. Visible carbonate deposits occurred near the surface, indicating that the pit was dug on a gilgai puff, ie. on an area that would have been a rise in the natural landscape before cultivation levelled the surface.

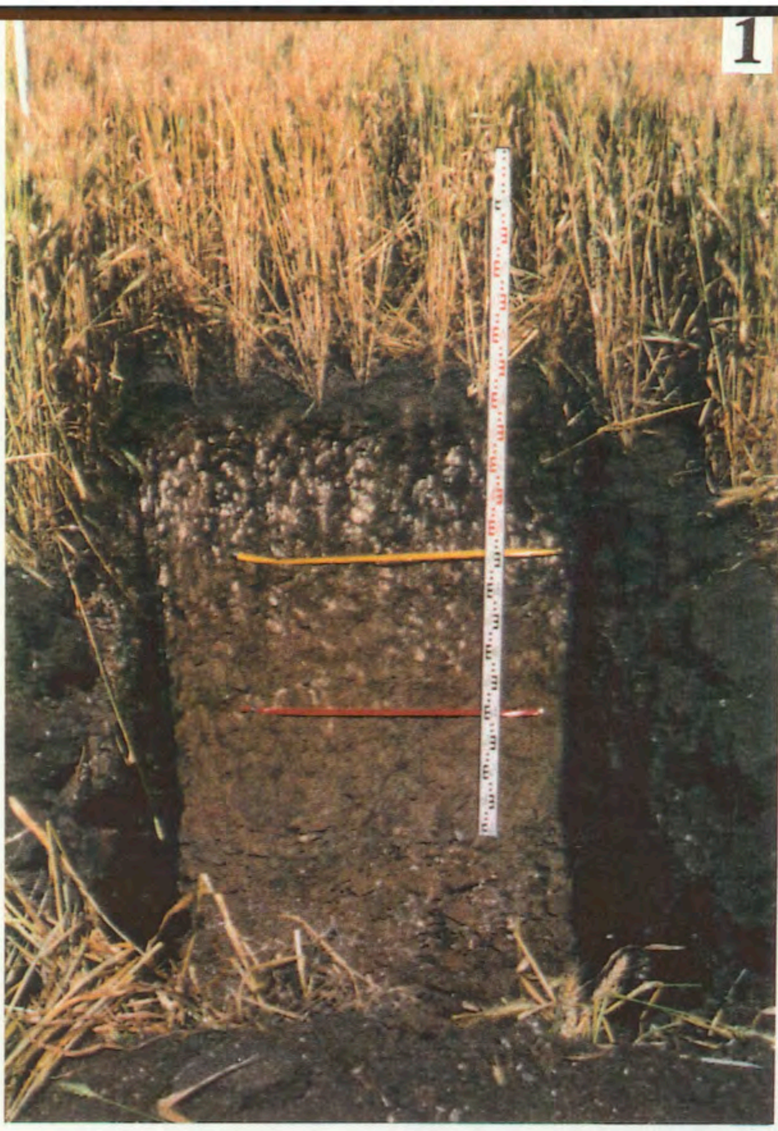
The majority of the wheat roots were found in the upper 55 cm of the profile (yellow tape). Some roots were found down to 105 cm (red tape). Generally, these followed old root and worm channels, even though soil tests indicated that the deep subsoil was inhospitable.

Free carbonate occurred in a distinct layer across the pit face, varying in depth from 15 to 30 cm below the surface (the area that was sampled had a deeper topsoil layer). The carbonate occurred as discrete pockets rather than as a uniform band.

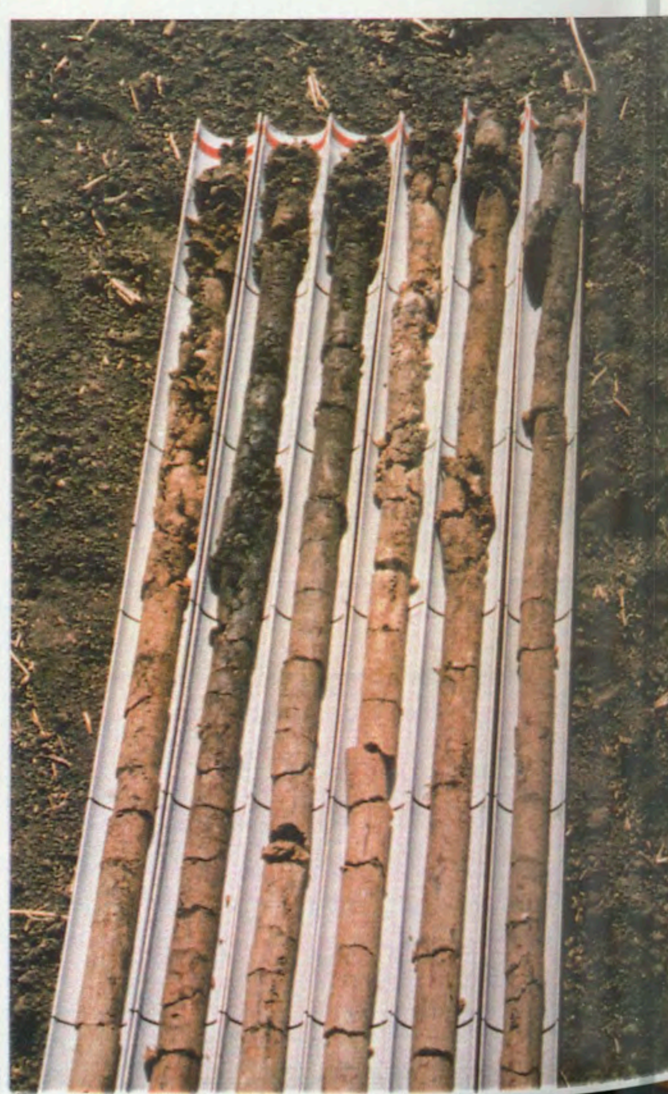
The paddock was bare when cores were taken. The topography was flat with the surface soil having a friable covering of a uniform grey colour. However, cores taken across the paddock showed a marked variation in the depth of the topsoil with at least one of them being in a similar gilgai formation.

For testing, the profile was sampled at the following depths:

0 - 10 cm	topsoil
10 - 30 cm	grey clay with cracking evident
30 - 80 cm	grey clay with an abundance of carbonate deposits.
80 - 140 cm	lighter grey clay, still calcareous looking



RUPANYUP



SITE 2 RUPANYUP

PHOTOGRAPH 1

This pit was 1.4 m deep and appeared to traverse a gilgai puff (rise). The grey clay topsoil was quite shallow over a concentrated layer of free carbonate nodules. However, the sides of the pit showed an increasing depth of grey clay over the carbonate nodules away from the pit face. This marked variation in the depth above the free carbonates was not indicated by the wheat crop. The site was chosen randomly in a very uniform, healthy Meering wheat crop.

The yellow tape indicates the depth of the majority of the wheat roots (55 cm) whilst the red tape indicates the depth of the lowest wheat root found (105 cm), there being only a couple of roots visible to this depth.

PHOTOGRAPH 2

The grey clay topsoil was very shallow at the pit face (10 cm sampled). The free carbonate was in nodule form, with the nodules being quite variable in size and density. A root barrier was not formed as grey clay was dispersed amongst the carbonate nodules allowing crop roots to penetrate to some depth.

PHOTOGRAPH 3

Soil cores were taken after harvest, at equal intervals of about 60 m across the paddock, to indicate possible variations in the soil profile. The left-most core was taken 60 m from the pit site and the others sequentially across the paddock.

The depth of the dark topsoil over the lighter subsoil clays and free carbonate nodules varied across the paddock. This marked variation did not result in corresponding variation in crop growth or health at the time the soil pit was excavated.

PHOTOGRAPH 4

View south in the direction of travel for taking the soil cores, overlooking the soil pit site, with the soil sampling rig in the distance. A flat terrain with slight undulations 30 or 40 m apart occurring across the paddock, indicating the presence of the gilgai formations and seen in the soil cores.

soil test results

Topsoil

Nutrition		Structure			
pH_{water}	8.2	Texture: Loamy medium clay.			
pH_{CaCl2}	7.5	Sodium me/kg	2.2	ESP	25.0
EC (dS/m)	0.14	Potassium me/kg	0.7	SAR	0.6
Total Nitrogen (%N)	0.05	Calcium me/kg	4.9	TCC (me/L)	1.49
Nitrate Nitrogen (mg N/kg)	5.6	Magnesium me/kg	1.0	Ca/Mg	4.9
Organic Carbon (% C)	1.0			Clay Dispersion %	<1
Phosphate (mg P/kg)	24.1				

The pH is alkaline but normal for most of the cracking grey clays. The salinity of the soil is quite low and is of no concern. The total nitrogen level is quite low for this soil type and would suggest that the area has been out of a legume pasture phase for some years or has been cropped with cereals dominant in the rotation for some time. The organic carbon levels are low for this soil type. The phosphate level is moderate (approaching high) for this soil type.

The low SAR indicates that the soil is 'low-sodic' and the high Ca/Mg is consistent with the low value for clay dispersion (<1%). This concurs with the field observation of the self-mulching appearance of the seedbed. The exceptionally high ESP value may be distorted with the presence of soluble sodium salts in the soil.

Subsoil

	10 - 30 cm	30 - 80 cm	80 - 140 cm
pH_{water}	8.7	9.3	9.4
pH_{CaCl2}	7.7	8.1	8.0
EC (dS/m)	0.18	0.32	0.89
Sodium (me/kg)	6.3	16.5	51.6
Potassium (me/kg)	0.3	0.4	0.5
Calcium (me/kg)	4.6	5.0	3.0
Magnesium (me/kg)	2.0	6.1	5.9
SAR	1.6	3.1	10.9
TCC (me/L)	1.87	3.22	8.70
Ca/Mg	2.30	0.82	0.5
Clay Dispersion (%)	5.2	12.2	10.3

Subsoil pH rapidly increases with depth, with the soil below 10 cm being strongly alkaline. This indicates that some nutrients will become less available to plants, although a tissue test would confirm particular deficiencies in a crop. Bear in mind that this pit is on a gilgai puff and that other areas in the paddock will have a much deeper topsoil layer, as indicated by some of the cores.

The salinity levels (EC) are low and are of no concern to plant growth until below 80 cm, where the level becomes high. Since the pH below 80 cm does not increase greatly from the zone above, but the root penetration stops at this level, the sodium salts present may include chloride and sulphate; these are phytotoxic and so may retard root development.

The highly sodic nature (SAR > 3) of the subsoil below 30 cm is consistent with the high levels of dispersible clay. The deteriorating Ca\Mg will be contributing to the poor soil structure at these depths. Potential soil structural stability is very poor at depths greater than 30 cm, indicating that subsoil permeability and root penetration may be restricted.

iii. SITE 3 BURRUM

This site was on David Mathew's property at Burrum, about one kilometre north west of the Burrum silos. The soil was a grey self-mulching cracking clay which was sown to wheat. The pit was in the south west corner of the paddock, on a slight rise which fell away to the north (Region 17 fire map reference 42E 544 468).

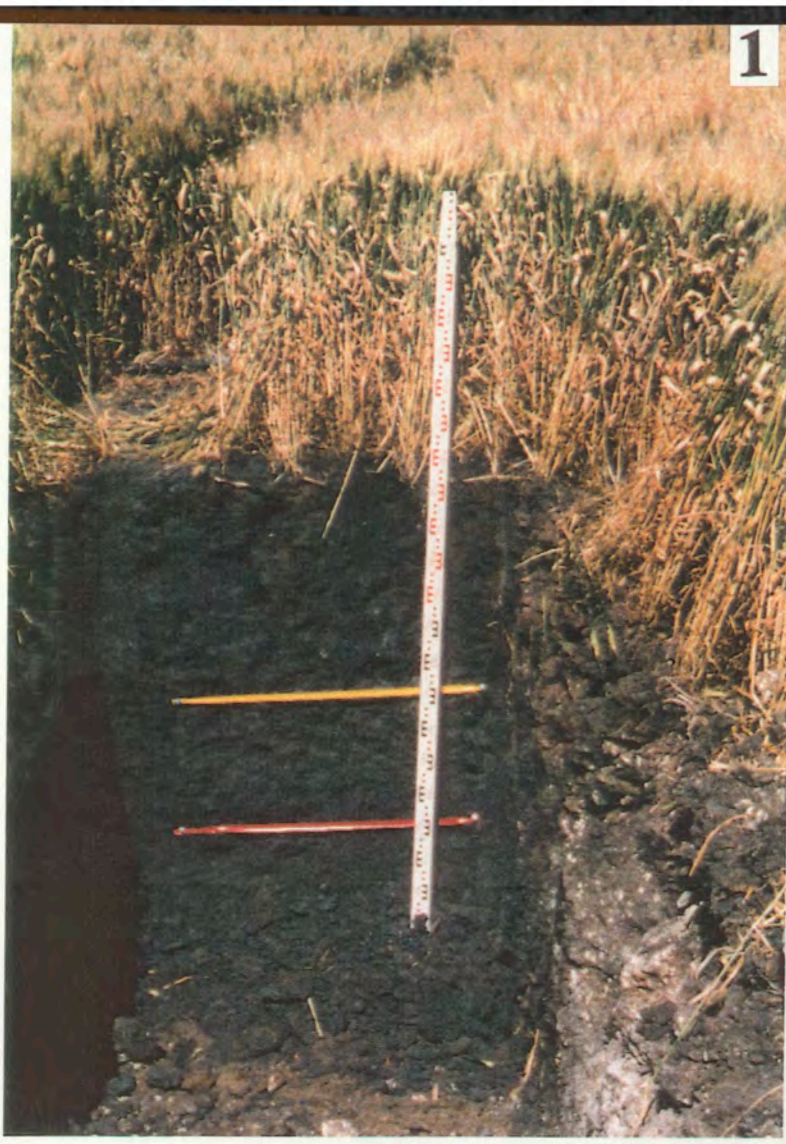
The soil profile showed a very typical self-mulching soil to a depth of over one metre. The dark soil mass had obvious cracks down to one metre and they had been filled with lighter topsoil. Root channels and worm cavities were not visible because of the extensive cracking and filling across the whole profile. The majority of the roots were down to 70 cm (yellow tape) with some roots going to 110 cm (red tape).

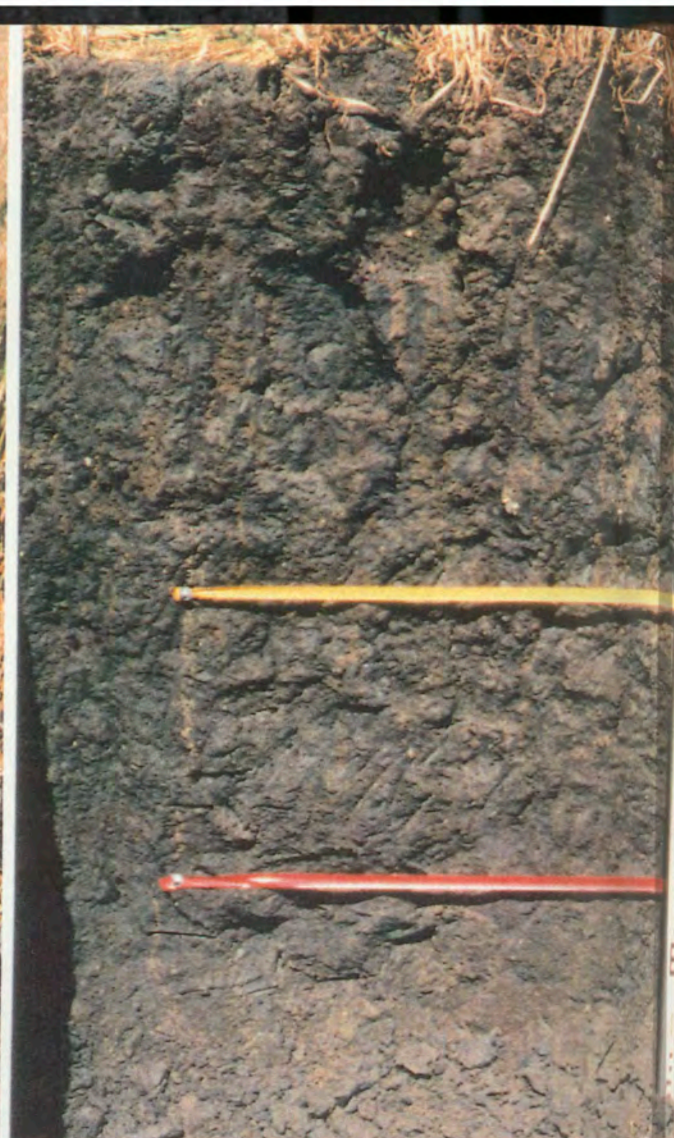
The variability of the soil in the area was highlighted by the side wall of the soil pit. An obvious "mound" of carbonate could be seen. If the pit was dug two metres back, the face would have had this through most of the profile. This carbonate mound is typical of a gilgai puff formation, and the area would have been a rise in the natural landscape prior to cultivation.

Soil cores taken in a north easterly direction across the paddock indicated that the soils were predominantly the grey self-mulching cracking clay. A couple of the cores indicated the presence of other gilgai puff formations.

For testing, the profile was separated sampled at the following depths:

0 - 10 cm	topsoil
10 - 50 cm	grey clay with obvious infill
50 - 90 cm	grey clay with obvious infill, depth of lowest infill in sampled area
90 - 140 cm	grey clay





BURRUM

SITE 3 BURRUM

PHOTOGRAPH 1

This pit was 1.4 m deep and exhibited a very deep profile of self-mulching grey clay. However, the side wall of the pit included a lot of free carbonate nodules to 25 cm below the surface. this indicates that gilgai puffs and depressions may occur at this site. This gilgai formation was not reflected by the wheat crop as its growth and health were quite uniform at the pit site.

The yellow tape indicates the depth of the majority of the wheat roots (70 cm) whilst the red tape indicates the depth of the lowest wheat root found (110 cm), there being only a couple of roots visible to this depth.

PHOTOGRAPH 2

The soil profile was that of a very deep self-mulching grey clay, with dark grey subsoils and light grey (topsoil) intrusions. The topsoil intrusions from previous seasons were seen to a depth of 100 cm will enhance water and root penetration. No free carbonates were sampled from this profile.

PHOTOGRAPH 3

Soil cores were taken after harvest, at equal intervals of about 80 m across the paddock, to indicate possible variations in the soil profile. The left-most core was taken 80 m from the pit site and the others sequentially across the paddock in a north-easterly direction. The cores indicate a uniform paddock self-mulching grey clay with some gilgai formations occurring. This was corroborated by the uniform colour of the soil surface and the terrain consisting of many very shallow undulations seen at the time of core sampling.

PHOTOGRAPH 4

View south-east at the time of the pit excavation with the Burrum silos in the background. The 90 cm high Meering wheat crop showed great yield potential. The wild oats indicate the presence of the boundary fence and a roadway. Variation in the growth of the wheat crop can be seen in the foreground, possible due to variation in the subsoils.

soil test results

Topsoil

Nutrition		Structure			
pH_{water}	8.1	Texture: Loamy medium clay			
pH_{CaCl2}	7.4	Sodium (me/kg)	2.2	ESP	22.0
EC (dS/m)	0.16	Potassium (me/kg)	0.7	SAR	0.5
Total Nitrogen (% N)	0.10	Calcium (me/kg)	6.0	TCC (me/L)	1.68
Nitrate Nitrogen (mg N/kg)	5.8	Magnesium (me/kg)	1.1	Ca/Mg	5.5
Organic Carbon (% C)	1.0			Clay Dispersion %	<1
Phosphate (mg P/kg)	38.6				

The pH is alkaline but normal for most of the cracking grey clays. The salinity of the soil is quite low and of no concern. Total nitrogen and organic carbon levels are typical of the cropped soils of this type but could be raised by management practices. The phosphate level is high and signifies a good history of phosphate application.

This soil does not appear to have major structural problems. The SAR is low and, despite the level of soluble salts (TCC) being below the flocculation threshold value, there is little clay dispersion, possibly associated with the high Ca/Mg (another indicator of aggregate stability). The high ESP may be the result of sodium salts present in the soil, obviously at low levels but enough to distort the values.

Subsoil

	10 - 50	50 - 90	90 - 140
pH_{water}	8.3	8.7	8.7
pH_{CaCl2}	7.3	7.7	7.9
EC (dS/m)	0.17	0.31	0.81
Sodium (me/kg)	7.2	13.2	34.4
Potassium (me/kg)	0.9	0.4	0.4
Calcium (me/kg)	4.9	6.9	2.2
Magnesium (me/kg)	1.0	2.2	0.8
SAR	1.9	2.8	12.6
TCC (me/L)	1.77	3.12	7.93
Ca/Mg	4.90	3.14	2.8
Clay Dispersion (%)	2.5	7.5	<1

The pH of the subsoil increases gradually with depth; carbonates were visible in the soil nearby. However, as the pH does not increase below 50 cm, it appears that there is little additional accumulation of sodium carbonate or bicarbonate. It is thus likely that there is more sodium associated with the clays (sodic) and the free sodium salts are mainly chloride and sulphate

The subsoils below 50 cm have are increasingly affected by sodium on the clays (becoming dispersive) and thus will become less accessible by moisture and plant root movement. The salinity level below 90 cm (EC > 0.8 dS/m) indicates likely additional retardation of root growth. The high levels of these soluble salts prevent clay dispersion.

c) THE KALKEE ASSOCIATION - UNIT 1

This soil association consists mainly of grey and dark grey self-mulching cracking clays. Brown self-mulching cracking clays are of only minor occurrence (ie. less than 10 %, by area, of the soil complex). This soil association is found only in the WIM 250 site and was represented by pit 8.

i. SITE 8 LAEN

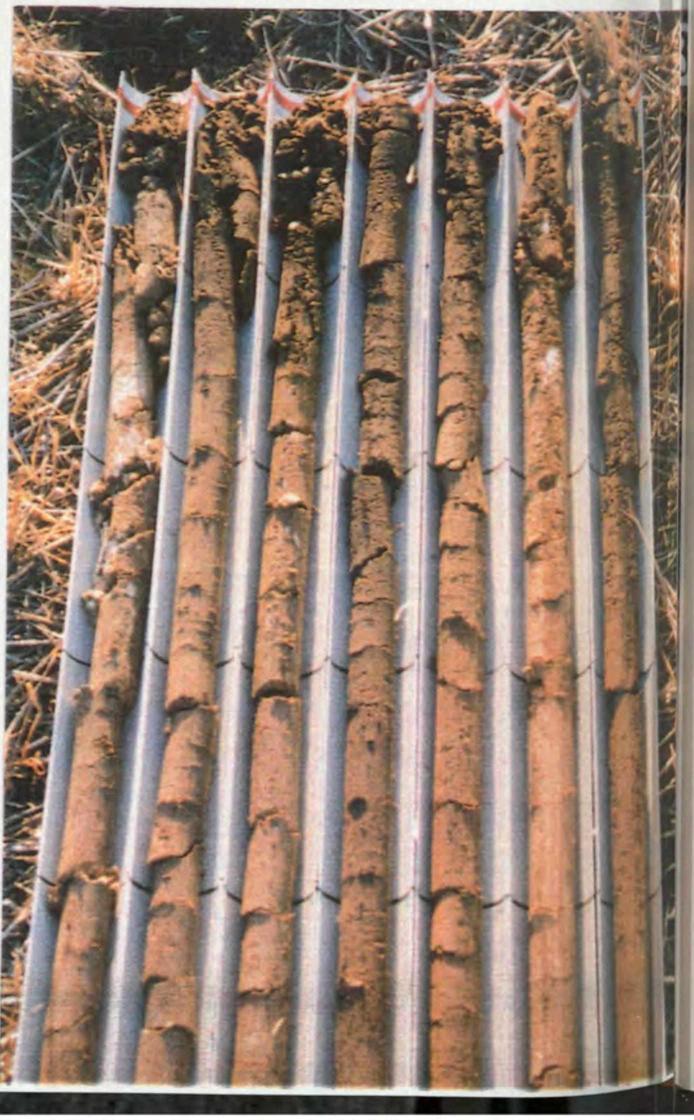
This pit was on the property of Mr Harold Flett at Laen, on K Woods Road. The pit was on the north east corner of a paddock of self-mulching grey clay sown to barley (region 17 fire map reference 42B, 636 674). The paddock was quite flat, with no obvious dips or rises.

The soil profile began with grey cracking clay to 30 cm which quickly changed to a light grey colour. The majority of the crop roots went down to 60 cm (yellow tape). Below 60 cm, many nodular deposits of carbonate were evident, these continuing to the bottom of the pit.

For testing, the profile was sampled at the following depths:

0 -10 cm	topsoil
10 - 30 cm	grey clay
30 - 50 cm	light grey clay
50 - 100 cm	nodular carbonate deposits
100 - 140 cm	carbonate deposits

LAEN



SITE 8 LAEN

PHOTOGRAPH 1

This pit was 1.4 m deep in a grey clay soil over an extensive area of free carbonate deposits. The pit was located in a barley crop that was harvested on the same day. The soil profile was quite dry and the shallow rooting depth would have contributed to the maturity of the crop.

The majority of the crop roots extended to the light grey clay at 50 cm but did not penetrate the free carbonate area to any extent (yellow tape). The roots followed cavities through the carbonate area, the longest visible to 1.3 m, as indicated by the red tape.

PHOTOGRAPH 2

The relatively shallow grey clay extended to 30 cm. A light grey clay area about 20 cm thick lay over the carbonate deposits. Evidence of old tree roots and quite a few old worm pathways were evident. These were filled with crop roots and often extended to below 1.0 m. Although damp, there was little moisture in the deep subsoils available for the crop.

PHOTOGRAPH 3

Soil cores were taken after harvest, at equal intervals of about 80 m across the paddock, to indicate possible variations in the soil profile. The left-most core was taken 80 m from the pit site and the others sequentially across the paddock in a south-westerly direction. The cores indicate a paddock of relatively shallow grey clay topsoil but with a variable subsoil. Free carbonates occur within 30 cm at some sites with other locations not having any visible to 1.0 m. Generally, the subsoils consist of light grey clays and, judging by the high moisture content of most samples, relatively inhospitable to plant roots.

PHOTOGRAPH 4

View south-west over the stubble paddock at the time of core sampling. The stubble cover obscured the soil surface but some small rises could be detected. These were probably of gilgai origin and would indicate a shallow depth to the free carbonates.Worm cavities were obvious in the top 40 cm of the profile. Some old tree root remains were evident, one going down to 100 cm. The crop roots followed the worm and tree pathways with the lowest visible root being at 130 cm (red tape).

Cores were taken diagonally across the paddock. The soil surface was a uniform grey colour. The depth of the grey clay above the free carbonate deposits varied considerably (from 15 to 50 cm). Some cores showed a colour change of the lower depths to a reddish-brown clay. This is probably related to a mosaic of grey and red clays that occurred in the paddock but are covered by a surface veneer of grey clay caused by cultivation.

soil test results

Topsoil

Nutrition		Structure			
pH_{water}	8.2	Texture: Light clay			
pH_{CaCl2}	0.14	Sodium (me/kg)	1.9	ESP	23.8
EC (dS/m)	0.14	Potassium (me/kg)	0.6	SAR	0.5
Total Nitrogen (% N)	0.10	Calcium (me/kg)	5.4	TCC (me/L)	1.8
Nitrate Nitrogen (mg N/kg)	11.6	Magnesium (me/kg)	1.0	Ca/Mg	5.4
Organic Carbon (% C)	1.2			Clay Dispersion %	<1
Phosphate (mg P/kg)	30.1				

Whilst the pH is alkaline, it is typical of most of the Wimmera grey clays. The salinity level is low and of no concern. The total nitrogen and organic carbon levels are medium for this soil type and could be improved. The phosphate level is high and indicates a good phosphate application history.

The soil test results indicate that the aggregate stability at this site is satisfactory. As it is low sodic (SAR 0.5) and the level of soluble salts is very low, there is no measurable dispersion. The high calcium to magnesium ratio (greater than 2) would assist aggregate stability. The high ESP is distorted by the amount of sodium salts in the overall low levels of total cations.

Subsoil

	10 - 30	30 - 50	50 - 100	100 - 140
pH_{water}	8.5	8.8	8.8	9.7
pH_{CaCl2}	7.6	7.8	8.1	8.2
EC (dS/m)	0.13	0.19	0.95	0.49
Sodium (me/kg)	3.3	8.0	42.3	22.3
Potassium (me/kg)	0.4	0.4	0.4	0.8
Calcium (me/kg)	4.7	6.4	2.3	3.9
Magnesium (me/kg)	1.2	2.9	2.1	3.8
SAR	0.9	1.7	12.8	5.1
TCC (me/L)	1.39	1.97	9.28	4.85
Ca/Mg	3.9	2.2	1.1	1.0
Clay Dispersion (%)	1.6	8.4	<1	10.9

Subsoil pH increases with depth, probably due to the increasing amounts of sodium carbonate and or sodium bicarbonate and reduce the availability of nutrients from the subsoils. This would be best confirmed by a tissue test on a subsequent crop.

The salinity level rises steeply below 50 cm to a level that would restrict the development of plant roots. The increased E.C. is associated with the increase in exchangeable sodium levels. As the pH did not rise as well, the sodium salts are probably sulphate and or chloride.

The 10 - 30 cm layer has few major problems for plant growth, although the deeper soil is clearly unfavourable (high levels of dispersible clay or high salinity, together with highly alkaline pH levels).

The clays in the 50 - 100 cm section of the profile are not dispersive because the area is so saline. The SAR is very high but is inflated by the soluble salts in the profile (high EC). The low calcium to magnesium ratio (less than 2) would add to the dispersive nature of already sodic clays. However, the high levels of soluble salts in the soil (high E.C. and TCC) flocculate the clay particles and hence maintain subsoil structure. If these salts were to be washed out of the soil, the dispersive nature of the soil would result in waterlogging and restricted root growth.

The lower section of the profile has less of these salts in the soil and so the swelling nature becomes evident, as indicated by the high clay dispersion value. This area will result in restricted root and water movement in the subsoil (if plant roots could get this far).

d) THE DONALD ASSOCIATION

This association consists mainly of hard alkaline red and mottled-yellow duplex soils and non-friable cracking grey clays. Also included in the association are sandy alkaline yellow duplex soils, cracking red clays and cracking clays with bleached subsurface horizons. This soil association covers only a small percentage of the total area of the mining sites, but does occur in both sites. Pit 4 was located in one of the soils in this soil association.

i. SITE 4 BANYENA (black soil)

This site was on the property of Mr Garry Trotter between Burrereo and Banyena. The soil was a self-mulching grey clay in an area where red rises are prevalent. The pit was on the western side of the paddock which was quite flat (Region 17 fire map reference 42D); the paddock having been sown to field peas.

The grey self-mulching component of this soil was not very deep when compared to other sites. The carbonate deposits were of a more uniform layer situated 50 to 60 cm below the surface. The upper layer of the soil profile was typical of the cracking clays, with the darker soil showing obvious lighter infill from previous years; these infill extending to depths of about 50 cm.

Soil cores were taken in an easterly direction across the paddock. The variability of the soils in this paddock was highlighted by the cores; the presence of red clay subsoils, the depth of the free carbonate and the depth of the grey clays all showed considerable variation.

Whilst the majority of the crop roots were down to 55 cm (yellow tape), some roots were found at depths down to 100 cm. There were few roots below the 60 cm level. However, those visible appeared to follow old root or worm paths through inhospitable soil layers.

For testing, the profile was sampled at the following depths:
0 - 10 cm topsoil
10 - 55 cm grey clay with obvious infill
55 - 90 cm layer with numerous carbonate deposits
90 - 140 cm light grey clay; calcareous looking but with no obviously free carbonate deposits

soil test results

Topsoil

Nutrition		Structure				
pH_{water}	8.1	Texture: Light clay				
pH_{CaCl2}	7.4	Sodium (me/kg)	3.9	ESP	32.5
EC (dS/m)	0.16	Potassium (me/kg)	0.7	SAR	0.9
Total Nitrogen (% N)	0.09	Calcium (me/kg)	5.9	TCC (me/L)	1.68
Nitrate Nitrogen (mg N/kg)	5.6	Magnesium (me/kg)	1.5	Ca/Mg	3.9
Organic Carbon (% C)	1.1			Clay Dispersion %	3.0
Phosphate (mg P/kg)	23.0				

The pH is alkaline but normal for most of the cracking grey clays. The salinity of the topsoil is quite low and is of no major concern. The total nitrogen and organic carbon levels are average for the cropped paddocks of this soil type and could be improved by management practices. The phosphate level is average for this soil type.

The soil structure at this site appears adequate with low SAR and adequate Ca\Mg values. Increased organic matter coupled with good management practices will enhance soil structure characteristics. Salinity is not an issue at this site.

BANYENA
black

SITE 4 BANYENA (black soil)

PHOTOGRAPH 1

This pit was 1.15 m deep and exhibited grey self-mulching clay over a wide band of free carbonate nodules. This carbonate band continued at the sides of the pit and appeared to be uniform, rather than as a gilgai formation. The plant population of the field pea crop was patchy, indicating possible uneven establishment (reflecting variations in the subsoil?)

The yellow tape indicates the depth of the majority of the wheat roots (55 cm) whilst the red tape indicates the depth of the lowest wheat root found (100 cm); there being only a couple of roots visible to this depth.

PHOTOGRAPH 2

The soil profile was that of a self-mulching grey clay, with dark grey subsoils and light grey (topsoil) intrusions. The topsoil intrusions from previous seasons were seen to a depth of 30 cm. The nodules of free carbonate appeared at about 40 cm and continued to 100 cm. Most of the soil surrounding the nodules was very light and of calcareous appearance and would be inhospitable to plant roots.

PHOTOGRAPH 3

Soil cores were taken after harvest, at equal intervals of about 70 m across the paddock, to indicate possible variations in the soil profile. The left-most core was taken 70 m from the pit site and the others sequentially across the paddock in an easterly direction. The cores indicate the presence of red subsoil clays and a continuation of free carbonate nodules below 40 cm.

PHOTOGRAPH 4

View east in the direction of the core sampling, with the sampling rig collecting the first core. The terrain was quite flat but there were obvious variations in plant density across the paddock (reflected by the variations in stubble density in the photograph).

Subsoil

	10 - 55	55 - 90	90 - 140
pH_{water}	8.7	9.3	9.6
pH_{CaCl2}	7.7	8.1	8.2
EC (dS/m)	0.22	0.45	0.50
Sodium (me/kg)	9.7	18.1	23.5
Potassium (me/kg)	0.3	0.4	0.5
Calcium (me/kg)	5.0	4.4	4.1
Magnesium (me/kg)	2.8	4.2	4.0
SAR	2.2	3.9	5.2
TCC (me/L)	2.26	4.47	4.95
Ca/Mg	1.8	1.1	1.0
Clay Dispersion (%)	6.7	7.7	7.1

The pH of the subsoil increases with depth to very high levels (pH_{water} = 9.6) indicating an increase in carbonate and bicarbonate salts, probably sodium based. The salinity levels rise slowly but are not of major concern. However, the increasing sodium levels, low Ca\Mg and high clay dispersion figures all indicate a soil that will readily swell when wet. Thus, these subsoils will be less amenable for plant root and moisture movement.

e) THE WAL WAL ASSOCIATION

The main soils included in this association are the cracking clays with bleached subsurface horizons and the hard alkaline red and yellow duplex soils. Sub-dominant soils include friable and non-friable grey and brown cracking clays and hard mottled-brown duplex soils. These soils are usually associated with ancient "water course" country.

Although just outside the WIM site areas, a soil pit was placed in this soil association to learn of its agricultural limitations.

i SITE 5 BANYENA (water course)

This site was on the property of Mr Frank Drum, about one kilometre west of Banyena, on the south side of the road. This was on "water course" type of ground that was sown to canola. The pit was on the northern part of the paddock which was generally flat but with a slight rise to the south west (Region 17 fire map reference 42D, 618 507). This soil is historically a problem soil to crop and may be prone to salinity.

The soil profile confirms the problems encountered when cropping these soils. The grey topsoil was very tight. Even though some cracking was evident, this was caused by drying and the soil between the cracks was still very hard. The yellow-grey lower layers were very much like plasticine, with quite a lot of moisture evident. The swelling nature of the soil and the reduced root penetration has meant that this moisture was unavailable to the crop.

Soil cores were taken in a south-south-westerly direction across the paddock. There was little variation in the cores; all were moist, some to a shallower depth than others. All consisted of grey clay over yellow-grey subsoils.

The majority of the roots were down to 50 cm (yellow tape). Some worm activity was evident in the lower levels of the profile, with the lowest roots following these pathways down to 85 cm (although there were very few of these).

For testing, the profile was sampled at the following depths:

0 - 10 cm	topsoil
10 - 30 cm	light grey clay, majority of the organic matter in this and upper layer
30 - 70 cm	yellow grey clay layer, very moist, plasticine like nature
70 - 120 cm	light grey clay with yellow and red mottling

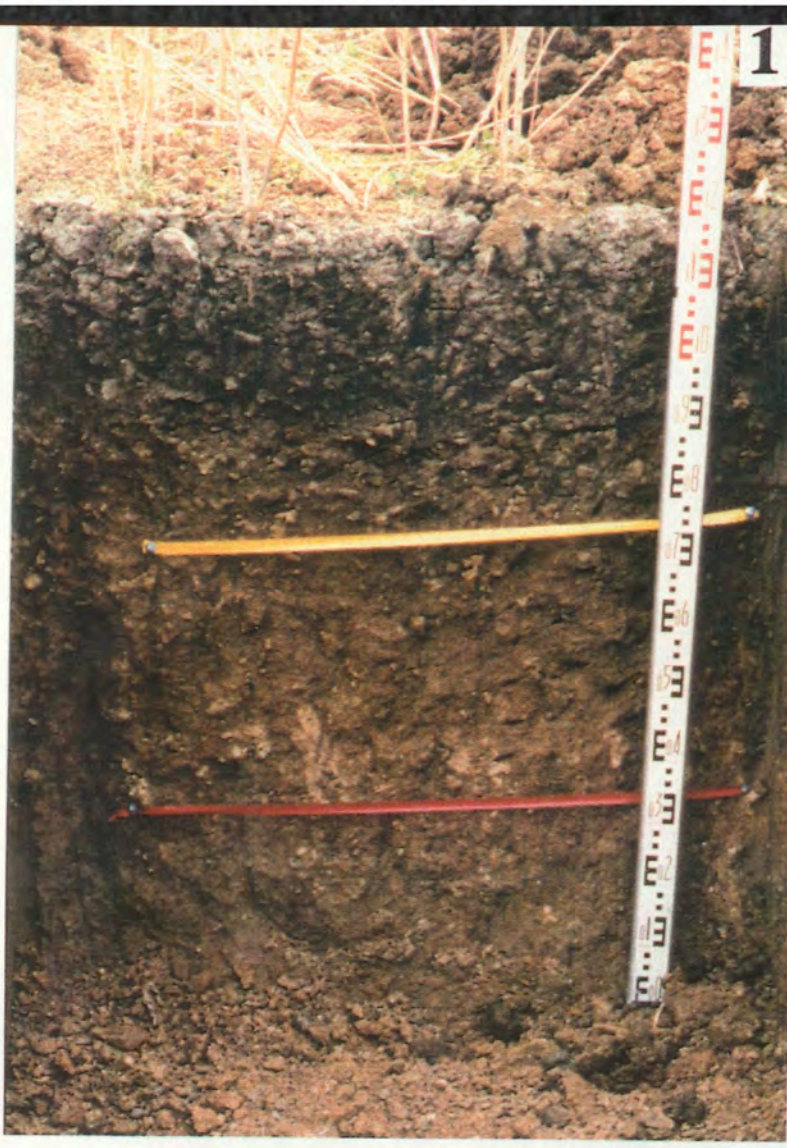
soil test results

Topsoil

Nutrition		Structure			
pH_{water}	7.7	Texture: Medium clay			
pH_{CaCl2}	6.9	Sodium (me/kg)	11.3	ESP	58.5
EC (dS/m)	0.29	Potassium (me/kg)	0.4	SAR	2.6
Total Nitrogen (% N)	0.07	Calcium (me/kg)	3.9	TCC (me/L)	2.93
Nitrate Nitrogen (mg N/kg)	5.2	Magnesium (me/kg)	3.7	Ca/Mg	1.1
Organic Carbon (% C)	1.0			Clay Dispersion %	7.9
Phosphate (mg P/kg)	6.8				

The pH is slightly alkaline and quite adequate for plant growth. The salinity of the topsoil is quite low and is not of concern. The total nitrogen and organic carbon levels are average for the cropped areas of these grey clays. The phosphate level is very low for this soil type and probably an influence of reduced returns from the paddock (reduced inputs). The soluble salt level (E.C.) is moderate and of no major concern to plant growth.

The problem nature of the soil structure at this site is confirmed with the soil test results. The SAR value is moderately high and, associated with a low Ca\Mg, indicates a capacity to disperse. This is confirmed with the high clay dispersion value. The high ESP is distorted by the amount of sodium salts in the overall levels of total cations.



BANYENA
water course

SITE 5 BANYENA (water course)

PHOTOGRAPH 1

This pit was 1.2 m deep in a remarkably different soil type, typical of those found in old watercourse areas. The soil profile consisted of clays varying in colour from grey at the surface, through yellow grey to a light grey with obvious mottling at depth.

The yellow tape indicates the depth of the majority of the canola roots (45 cm) whilst the red tape indicates the depth of the lowest wheat root found (85 cm), there being only a couple of roots visible to this depth. Some worm activity was evident to this depth, enhancing root penetration.

PHOTOGRAPH 2

The soil profile was that of very dispersive clays, the profile below 20 cm being quite moist and plasticine-like in consistency (the topsoil being dried by the crop and the season). The soil moisture occurring below 20 cm was not being fully exploited by the crop. The subsoil below 30 cm was yellow-grey and calcareous in appearance and of very plastic consistence. A few nodules of free carbonate were scattered below 80 cm.

PHOTOGRAPH 3

Soil cores were taken after harvest, at equal intervals of about 80 m across the paddock, to indicate possible variations in the soil profile. The left-most core was taken 80 m from the pit site and the others sequentially across the paddock in a south-westerly direction. The cores indicate a uniform paddock of heavy dispersive clays not ideally suited to plant growth.

PHOTOGRAPH 4

View south-west in the direction of the core sampling with the sampling rig preparing for the first core. Gypsum had been applied to the paddock prior to the canola crop, evidence of the gypsum heap being evident after the canola stubble had been burnt.

Subsoils

	10 - 30	30 - 70	70 - 120
pH_{water}	8.4	9.4	8.7
pH_{CaCl2}	7.6	8.0	8.1
EC (dS/m)	0.65	0.35	1.40
Sodium (me/kg)	24.9	22.1	66.4
Potassium (me/kg)	0.4	0.7	0.6
Calcium (me/kg)	2.2	4.2	2.8
Magnesium (me/kg)	1.9	4.5	3.4
SAR	7.8	4.7	16.9
TCC (me/L)	6.87	3.99	13.61
Ca/Mg	1.20	0.90	0.80
Clay Dispersion (%)	<1	13.2	<1

The pH of the subsoil increases with depth, indicating an influence of sodium carbonate and or sodium bicarbonate below 30 cm. This is confirmed by the corresponding increase SAR levels. The E.C. level of the 10 - 30 cm layer is high and would reduce plant. Although this layer is highly sodic (SAR well above 3), there is so much soluble salt in the soil (high E.C. &, TCC) that flocculation of the clay particles occurs, hence the low clay dispersion value.

The soil test data appear atypical for the horizon between 30 cm and 70 cm, with lower salinity, more carbonate or bicarbonate (higher pH) and increased Calcium and Magnesium present (which may give rise to the yellow colour in the profile). Compared to the layer above, the pH is higher but the level of soluble sodium is similar and the E.C. level is lower.

The layer below 70 cm appears to have less soluble calcium but more of the soluble chloride salts of sodium as indicated by an increased EC; a very high sodium level but a lowered pH. Soil salinity at this level (greater than 1.0 dS/m) is detrimental to plant growth and would reduce the growth of crop roots, assuming they could get to this level.

The subsurface layers exhibit very high levels of soluble sodium indicating their highly sodic nature. The high SAR values (>3), low calcium to magnesium ratio (< 2) and high clay dispersion all indicate soils that are prone to swelling. Once wet, these soils will have little air in the profile and become tightly packed, reducing root penetration. Moisture and nutrients would thus not be available to the developing crop.

4. DISCUSSION

The soil pit sites were chosen to be in those soil associations described by Badawy (1984) that occur within the WIM 200 and WIM 250 mining sites. The site within each association was placed in the major cropping soils found within that association. The soil test results from that pit show relative variability down the soil profile. However, the pit is only one location within that soil type. Further tests need to be carried out across each soil type to give truly representative results of the soil types. The soil cores show variation across the paddock, the direction of travel taken to be the longest distance within the paddock but not crossing visible variation in soil types across the paddock.

The purpose of using the soil pit approach was to allow a comparative view of each of the soils to be gained and to allow the farming community to learn about their soils. If further study were to be commissioned, then this paper, along with Badawy (1984) would give direction.

The results of this preliminary soil study identify implications for management for continued cropping activities in the areas of the mining sites and for the rehabilitation after proposed mining activities on the WIM 200 and WIM 250 sites. These subjects are discussed separately.

a) MANAGEMENT IMPLICATIONS.

Two soil pits excavated in this study are exceptional; those being pit 5 on the water-course clays and pit 6 on the red rise. The other six pits are similar in that they are on grey cracking clays with free carbonate in the profile, albeit at varying depth. The exceptional sites will be discussed separately.

Grey clays

The salinity of the soils was not of major concern at most sites as the higher levels were generally below 80 - 90 cm, ie below the crop root zone. The highly saline level at 60 cm for pits 7 and 8 is more disturbing as this will be restricting crop root development. Management decisions to cope with saline situation will be to allow for a yield penalty when growing susceptible crops (grain legumes particularly) or restrict their use in the cropping rotation. The cause of the saline subsoils is of a regional rather than localised event. Amelioration by tree planting will have marginal effect and will make the land less productive and the whole farm enterprise less economically viable. The use of a deep-rooted perennial plant such as lucerne may be useful.

The pH_w of the topsoil was generally 8.1, with pH_w increasing down the profile to above 9.0. At pH_w levels of this magnitude, the availability of many plant for plant growth is low. This is particularly so of the subsoils, making the crop effectively dependant on the topsoils for nutrients. In particular, the nutrients concerned are phosphate and the trace elements iron, zinc and copper. Hence, the application of these nutrients as fertilisers will be required more frequently to maintain optimal plant growth. Smaller amounts applied frequently will be more beneficial to plants that larger applications less frequently.

The organic carbon levels are average for the grey clays intensively cropped in the Wimmera, around 1.0 %. These clay soils could maintain higher levels if managed adequately. The inclusion of more years of pasture, fewer cultivations that break down the organic matter quicker and less burning of crop residues will all allow the level of organic matter to rise. The organic matter in the soil degrades to release nutrients for future plant growth as well as material that hold soil aggregates together to maintain soil structure.

The ratio of carbon to nitrogen in typical cropped soils in the Wimmera is around 10 or 12. This was the case for all of the grey clay sites except for site 2, where C:N was 20. This suggests that there was quite a lot of undecomposed plant material (straw) in the soil that will reduce soil mineral nitrogen levels as it decomposes. The nature of the material incorporated into the soil will help determine the C:N ratio. Material with a higher protein content (legume) will help lower the ratio and increase available soil nitrogen.

The survey results suggest that all of the sites were associated with gilgai puff and depression systems, seen either in the soil profile or in the core samples. The puff rises are upon the abundant deposits of highly calcareous material whereas the depressions consist of deeper self-mulching cracking clays. Over time, the topsoil over the gilgai puffs have been levelled off, exposing soil of slightly different soil properties (eg. structure, pH salinity, etc). The gilgai areas may show signs of surface ponding when excessively wet and usually show as late maturing patches in a crop. This is due to the more water held in the deeper clays (including more from "run-on") and the deeper root penetration into less alkaline subsoils.

The subsoils under the grey clays increase in both sodicity (SAR) and clay dispersion values with depth. This indicates that these subsurface clays will tend to swell when they become wet. Upon swelling, these clays will become tight, preventing access by more water and reducing air pockets necessary for root growth. Along with high pH and high salinity, this will be limit the rooting depth of the crops grown on these soils.

Red rise (pit 6)
The salinity of this soil is low, and in fact too low! Although excessive salts in the soil are detrimental to plant growth, some electrolyte is required to flocculate the clay particles within aggregates. The E.C. and TCC levels are too low to assist flocculation; the soil surface will be prone to dispersion and the subsoils will swell when wet (reflected in the high clay dispersion values).
The soil surface at this site is prone to compaction, restricting water penetration and plant emergence and growth. The soil is low sodic with very low levels of soluble salts (EC <0.1%). Hence the clays will disperse (see above). Management options to remedy the situation are the addition of gypsum to reduce aggregate breakdown and subsoil swelling, the incorporation of organic matter to maintain structure, maintenance of surface stubble to protect the soil surface from rain, reduced mechanical cultivations to maintain structure improvements and the restriction of stock movements (especially camps on rising ground) to prevent compaction. This is particularly important when the soils are wet. Animal traffic on these soils at any time will reduce surface soil structure, either by powdering dry soils or pugging wet soils.

This soil is prone to the formation of a hard pan immediately below the cultivation layer. This is due to physical compaction, either by machinery of stock traffic. Initial ripping to break up the pan and the adoption of the above management practices will help remedy the situation.

The high pH levels in the subsoils indicate reduced availability of nutrients to crop plants. This, coupled with the swelling nature of the subsoils and associated reduction in moisture and root penetration, will be limiting factors in crop production.

Water course clays (pit 5)
The presence of saline soil near the surface (10 - 30 cm) will reduce the productivity of many crops, especially for susceptible crops such as grain legumes and legume pastures. Although adequate at the surface, the pH values rise quickly in the subsoils and hence will reduce the productivity of the growing crops (as discussed earlier).

Although the sodicity of the surface soil is low (SAR <3), there are insufficient soluble salts (EC 0.3 dS/m) to flocculate the soil clay, resulting in a high test value for clay dispersion (8 %). To help overcome this, gypsum application at the time of sowing of a pasture will allow better plant emergence and establishment. The increased soil organic matter from the pasture will help stabilise the soil aggregates. These aggregates will still be unstable when wet, so careful grazing management will be required to avoid surface compaction.

b) AFTER MINING REHABILITATION

The issues of salinity, sodicity and high pH discussed in the previous section will also impact on the ability to rehabilitate the sites if they were to be mined.

The majority of the soils in the area consist of three major zones;

0 - 15 cm	the topsoil with the majority of the soil organic matter and available plant nutrients.
15 - 80 cm	rooting zone of the crops, generally sodic, alkaline and non-saline
>80 cm	deep subsoil which is generally hostile to plant growth, varying in salinity, sodicity and alkalinity.

These soils will be required to be handled separately, stockpiling individually prior to rehabilitation. Of the soils inspected, the topsoils are relatively uniform, the subsoils vary to the extent of their alkalinity but the deep subsoils are most variable. The deep subsoils can be grouped as

pits 3,6	low sodic, alkaline
pits 1,4	high sodic, alkaline
pits 2,7,8	high sodic, alkaline, saline.

Issues relating to these subsoils include:

- The complete removal of the stockpiles from underlying topsoils (where that occurs) to prevent surface crusting and sealing, preventing water infiltration and crop emergence.
- Rainfall runoff carrying the salts from subsoil stockpiles onto neighbouring topsoil areas
- Rainfall causing dispersion and subsequent erosion of subsoils onto neighbouring topsoils.

The present of Boron in the subsoils will also be of concern, once they are bought to the surface and prone to rain induced erosion. Being readily soluble, the Boron will carry to neighbouring soils with the potential to cause plant toxicity problems. The Boron will most likely be associated with the high salinity levels, although may occur elsewhere in the profile.

Backfilling an open-cut will be the most likely method of extracting the mineral sands so as to reduce the double handling of the overburden. This method will reduce the stockpiling issues discussed above and reduce the occurrence to only minor sites. However, it will raise the concern of inheriting soils from some distance away.

The location of the troublesome topsoils, the red rises and the watercourse clays, may change from one property to another. Conversely, the well managed, well structured soils may move onto the property. Concerns about property values and or compensation may arise.

5. SUMMARY

The soils of the WIM 200 and WIM 250 sites are generally productive, broadacre cropping soils with the root zone occupying the top 80 cm of the profile. The organic matter component is similar to many cropped paddocks with similar soils types. However, the levels could be maintained higher with more stubble retention and less cultivation operations.

The subsoils are variable in their hostility to root growth. In many cases, the subsoils below 80 cm become saline, with the salinity levels at levels detrimental to plant root development.

Many of the subsoils in this study were sodic, with the subsequent properties of being tight, (with few air spaces) and thus restrictive of moisture and root movement.

If mining of the sub-surface mineral sands was to occur, stockpiling of soils is undesirable and may cause subsequent problems due to the saline and sodic nature of the subsoils. The relocation of topsoils some distance away from their original location during backfilling operations may also be a concern.

REFERENCES

Badawy, N. S. 1984. Soils of the eastern Wimmera, Victoria. *Research Project Series No 189.* Department of Agriculture, Victoria.

Ford, G.W. and Greene, R.S.B. 1984. The effect of gypsum on cation exchange in two red duplex soils. *Aust. J. Soil Res.* **23:** 233-239

Hillel, D., 1991. *Soil and water: Physical properties and processes.* Academic Press, New York

Rengasamy, P. and Olsen, K.A. 1991. Sodicity and soil structure. *Aust. J. Soil Res.* **29**: 935-52

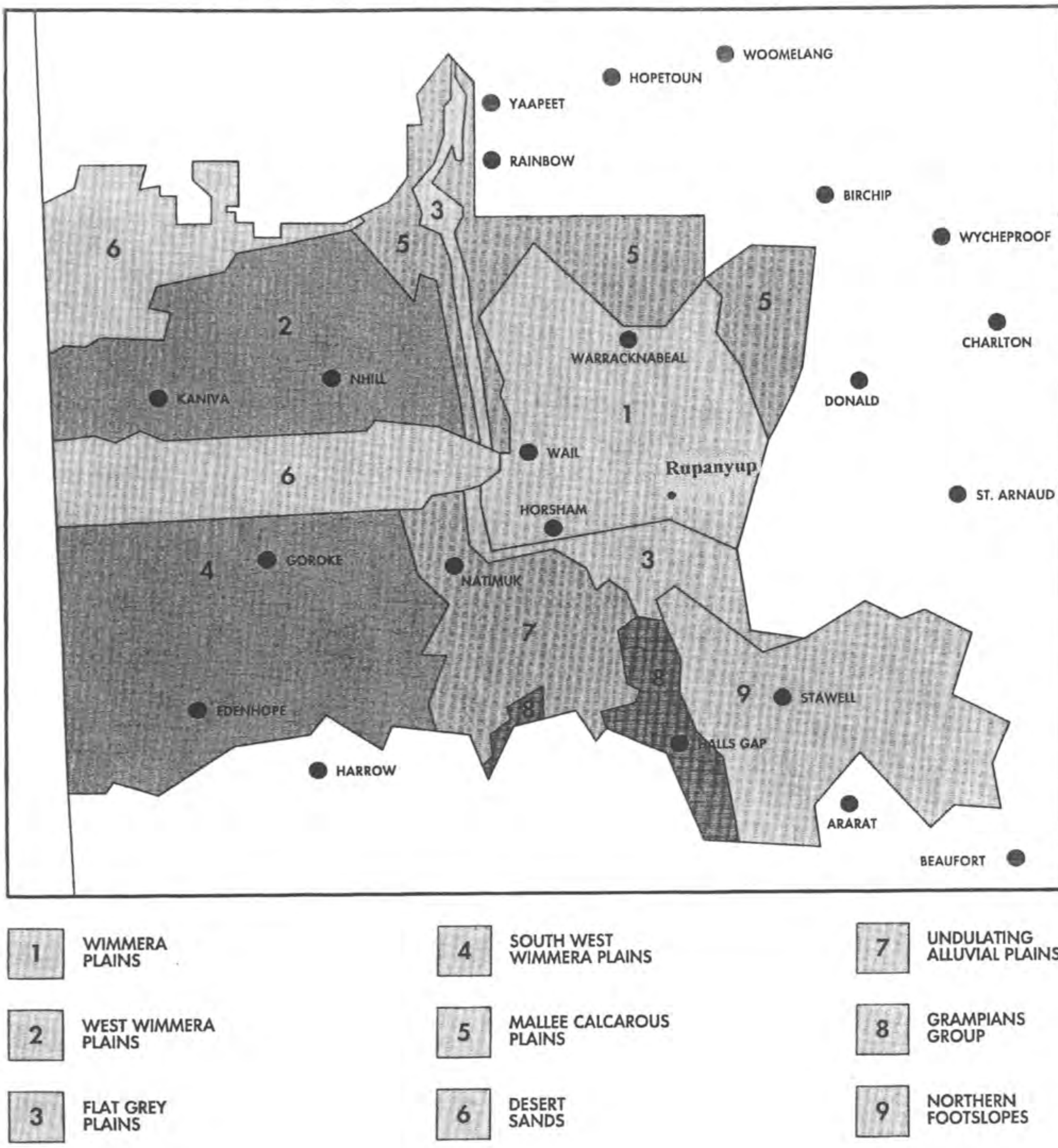
Sumner, ME (1995) *Sodic Soils: New Perspectives.* In 'Australian Sodic Soils - Distribution, properties and management'.(Eds. R Naidu, ME Sumner, and P Rengasamy). CSIRO Melbourne.

APPENDIX 10

Map of Resource Management Units. Wimmera Regional Catchment & land Protection Board (1997) Wimmera Regional Catchment Strategy, DNRE, Horsham, Victoria.

Appendix 10

Resource Management Units. Wimmera Region



From: Wimmera Regional Catchment & Land Protection Board (1997) Wimmera Regional Catchment Strategy, Dept Natural Resources and Environment, Victoria.