The impact of mining and mining exploration on range resources and pastoral pursuits in the Pilbara, Gascoyne, Murchison and Goldfields regions of Western Australia

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H.J. Pringle, G.A. Carter, J.L. James, R.E.Y. O’Connor

Disclaimer

The contents of this report were based on the best available information at the time of publication. It is based in part on various assumptions and predictions. Conditions may change over time and conclusions should be interpreted in the light of the latest information available.

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1. Summary and General Recommendations

**Summary**

This report was produced in response to a request for information on the current impact of mining on pastoral leasehold land, and on the operations of pastoral business from the Commissioner for Soil Conservation. The data was collected firstly by a voluntary questionnaire survey, and secondly by selected pastoral lease case studies carried out by Pastoral Inspectors from Western Australian Department of Agriculture district offices.

Mining activity occurs very widely over relatively small areas of the rangelands. However, it is an intense landuse which can create significant offsite effects. Mining activity is not a general factor influencing every pastoral business. However, where mining activity occurs on a pastoral lease it can have a negative impact on the pastoral business, quality of life for the pastoralist and the range resource.

Mining activity is most common around metamorphic ‘greenstone’ belts and broad drainages. Fifty-six (66 per cent) lessees reported the presence of some type of mining activity within their boundaries. Fifteen and a half per cent of the shire areas covered in this report were under some form of mining tenement, whilst 41% of the area consisted of pastoral leases. In some shires almost all of the land was under pastoral lease and about half of the same area was also under mining tenements.

Pastoralists reported both benefits and adverse affects as a consequence of mining activity. Most pastoralists who responded to the questionnaire perceived the presence of mining activity within their lease boundaries as disadvantageous to their pastoral business and harmful to land resources.

The main grievances related to unnecessary and excessive disturbance of pastoral land, the failure of operators to inform the pastoralist of their intentions, and the general (rather than exceptional) practice of abandoning the land without attempting rehabilitation.

Much of the mining activity-related degradation in the rangelands is a legacy of the past, when environmental impact regulations and their implementation were totally inadequate. The Mines Department has recently deployed additional resources to improve this situation; particularly with the formation of an environmental management section within the Mining Engineering Division.

At the time of writing this report there were three Mines Department environmental officers, in Karratha, Kalgoorlie and Perth. This level of staffing is inadequate to monitor mining impacts on the environment over such a huge area.

The mining industry brings new growth to pastoral areas. Mining operations require bore-fields, airstrips, access roads and other such facilities, which can bring
considerable economic and infrastructural benefits for pastoral concerns. A co-operative relationship between miners and pastoralists can facilitate each one’s activities.

The establishment of an environmental unit in the Mines Department, increasing environmental awareness in the mining industry, the provisions for compensation in recent legislation and developing co-operation and goodwill between the two industries should ensure that conflict is avoided and equitable shared land use can be achieved.

**General Recommendations**

1. Extra conditions. It is recommended that the following conditions be included in the “List of Conditions” for all tenement holders:

   a) that all tenement holders when notifying the lease holder of their tenement will include a map showing the position of the tenement with reference to existing structural improvements;

   b) that tenement holders pay a noxious weed and vermin levy in the same way other land holders are levied;

   c) that all dogs be banned from tenements and that the question of firearms be considered in the light of pastoralists’ concerns.

2. There is a need for the Guidelines for Environmental Management of Mining in Arid Areas (Dept. Mines Western Australia, 1988) to be extended to include:

   a) Exploration (Prospecting and Exploration Leases).

   b) Alluvial mining.

   c) Small scale mining.

3. It is recommended that all sectors of the mining industry involve themselves with local Land Conservation Districts. These groups can be a valuable source of land management expertise and they provide an opportunity for community liaison.

4. It is recommended that a standard procedure be formulated for evaluating the impacts of mining activity on the resale value of pastoral leases. The Department of Mines, the Department of Agriculture, representatives from the mining and pastoral industries and qualified valuers should be involved in the formulation of the procedure.
2. Introduction

The shrubland and spinifex rangelands of Western Australia occur south of latitude 20°s, east of those lands used for agricultural production in the South West Land Division and west of arid lands of central Australia (Figure 1). Within this huge area, about 70 million hectares are held as pastoral leases and are used for the extensive grazing of sheep and cattle on native pastures. There are 447 individual stations in this area, supporting about 200,000 cattle and 2.2 million sheep. The gross value of production is about $70 million per annum.

Grazing is the most extensive use of these rangelands, but the land is also used for tourism, commercial timber harvesting, recreation and mining. Furthermore, there are numerous Aboriginal settlements and conservation reserves. The area includes stock routes and water reserves, reminders of the past, which have not been incorporated into the surrounding leases, though they are rarely fenced off. Where there is multiple use of the same or adjacent areas of land one form of land use may disadvantage another. This report attempts to assess the impact of mining activity on pastoralism.

2.1 Aims

This study had the general aim of determining and researching the current impact of mining on pastoral leases south of the Kimberley. Specific information was to be collected on:

- the number and type of mining operations in the rangelands;
- the area of land affected by mining and mining exploration activity;
- and the principal land systems being used;
- effects of mining on the soil and plant resources;
- effects on the business and daily operations of the pastoral industry.

In addition, the study has briefly considered the manner in which mining activity on pastoral leases is regulated, and the requirements for rehabilitation of land subject to mining or mining exploration.

The study was done by the Rangeland Management Branch of the Department of Agriculture. G.A. Carter, J.L. James and R.E.Y. O'Connor collected the questionnaire data. D.G. Burnside and M.L. Fletcher assisted with the preparation of parts of the report, which was collated and finalized by H.J. Pringle.
2.2 Previous Studies on Mining Impacts in the Semi-arid Rangelands

The upsurge in mining activity in the semi-arid rangelands has been the subject of a number of published documents in recent years. The most significant of these is the “Report on Conservation and Rehabilitation in the Gold-Mining Industry” (the Playford Report). The Working Party on Conservation and Rehabilitation in the Mining Industry (WPCRMI) which prepared this report for the Hon. Minister for Minerals and Energy included representation from the Mines Department, the Association of Mining and Exploration Companies, The Chamber of Mines of Western Australia, The Department of Conservation and Land Management, The Pastoralist and Graziers Association, the Department of Agriculture and the Land Resource Policy Council. Their report was submitted to the Hon. Minister for Minerals and Energy in 1985.

a) Several recommendations were of special significance to the rangelands used by the pastoral industry. These are listed below:

b) Existing provisions of the Mining Act (1978-1985) to control environmental aspects of gold mining and exploration of Crown land, including public reserves, are generally considered to be adequate. However, minor amendments are required to enable the Mines Department to enforce conditions on all types of tenements for environmental as well as safety reasons.

c) The Mines Department is unable to adequately enforce the existing environmental provisions of the Mining Act because of the lack of sufficient staff, consequently many operators fail to achieve satisfactory standards of conservation and rehabilitation.

d) Criteria need to be developed that will identify those mining and exploration proposals that should be referred by the Mines Department to the Environmental Protection Authority.

e) Broad environmental objectives should be developed for exploration and mining in particular regions of the State.

f) Specific rehabilitation standards need to be defined for each mining or exploration project involving significant ground disturbance, taking into consideration the surrounding environment and land use as well as the nature of the operation.

g) Environmental objectives and rehabilitation standards should be established before operations commence to enable adequate planning and costing to be undertaken.

h) Rehabilitation standards on pastoral leasehold land should be based on minimizing adverse impacts on the viability of the pastoral operation; land that will not be rehabilitated to its former condition needs to be stabilized, and, where necessary, isolated from the surrounding land; and operators of mines on
pastoral leases should fully compensate the leaseholder for any losses incurred as a result of the mining operations.

i) In all cases equipment and rubbish need to be removed or buried at the completion of exploration and mining operations.

j) An environmental management unit should be established in the Mining Engineering Division of the Department of Mines to formulate environmental objectives, assess environmental proposals submitted by operators, supervise the implementation of approved proposals, and enforce the environmental provisions of the Mining Act.

k) Tenement holders not subject to State Agreements should be required to submit written environmental proposals detailing the nature of any significant surface disturbance to be undertaken and the planned rehabilitation measures. Any such operations should not be allowed to commence until written approval is obtained from designated staff of the Mines Department following any necessary consultations.

l) Administrative procedures should be developed to enable the Mines Department to require a bond for any operation, if it is considered necessary, prior to or during the course of any work involving surface disturbance. Such a bond would be available to the Department to finance remedial work when rehabilitation conditions are not met.

m) The desired end use of land following mining should be clearly defined before the commencement of mining operations, so that appropriate rehabilitation procedures can be formulated.

n) Regional mining environmental advisory committees should be established, so that community-based environmental objectives and rehabilitation standards can be formulated for submission to the Director General of Mines.

o) Legislation should be passed to amend the Mining Act to define the offence of illegal mining and establish procedures for the apprehension and prosecution of offenders.
Figure 1. Principal Zones of the Pastoral Areas in Western Australia
Since the release of the working party’s report in 1985 the Environmental Management Unit has been established in the Mining Engineering Division of the Department of Mines. This unit has located an Environmental Officer in each of the Eastern Goldfields, the Pilbara and in Perth. These officers provide a valuable point of contact for pastoralists’ concerned about mining activity. They are members of many Land Conservation District Committees in the pastoral areas where mining and mining exploration is a significant land use.

As a further response to the working party’s report, the Mining Engineering Division of the Department of Mines published “Guidelines for Environmental Management of Mining in Arid Areas” in May 1988. These guidelines state that “for mines in the semi-arid or arid environments the most realistic short term reliable goal is to establish a ground cover resistant to erosion. The long-term goal should be to establish a community of plants which is as stable, diverse and resilient as the pre-mining vegetation and which is compatible with the surrounding environment and land areas. Therefore the aim should be to rehabilitate land to enable normal grazing practices to be re-instated.” Although these guidelines are concerned mainly with the rehabilitation needs following large scale mining, the above statements can apply equally to rehabilitation following small scale open pit and underground mining, alluvial mining and exploration work.

Exploration Guidelines for Field Personnel (1988) were published by the Chamber of Mines of Western Australia (Inc.) and distributed widely within the mining and pastoral industries. These guidelines state that “the exploration company’s aims should be:

- to adequately test the ground in question;
- to liaise with all landholders in the area;
- to minimize disruption to landholders, livestock, vegetation and land;
- to rectify, by repairs or compensation, any damage caused by exploration.

2.3 The Pastoral Industry’s Response to Mining and Mining Exploration Activity

The reports and published guidelines discussed in the previous sections have recognized a commitment to better environmental management by the mining industry operating in the rangelands. However, there is a strong perception within the pastoral industry that the mining industry’s performance as a land manager falls somewhat short of the standards recommended in the published guidelines referred to earlier. Concern has been expressed by pastoralists about this issue since the upsurge in gold mining and exploration activity in 1980. There have been direct complaints to mining companies and to the Department of Mines. Some individual instances have involved officers of the Resource Management Division of the Department of Agriculture. In more recent times, Land Conservation District Committees have investigated and reported on land...
management problems related to mining and exploration activity. Specific grievances raised by pastoralists have included the following:

- excessive clearing of grid lines;
- failure to cap drill holes or to fill costeans;
- alluvial mining not followed by rehabilitation; use of hyper saline water in sluice mining operations;
- damage to fixed station infrastructure; use of station access roads during wet weather;
- increased interference with normal station management;
- poorly sited and constructed access ways for pipelines and powerlines.

In September 1987, the North Eastern Goldfields Land Conservation District Committee (NEGLCDC) recommended a range of conditions that should apply to all forms of mining tenement in pastoral areas. Those suggested conditions are attached as Appendix 1.

Partly in response to that recommendation, the Department of Mines extended the conditions which applied to mining leases to prospecting licences and exploration licences. These conditions effectively satisfy NEGLCDC’s recommendations in respect of points 2 and 3. Section 98 of the Mining Regulations Act satisfy points 4 and 5, and at the time of preparation of this technical report, the suggested condition in point 1 is being considered by the Mining Industry Liaison Committee (MILC).

2.4 The Current Study

In July 1987, the Commissioner of Soil Conservation requested a report on the current impact of mining on pastoral leasehold land, and on the operations of pastoral businesses. This technical report was prepared in response to that request and describes the impacts that mining and mining exploration are having on the range resources and pastoral pursuits in the pastoral areas south of the Kimberley.
3. **Historical Perspective**

The development of the mining and pastoral industries in these semi-arid rangelands occurred concurrently in the last decades of the nineteenth century (Burnside, 1979). Sheep grazing on native pastures commenced near Roebourne and along the Greenough River in the 1860s. Gold discoveries in the Murchison and in the Pilbara in the 1880s hastened the settlement of these areas for both mining and pastoral purposes. The discovery of gold in the Eastern and North Eastern Goldfields in the 1890s was followed by the establishment of a pastoral industry in these areas in the early years of this century. A steady decline in gold mining activity occurred from 1920 onwards, with mining confined to major mines in centres such as Kalgoorlie-Boulder, Leonora and Mt Magnet. The major iron ore deposits in the Pilbara were first exploited in the mid 1960s. This industry now supports a large population in the Pilbara and an extensive infrastructure of transport and water supply facilities. The discovery of nickel in the late 1960s led to a renewal of mining exploration and mining in the Eastern and North Eastern Goldfields. The so-called “nickel boom” was over by 1973, to be followed in 1980 by a major upsurge in gold mining activity throughout the semi-arid pastoral areas. In areas of the Carnarvon and Ashburton shires, exploration for oil has become a significant activity in recent years.

The nature, location and extent of the adverse impacts of pastoralism on rangeland soils and vegetation has been described for about 35,000 km² of the area considered by this report (Payne et al. 1988, Payne et al. 1983, Mitchell et al. 1979, and Wilcox and McKinnon, 1972). A programme to assess the remainder is in progress. Prior to this report no similar assessment had been made of the adverse impacts of mining activities.
4. The Physical Environment

The rangelands south of the Kimberley easily divide into two main natural regions, each of which has a distinct climate and vegetation. These are the north western spinifex region, which includes the Pilbara and the Ashburton and the Acacia shrubland region of the Gascoyne, Murchison, Goldfields and Nullarbor areas. Areas which have been mapped into land systems or equivalent units include the Ashburton River catchment (Payne et al. 1983), the Roebourne Plains and surrounds (Payne et al. in prep.), South Broome Shire (Cotching, W. in prep.) the Carnarvon Basin (Payne et al. 1988), the Gascoyne catchment (Wilcox et al. 1972), the Murchison catchment (Curry et al. in prep.), the Wiluna - Meekatharra area (Mabbutt et al. 1963) and western parts of the Nullarbor Plain (Mitchell et al. 1979). A rangeland survey of the North Eastern Goldfields is in progress.

4.1 The North-Western Spinifex Region (Pilbara and Ashburton)

This region is situated between the Kimberley region and latitude 23°s. The climate is arid to semi-arid with unreliable annual rainfall averaging 300 mm. The major portion of the annual rainfall occurs during summer cyclones. Daily rainfall events as high as 500 mm have been recorded. The dominant natural features are the Hamersley and Chichester ranges, and the river valleys of the De Grey-Oakover, Yule, Turner, Fortescue and Ashburton. There are extensive alluvial plains associated with these rivers, the plains broaden at the coast. The vegetation is dominated by the hummock grasses known as spinifex (*Triodia* and *Plectrachne* species) which occur on the hills and sandy plains. The alluvial plains support native grasses such as Roebourne Plains grass (*Eragrostis xerophila*) and buffel grass (*Cenchrus ciliaris*) which was an accidental introduction from Afghanistan in the packing of camel saddles. In this region, sheep predominate along the coastal plain, giving way to cattle on the open range inland. Regional officers estimate that the area supports about 150,000 cattle and 220,000 sheep.

Iron ore is the most important mineral in the Pilbara. The iron ore mines are usually located in mountainous regions which have little attraction for grazing animals. The mining areas are discrete and few in number. Gold mining occurs in the Marble Bar-Nullagine area, and in isolated areas in the Ashburton. The gold is recovered through alluvial mining in most cases.

Nearly 100,000 square kilometres of this region have been covered by rangeland resource inventory and condition surveys (Payne et al. 1983, Cotching, W. in prep., and Payne et al. in prep.).
4.2  The Acacia Shrubland Region - (Gascoyne, Murchison, Goldfields and Nullarbor Areas)

The arid shrublands lie south of latitude 23°S and east of the area used for crop production in the South West Land Division.

Average annual rainfall is between 200 and 250 mm, with most useful rain being received in winter. Droughts of more than one year’s duration are common. The dominant physical features are the coastal plains of the Carnarvon Basin, the river basins of the Gascoyne, Wooramel, Murchison and Greenough rivers, the greenstone belts and palaeodrainages of the Eastern and North Eastern Goldfields and the extensive limestone karst known as the Nullarbor Plain.

The vegetation is a complex of trees, shrubs, perennial grasses and annual herbs and grasses. Acacias dominate the tree layer, except in the Eastern Goldfields where eucalypts occur. Tree growth is absent from all but the western and southern fringes of the Nullarbor Plain.

The shrub layer in these areas is long lived and provides an important element of stability in the environment. The perennial plants are important for providing nutrition for the grazing animals at those times when annual growth is limited. Regional officers estimate that currently the shrubland region is supporting about 1.8 million sheep and about 50,000 cattle.

Gold and nickel are the main minerals mined in these areas. Normally both minerals are associated with Archaean greenstones which occur as belts aligned roughly N-S in the Murchison and Eastern Goldfields. The soils formed on these greenstones are well developed and relatively fertile and support valuable chenopod shrubland pastures. Land systems describing these areas include Laverton, Leonora, Gundockerta, Bevon, Nubev, Gabanintha, Wiluna and Violet. Their characteristics are described in Section 6.2.1.

Of this area, 247,000 square kilometres have been covered by rangeland resource inventory and condition surveys (Payne et al. 1988; Wilcox et al. 1972; Mabbut et al. 1993; Curry et al. in prep. and Mitchell et al. 1979).
5. Methods

5.1 Mining Tenement and Pastoral Lease Areas

In order to discuss mining impacts in pastoral areas, quantitative data on the distribution of both land uses was sought. The mining tenement area information was kindly supplied by the Mines Department, pastoral lease areas by the Pastoral Board, and shire areas by the Local Government Association of LA. (Inc.).

There are considerable areas under both mining tenement and pastoral lease that are not currently being used for the purpose for which they are rated. These figures represent the only reasonably accessible quantitative spatial data regarding these land-uses and provide useful information regarding potential distribution of these land-uses, indicating the possible extent of land-use conflict.

The data were collected by shire areas.

5.2 Questionnaire to Pastoralists

A questionnaire (Appendix 2) was sent to each pastoral station lessee in the Goldfields, Murchison and Pilbara regions. Lessees were asked to make general statements regarding the effects of mining activity on the rangelands, their management practices, and station maintenance. In addition they were asked to estimate mining activity by categorizing the area affected by mining activity on their property into one of three broad categories: Extensive (> 100 ha), Minor (10 ha) and Nil. They were also asked whether they had been notified of the mining companies' presence, whether they had success in resolving any problems caused by mining activity and how the existing arrangements for allowing multiple use of rangeland could be improved.

Three hundred and twenty-seven questionnaires were sent out and 128 were returned.

5.3 Individual Property Visits

Following consideration of individual questionnaires from the 128 replies to the survey, five stations were selected for visits to obtain more detailed information.

In the hope that the full range of mining activities and impacts would be observed, the selected properties were those which indicated a greater than average level of mining activity. Obviously these stations are not a representative sample.
The property inspection involved consideration of all or some of the following aspects:

a) Examination of the areas on the property where mining or exploration was taking place.

b) Discussion with the affected pastoralist to determine his view of the impact of mining activity on:
   1) changes in management practices;
   2) alterations to stocking levels;
   3) future effects on property viability.

c) Discussion, where possible with the mine operators with regard to: life of project and extent of operation.

d) Measurement or estimation of the areas effected by each form of mining or exploration, including the development of roads and pipelines servicing the mining operation.

e) Photography of mining and exploration areas.

f) Assessment of the actual and potential effect of mining, on vegetation, soil erosion and salinity and changes to the area available for the pastoral enterprise at that time and in the future.

g) A consideration of the most appropriate methods for rehabilitation of mined and explored areas.
6. Results

6.1 Mining Tenement and Pastoral Lease Areas

Mining tenement data provided by the Department of Mines show that nearly 15.5% of the area of the shires in the study area were under some form of mining tenement (Table 1). Exploration licences were responsible for most of this area. Prospecting licences and mining leases, were the next most extensive tenement type and these accounted for less than one per cent of the shire area. Pastoral leases occupied nearly 41% of the shire area.

Table 1. Area statements of mining tenements and pastoral leases (in rangeland shires south of Kimberley)

<table>
<thead>
<tr>
<th>GENERAL PURPOSE LEASE</th>
<th>NO. OF LEASES OR LICENCES</th>
<th>AREA (ha)</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exploration licences</td>
<td>2,797</td>
<td>23,958,134</td>
<td>13.9</td>
</tr>
<tr>
<td>Prospecting licences</td>
<td>10,632</td>
<td>1,390,145</td>
<td>.8</td>
</tr>
<tr>
<td>Mining leases</td>
<td>4,026</td>
<td>1,219,904</td>
<td>.7</td>
</tr>
<tr>
<td>Miscellaneous licences</td>
<td>752</td>
<td>63,134</td>
<td>-</td>
</tr>
<tr>
<td>Mineral lease</td>
<td>534</td>
<td>58,091</td>
<td>-</td>
</tr>
<tr>
<td>Goldmining lease</td>
<td>728</td>
<td>5,515</td>
<td>-</td>
</tr>
<tr>
<td>General purpose lease</td>
<td>186</td>
<td>3,904</td>
<td>-</td>
</tr>
<tr>
<td>Total mining</td>
<td></td>
<td>26,698,836</td>
<td>(15.5)</td>
</tr>
<tr>
<td>Total pastoral leases</td>
<td></td>
<td>70,391,881</td>
<td>(40.8)</td>
</tr>
<tr>
<td>Total area of shires</td>
<td></td>
<td>172,686,943</td>
<td>(100.0)</td>
</tr>
</tbody>
</table>

(Note: Gold mining leases and mineral leases are residuals from the 1904 Mining Act. Since the 1978 Mining Act was passed, all new leases come under the “Mining lease” tenement type. Some pre-1978 leases have not been transferred to the new categories defined in the Act. Miscellaneous and General Purpose leases involve ancillary facilities such as accommodation areas, roads and bore-fields.)
The potential for land-use conflict is evident from these figures, however, because more than half the shire areas include the deserts of central Western Australia where there is no pastoralism and little mining activity the full significance of the coincidence of mining tenements and pastoral leases is obscured. Where the basalt and metamorphic greenstone belts and the palaeodrainage frontages occur together the overlap of pastoralism and mining is more complete.

The shire of Leonora (Figure 2) illustrates the extent of dual land use. Practically all of the shire is under pastoral lease and half of the area is also under mining tenements. In these circumstances it is imperative that a co-operative and constructive relationship exist between the two industries.

6.2 Results from Questionnaire

6.2.1 The extent of mining or mineral exploration activity

Investigation of the 128 replies to the questionnaire showed that some form of mining had or was occurring on 68 (53%) leases, exploration activity was reported on 84 (66%) leases, whilst one or more active mines were in operation on 28 (22%) leases. Both exploration and mining activity were present on many of these leases. Thirty four per cent of leases reported neither mining activity nor exploration within their boundaries.

In the following tables, the percentage values in brackets refer to the percentage of the 128 replies. Pastoralists often recorded a number of effects in each category, thus the figures do not necessarily add up to 128.
THE IMPACT OF MINING AND MINING EXPLORATION ACTIVITY

FIG 2 MINING TENEMENTS AND GENERALLY AURIFEROUS GEOLOGICAL ASSOCIATIONS ON LEONORA SH51-1
Compiled from scanned data May 1988 supplied by Mineral Mapping

LEGEND

- Mining Lease Area
- Greenstone and associated Geological Formations

VERY INTENSE MINING ACTIVITY ON GWAIA 1000000 SHEET

LEONORA SH51-1

KILOMETRES

PRODUCED BY H.E. GROUP W.A. DEPARTMENT OF AGRICULTURE GIS
A.F.M. NOV 1990
Table 2. The extent of mining and exploration activity

<table>
<thead>
<tr>
<th>LEASES REPORTING</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Leases with mining and exploration</td>
</tr>
<tr>
<td>2. Leases with mining only</td>
</tr>
<tr>
<td>3. Leases with exploration only</td>
</tr>
<tr>
<td>4. Leases remaining</td>
</tr>
<tr>
<td><strong>Total</strong></td>
</tr>
</tbody>
</table>

Table 3. The extent of various types of mining

<table>
<thead>
<tr>
<th>TYPE OF MINING</th>
<th>AREA DISTURBED GREATER THAN 100 ha</th>
<th>AREA DISTURBED LESS THAN 10 ha</th>
<th>NIL (OR NO RESPONSE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underground</td>
<td>2 (1.5)</td>
<td>9 (7)</td>
<td>117 (91)</td>
</tr>
<tr>
<td>Open cut</td>
<td>16 (12)</td>
<td>15 (12)</td>
<td>97 (76)</td>
</tr>
<tr>
<td>Alluvial or topsoil</td>
<td>30 (23)</td>
<td>17 (13)</td>
<td>81 (63)</td>
</tr>
<tr>
<td>Metal detecting</td>
<td>39 (30)</td>
<td>21 (16)</td>
<td>68 (53)</td>
</tr>
</tbody>
</table>

Table 4. The extent of exploration

<table>
<thead>
<tr>
<th>TYPE OF EXPLORATION</th>
<th>AREA DISTURBED &lt; 100 ha</th>
<th>AREA DISTURBED &gt; 100 ha</th>
<th>NIL (OR NO RESPONSE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No soil disturbance</td>
<td>22 (17)</td>
<td>10 (8)</td>
<td>96 (75)</td>
</tr>
<tr>
<td>Soil disturbance</td>
<td>46 (36)</td>
<td>27 (21)</td>
<td>55 (43)</td>
</tr>
</tbody>
</table>
Table 5. The number of gold mines occurring on lease

<table>
<thead>
<tr>
<th>NUMBER OF MINES PER LEASE</th>
<th>NUMBER. OF LEASES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>13 (10)</td>
</tr>
<tr>
<td>2</td>
<td>10 (8)</td>
</tr>
<tr>
<td>3</td>
<td>2 (1.5)</td>
</tr>
<tr>
<td>5</td>
<td>1 (1)</td>
</tr>
<tr>
<td>7</td>
<td>1 (1)</td>
</tr>
<tr>
<td>10</td>
<td>1 (1)</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong> 28 (22)</td>
</tr>
</tbody>
</table>

Total number of mines = 61.

6.2.2 The impact of mining and mineral exploration on the rangeland resources

Responses to the question regarding the major impact on the range and were classified into one of two categories:

- Specific rangeland impacts (involving damage to vegetation or soil erosion).
- Pollution.

The comments in response to this question were considered sufficiently significant for each category to be subdivided into several smaller classes. Lessees often listed more than one major impact in their responses.

a) Rangeland Impacts

Fifty-two (41%) reported one or more erosion or vegetation degradation impact.
Table 6. Mining activity - related damage to the rangeland resource

<table>
<thead>
<tr>
<th>TYPE OF IMPACT</th>
<th>NO. OF LEASES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Erosion caused by poor siting of roads/tracks/grid lines</td>
<td>28 (22)</td>
</tr>
<tr>
<td>2. Erosion caused by unnecessary clearing of vegetation and soil</td>
<td>16 (12)</td>
</tr>
<tr>
<td>3. Erosion caused by dryblowing</td>
<td>6 (5)</td>
</tr>
<tr>
<td>4. Vegetation damage due to clearing/removal of topsoil</td>
<td>25 (20)</td>
</tr>
<tr>
<td>5. Physical damage done to perennial vegetation</td>
<td>18 (14)</td>
</tr>
<tr>
<td>6. Vegetation damage caused by dust</td>
<td>5 (4)</td>
</tr>
<tr>
<td>7. Vegetation damage caused by lowering of watertable</td>
<td>4 (3)</td>
</tr>
<tr>
<td>8. Cases of no rehabilitation attempts</td>
<td>20 (15)</td>
</tr>
<tr>
<td>9. Introduction of weeds</td>
<td>1 (1)</td>
</tr>
<tr>
<td>10. No impacts</td>
<td>76 (59.5)</td>
</tr>
</tbody>
</table>

b) Pollution

Some form of pollution was reported on 16 (13%) pastoral leases.

Table 7. The incidence and types of pollution resulting from mining activity

<table>
<thead>
<tr>
<th>TYPES OF POLLUTION</th>
<th>NO. OF LEASES REPORTING</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Tailings dam/salt water leakages</td>
<td>8 (6)</td>
</tr>
<tr>
<td>2. Uncollected/loose sample bags</td>
<td>5 (4)</td>
</tr>
<tr>
<td>3. Polluted campsites (refuse, oil, machinery, etc.)</td>
<td>4 (3)</td>
</tr>
<tr>
<td>4. Dust pollution</td>
<td>2 (1.5)</td>
</tr>
<tr>
<td>5. No pollution</td>
<td>112 (87.5)</td>
</tr>
</tbody>
</table>
6.2.3 The impact of mining and mineral exploration on station infrastructure and management

a) Damage to station infrastructure

Twenty-three (18%) of leases reported one or more of the types of damage to infrastructure listed below.

Table 8. The damage to station infrastructure

<table>
<thead>
<tr>
<th>TYPE OF DAMAGE</th>
<th>NO. OF LEASES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Cut fencelines (uzirepaired), gates left open</td>
<td>12 (9)</td>
</tr>
<tr>
<td>2. Drained tanks, interference with watering points</td>
<td>12 (9)</td>
</tr>
<tr>
<td>3. Damage to station roads</td>
<td>9 (7)</td>
</tr>
<tr>
<td>4. No damage reported</td>
<td>105 (82)</td>
</tr>
</tbody>
</table>

Effects on stock husbandry or carrying capacity of the lease Thirty lessees reported some effect on their stock.

Table 9. Mining activity related impacts on stock husbandry and carrying capacities

<table>
<thead>
<tr>
<th>TYPE OF IMPACT</th>
<th>NO. OF LEASES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Reduced stocking rates due to mining activity</td>
<td>8 (6)</td>
</tr>
<tr>
<td>2. Mismothering of ewes and lambs</td>
<td>4 (3)</td>
</tr>
<tr>
<td>3. Forced closure of paddocks for grazing use</td>
<td>6 (5)</td>
</tr>
<tr>
<td>4. Loss of sheep in costeans or mines</td>
<td>4 (3)</td>
</tr>
<tr>
<td>5. Disrupted grazing patterns</td>
<td>15 (12)</td>
</tr>
<tr>
<td>6. Increased number of dogs</td>
<td>6 (5)</td>
</tr>
<tr>
<td>7. No impact reported</td>
<td>98 (71)</td>
</tr>
</tbody>
</table>
c) Management impacts

Table 10. Impacts on the day-to-day running of station leases

<table>
<thead>
<tr>
<th>TYPE OF IMPACT</th>
<th>NO. OF LEASES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Increased surveillance of fences/dams/gates</td>
<td>20 (16)</td>
</tr>
<tr>
<td>2. Removal of stock from active areas</td>
<td>19 (15)</td>
</tr>
<tr>
<td>3. Costeans causing mustering inconvenience</td>
<td>2 (1.5)</td>
</tr>
<tr>
<td>4. Increased paperwork</td>
<td>3 (2)</td>
</tr>
<tr>
<td>5. Some impact reported</td>
<td>35 (27.5)</td>
</tr>
</tbody>
</table>

The direct effect on the rangeland resource in terms of soil erosion or loss of vegetation was the most frequently reported impact with 53 (41%) reporting some form of erosion or vegetation damage caused by mining activity. Thirty-five (27%) lessees reported that the presence of mining activity had affected the management of their property in one or more ways, whilst 10 (8%) stated specifically that mining activity had not impacted on their leases.

6.2.4 Reported benefits to stations affected by mining or mining exploration work

Many lessees benefit through capital improvement made by mining companies and the increased availability of contract work. These benefits are summarized in Table 11 below.

Table 11. Mining company inputs into station leases

<table>
<thead>
<tr>
<th>TYPE OF IMPACT</th>
<th>NO. OF LEASES REPORTING</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. New bore</td>
<td>19 (15)</td>
</tr>
<tr>
<td>2. New dam</td>
<td>1 (1)</td>
</tr>
<tr>
<td>3. New road or unspecified input</td>
<td>36 (28)</td>
</tr>
<tr>
<td>4. Contracts (bulldozing)</td>
<td>42 (33)</td>
</tr>
<tr>
<td>5. Regeneration work</td>
<td>1 (1)</td>
</tr>
<tr>
<td>6. No input</td>
<td>63 (49)</td>
</tr>
</tbody>
</table>
Only one station reported that there had been attempts to rehabilitate mine sites by a mining company involved on their station whilst approximately half reported some beneficial input by mining concerns.

6.3 Case Studies of Property Visits

6.3.1 Station One

This 90,000 ha station is situated south-east of Meekatharra.

Types of Mining Activity

There are exploration grid lines with drill holes, three bore fields, and an open cut mine on this property; generally these are confined to greenstone hills and adjacent footslopes. The affected land systems comprise short grass mixed forb pastures with minor areas of perennial grasses and halophytic shrubs. They support a low stocking density and are generally resistant to erosion except in the susceptible drainage floors which support productive halophytic low shrublands.

Impacts of Mining Activity

(a) The natural resource

An estimated 100 km of gridlines have been graded, some of which constitute an erosion hazard. It is expected that approximately 2,000 ha of grazing land will be lost to the pastoral business because of previous and current open cut and sluice mining, metal detecting, and dry blowing. This loss has occurred because the surface soil has been removed or damaged such that the growth of vegetation is precluded.

(b) The pastoral business

Stock has been removed from the paddocks adjacent to the open cut mine. The pastoralist has suggested that one man day per week is required to ensure that damage to improvements and interference to livestock is minimized. The mining company operating the open cut mine has upgraded the station airstrip.

(c) Quality of life

The proximity of the homestead to the open cut mine and the mine access roads have resulted in regular requests from mining personnel and prospectors for access to the homestead telephone thus disrupting domestic routines.
Relations with the Mining Industry

A compensation agreement has been reached with the open cut mine operator to offset the loss of earnings resulting from the removal of stock from paddocks adjacent to the mine.

6.3.2 Station Two

This 168,000 ha station is situated south-west of Meekatharra.

Types of Mining Activity

On this property there are two open cut mines, an alluvial/sluice operation, abandoned underground workings and exploratory scrapings and costeans. These workings are concentrated in and around the greenstone hills within the Wiluna and Gabanintha land systems.

Metal detecting and alluvial mining activities are concentrated around palaeodrainages (lake country) within the Carnegie land system. This land system is characterized by short grass chenopod pastures with halophytic shrublands and samphire flats. Where this vegetation is in good range condition it has the capacity to support livestock at relatively high stocking rates, therefore loss of land to mining has a more significant economic impact in these areas of this property.

Impacts of Mining Activity

(a) The natural resource

The pumping of saline water from an open cut pit into a nearby creek has caused localized salinity and erosion problems between the pump outlet and the lake into which the creek drains. The areas which are unlikely to return to a useful state for pastoralism include open pits, over burden dumps, tailings dams, 25 km of access roads, camp and workshop sites, pipeline tracks, plant sites, alluvial scrapings, 20 km of gridlines and the saltwater affected creekline.

(b) The pastoral business

Mining is restricted to one paddock for which the Western Australian Department of Agriculture has recommended an annual stocking rate of 570 sheep. The lessee has been forced to make a significant reduction in stock numbers in the paddock.

Relations with the Mining Industry

An agreement has been reached with one operator to compensate for loss of earnings. This agreement was reached outside the Mining Act (1978).
6.3.3 Station Three

This station, situated near Nullagine, was granted an additional lease of approximately 137,000 ha in 1983. It is on this block that mining activities have occurred.

Types of Mining Activity

The following table details the categories of mining activity on this station.

Table 12. Categories of mining activity

<table>
<thead>
<tr>
<th>AREA AFFECTED</th>
<th>AREA AFFECTED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open cuts, shafts</td>
<td>200 ha</td>
</tr>
<tr>
<td>Alluvial mining</td>
<td>6,000 ha</td>
</tr>
<tr>
<td>Treatment plants</td>
<td>100 ha</td>
</tr>
<tr>
<td>Exploration drilling and gridlines</td>
<td>100 ha</td>
</tr>
<tr>
<td>Costeanean area</td>
<td>500 ha</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>6,900 ha</strong></td>
</tr>
</tbody>
</table>

The total area affected represents 5% of the new block.

The activity occurs on an extensive belt of gibber strewn country over siliceous Archean rocks which are characterized by the following land-vegetation sequence:

a) Steep, mostly conical hills - hard spinifex (*Triodia wiseana*).

b) Undulating country - acacia shrub steppe.

c) Flats and drainages with *Eucalyptus brevifolia*.

*Cenchrus ciliaris* (buffel grass) and *C. setigerus* (Birdwood grass) have established on the narrow floodplains and in some drainage areas. These areas which are the most productive pastoral country on the lease are quite susceptible to erosion.
Impacts of Mining Activity

(a) The natural resource

Mining activity on this lease largely involves the reworking of previously mined areas. New technology such as carbon in pulp (CIP) treatment allows hundreds of tonnes of material to be processed each day therefore broadacre stripping of topsoil to feed the extraction process occurs. Rehabilitation has not been attempted, though natural colonization with either buffel grass or spinifex is likely following good seasons.

Stripping topsoil and the consequent removal of soft spinifex and buffel grass from alluvial areas receiving concentrated drainage has destabilized the land and gullies have developed. Material from one large mine’s waste dump has accumulated in creeks and waterways, as no attempts have been made to stabilize the dump to prevent this outcome. Natural revegetation of the affected areas below the dump is slow.

(b) The pastoral business

The lessee claims that mining activity and the associated offsite effects have removed 60,000 ha, or 44% of the new block, from pastoral use.

Further management problems have arisen regarding costeans and treatment ponds. Where costeans have not been back-filled; they are a hazard to stock, station personnel and the public. Unfenced active treatment ponds place stock at risk from poisoning, however, no stock losses were reported. Cyanide poisoning is not a concern with disused treatment ponds.

Conversely, by damming creeks operators of wet treatment alluvial operations have provided watering places for stock and native fauna. The pastoralist also reported that mining access tracks now provide access to formerly inaccessible areas of his property, whilst new airstrips and campsites are helpful during mustering. Normally drill holes are available as water bores once the exploration is completed which was reported as a further beneficial outcome from mining.

The pastoralist noted that some land is being double-rated, as both he and mining tenement holders are paying rent on the same land. This is a regular comment from pastoralists, however, the financial consequences are insignificant in the overall station running costs.

Relations with the Mining Industry

No agreements between the mining industry and the pastoralist were reported. The pastoralist appeared to be unimpressed by the mining operators on his lease, although he acknowledged that many of the problems were present before he gained the lease for the block on which the mining activity is located.
6.3.4 Station Four

This Goldfields property consists of three pastoral leases being run as a single management unit of approximately 264,000 ha.

*Types of Mining Activity*

Within the past five years production has occurred from thirty-eight mines located on this property. Some of these are now abandoned, whilst it is expected that several new mines will become established in the near future. One of the component leases has a mine in every paddock.

Approximately 90 per cent of the property is, or has recently been, held under some form of mining tenement. Gridlines are common throughout the property and cover approximately 240 hectares, whilst mine access roads cover approximately 800 ha.

The mining activity is widespread, occurring on sandplain, greenstone hills and their footsteps and drainages, and on broad eucalypt-chenopod shrub plains.

*Impacts of Mining Activity*

On this property the areas of pasture lost to pastoralism as a consequence of mining activity fall into two categories. Firstly there are areas occupied by mine workings and waste dumps and by haul roads, gridlines and exploration tracks. These areas are difficult to rehabilitate and they can be considered as pastures which are lost permanently. Secondly there are the offsite areas associated with the above group where livestock are regularly disturbed therefore they are temporarily lost as a pasture resource as long as mining activity continues. Table 2 shows that a total of 3,040 ha of this lease will no longer be capable of supporting pastoral use, whilst 8,600 ha is lost temporarily.

<table>
<thead>
<tr>
<th>TYPE OF ACTIVITY</th>
<th>TEMPORARY LOSS</th>
<th>PERMANENT LOSS DUE TO PHYSICAL DAMAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mines and waste dumps</td>
<td>2,000</td>
<td>2,000</td>
</tr>
<tr>
<td>Gridlines</td>
<td></td>
<td>240</td>
</tr>
<tr>
<td>Access roads</td>
<td>6,400</td>
<td>800</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>8,600 ha</strong></td>
<td><strong>3,040</strong></td>
</tr>
</tbody>
</table>
Determination of the area of the offsite land where stock are disturbed was based on a zone of 10 metres either side of the roads or sites involved. Based on an average stocking rate of 1 s.s.u. :12 ha, the permanent loss of pasture represents a lost stocking capacity of 253 s.s.u., and a temporary loss of capacity for 717 s.s.u. These figures assume the areas lost were adequately fenced and watered before mining commenced. (s.s.u. = small stock units).

A further three paddocks occupying 20,500 ha with a grazing capacity of 1,900 s.s.u. cannot be stocked due to mining activity. The pastoralist claimed that a combination of intense mining traffic and damage to fences, grids and gates had rendered these paddocks unsuitable for pastoral use. A particular problem was the damage to the gates and grids which were too narrow for mining vehicles and machinery. These structures had been bull-dozed and not replaced by the operators of the mines.

A concern raised by the pastoralist on this property was that dust raised from roads and mine sites would lead to dust contamination of fleeces and may reduce return from his wool clip. It is very difficult to quantify this effect or the resultant effects on financial returns. Though heavy traffic along mine access roads may result in fleece contamination by dust and reduced yields, it is unlikely that clean wool production would be affected. The major offsite impact of the roads is that dust-covered plants are unattractive to stock as pasture.

The pastoralist reported that a greatly increased workload has resulted from the need to monitor damage to station improvements, the clearing of vegetation and to check for stock caught in unfilled and unfenced costeans.

**Relations with the Mining Industry**

The pastoralist expressed dissatisfaction with the current regulation of mining activity in the rangelands. His primary concerns were that he has by default become the caretaker and policeman for the Mines Department, because some mining operators were transient and often eluded scrutiny by that department. In his experience miners were reluctant to offer compensation even if they do admit responsibility for particular problems. The pastoralist stated that the Mines Department could not process all of his complaints and he had had to accommodate several breaches of the Mining Act (1978-1985).

Some compensation has been paid for loss of grazing, however negotiations between the pastoralist and mining concerns are continuing. The pastoralist noted that the large number of mining operators involved made it difficult to apportion blame or responsibility for adverse affects on his station business between the mine operators. This was compounded by frequent changes of ownership of tenements. The pastoralist is currently suing a mining company for compensation for lost income due to its mining operations.
6.3.5 Station Five

On its own, this Goldfields lease is too small to support a viable pastoral enterprise, currently this lease supports up to 1,000 s.s.u. Part of this property is a reserve for which the pastoralist has grazing rights.

Types of Mining Activities

There are two areas of intense exploration involving gridlines and drill holes. As well, an open cut operation is being established on the grazing lease reserve and a second open cut on the pastoral lease is likely to be initiated in the near future. These activities are concentrated on and around very productive lake country (1 s.s.u. to 10 h.a.) which is sensitive to erosion.

Impacts of Mining Activity

(a) The natural resource

Seventy nine kilometres of grid lines, covering an estimated 39 ha have been cleared on this station. The clearing involves felling of large eucalypt trees (up to 20 m high) and the removal of all understorey vegetation. Much of this clearing was through low shrublands with occasional trees where access for mining machinery could easily have been obtained without clearing and the consequent disturbance to the soil and vegetation, thus minimizing the risk of soil erosion. The grid lines were cleared without the prior approval of the Mines Department.

(b) The pastoral business

Although 200 ha has been lost due to the development of the open cut mine on the reserve, the pastoralist is not entitled to compensation under the terms of the grazing lease.

The pastoralist was concerned about the damage to station tracks by mine vehicles in wet weather however the mining company concerned has offered to remedy this situation by constructing a fenced bitumen road which will be to the pastoralist’s advantage. Another mining company has constructed a dam to provide water for stock.

Approximately 45 ha of mining access roads and 342 ha of associated dust-contaminated grazing land has resulted in the loss in grazing capacity for 32 s.s.u.

Relations with the Mining Industry

The 900 ha lost from grazing due to mining road construction and adjacent dust disturbed areas has been more than adequately compensated for by the mining concern involved. Constructive discussions between the lessee and mining personnel have averted conflict and this commendable situation appears likely to persist.
7. Discussion

7.1 Survey Representativeness

Questionnaires were sent to 327 pastoral leaseholders south of the Kimberley, 128 (C40%) replied. The WADA Meekatharra office received 50 per cent (65 from 131) whilst the Carnarvon and Kalgoorlie offices received approximately a third of the number of questionnaires sent out.

The response rate may be considered high given that this was a voluntary survey. Bias is natural in any questionnaire survey; perhaps the respondents represent, to some extent, those pastoralists who have had adverse experiences with the mining industry and felt strongly enough to respond. This observation is supported by the generally negative views expressed by pastoralists in the replies with regard to the impacts of mining on the range resources and their pastoral businesses.

Although mining and mining exploration has a direct effect on comparatively little of the land surface in the semi-arid rangelands, it is an intensive form of land use, and therefore it has a significant impact on the rangeland resource in those areas, and by implication, on other users of that rangeland resource. Mineral exploration and mining activity of significance to the pastoral industry is largely confined to areas where there is potential for gold or petroleum mineralization. Most of this activity occurs in the Exmouth Gulf-Onslow area (oil), the Marble Bar - Nullagine area (gold), the East Murchison area (gold) and the Eastern and North Eastern Goldfields (gold).

7.2 Incidence and Extent of Mining Activity and its Impacts

Overall, approximately two-thirds of reporting lessees stated that their property was affected by mining and/or exploration. Metal-detecting was the most common form of mining and a quarter of leases had open cut mines (Table 2). There were 61 mines on the 128 leases replying to the questionnaire. Exploration involving soil disturbance was reported on 57 per cent of leases, whilst one-fifth of the reporting leases stated that exploration disturbance affected an area of more than 100 ha (Table 3).

The most common cause of increased erosion was attributed to poorly sited and constructed roads, tracks and seismic lines, however, the land degradation problems associated with roads and tracks are not unique to those constructed by the mining industry. An eighth of lessees reported some form of pollution from mining activity, whilst nearly one-fifth reported damage to station infrastructure.

Pastoral businesses were most commonly affected by the disruption of established grazing management systems, the reduction of stock numbers and forced closure of the paddocks affected by intense activity. Five per cent of lessees reported dogs roaming on their stations as a consequence of mining activity, whilst 16 per cent stated that they had
been compelled to increase surveillance of their properties. Nearly three quarters of reporting lessees stated that they had had to alter their weekly routine.

A third of reporting lessees had been given contract work, whilst other beneficial inputs included new roads, dams, bores and the upgrading of airstrips. Half of the reporting lessees acknowledged beneficial inputs from mining operations to their leases.

Only one lessee reported that mining concerns had carried out rehabilitation work. The situation has probably improved substantially since the time the questionnaires were sent out. There has been an increasing environmental awareness, within the mining industry and the Environmental Management Unit has been established in the Mines Department.

The survey responses suggest that pastoralists are concerned about the impact that some practices associated with mining are having on the soil, water and vegetation resources. They are also concerned by the additional costs they incur as a result of the presence of mining activity on their leases. It is evident that the adverse effects of mining activities are not necessarily restricted to the mine site. Understanding of the full extent of mining impacts requires consideration of indirect, more subtle impacts involving, for example, alteration of hydrological regimes, animal behaviour patterns and pastoral management strategies.

7.2.1 The rangeland types most commonly affected by mining

Mining activity occurs in a range of environments, however many of the the land systems most affected by mining are those characterized by the relatively fertile soils associated with metamorphic ‘greenstone’ uplands and the palaeodrainages; and which support stands of long lived palatable shrubs. Examples cited in this report are Wiluna and Gabanintha land systems (Murchison and Meekatharra-Wiluna area), Nubev, Bevon, Laverton, Gundockerta, and Leonora land systems (North Eastern Goldfields) whilst Violet and Carnegie land system occur in all of these areas. Land systems have not yet been described for the Eastern Goldfields and East Pilbara however it is common for mining activity to occur in the better pasture types in these districts also.
Table 14. Land systems commonly associated with mining activity

<table>
<thead>
<tr>
<th>LAND SYSTEM</th>
<th>LANDFORM, SOILS AND VEGETATION</th>
<th>REGIONAL OCCURRENCE</th>
<th>SPECIAL FEATURES</th>
<th>PASTORAL VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bevon</td>
<td>Limonitic low hills and rises with generally shallow loamy soils supporting sparse mulga shrublands</td>
<td>North Eastern Goldfields</td>
<td>Narrow drainages susceptible to water erosion</td>
<td>Low</td>
</tr>
<tr>
<td>Carnegie</td>
<td>Bare salt-lake beds with fringing alluvial plains supporting mixed succulent low shrub steppe</td>
<td>Wiluna-Meekatharra, Murchison and North Eastern Goldfields</td>
<td>Alluvial plains susceptible to wind and water erosion</td>
<td>Very high</td>
</tr>
<tr>
<td>Gabanintha</td>
<td>Greenstone hills with shallow loamy soils supporting sparse mulga shrublands</td>
<td>Wiluna-Meekatharra and Murchison</td>
<td>High gradient slopes susceptible to water erosion if protective mantles removed</td>
<td>Low to moderate</td>
</tr>
<tr>
<td>Gundockerta</td>
<td>Undulating stony plains and low rises based on greenstones with calcareous texture contrast soils supporting mainly succulent low shrub steppe, particularly Maireana sedifolia</td>
<td>North Eastern Goldfields</td>
<td>Drainage floors susceptible to rilling and guttering, concave slopes of low rises susceptible to sheet erosion</td>
<td>High to very high</td>
</tr>
<tr>
<td>Laverton</td>
<td>Greenstone hills, ridges and stony footslopes with shallow loamy soils supporting sparse mulga and other Acacia shrublands</td>
<td>North Eastern Goldfields</td>
<td>High gradient slopes susceptible to water erosion if protective mantles removed</td>
<td>Low to moderate</td>
</tr>
</tbody>
</table>
7.2.2 Main types of ecological impacts.

Disturbance of vegetation and surface soil and the alteration of hydrological regimes are the activities most commonly reported to damage the land. The release of polluting substances from mining site was less frequently reported.

i) The disturbance of vegetation and surface soil

The disturbance of perennial vegetation and surface soil is commonly associated with all types of mining, however it was reported to be most extensively associated with the

<table>
<thead>
<tr>
<th>LAND SYSTEM</th>
<th>LANDFORM, SOILS AND VEGETATION</th>
<th>REGIONAL OCCURRENCE</th>
<th>SPECIAL FEATURES</th>
<th>PASTORAL VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leonora</td>
<td>Rounded greenstone hills with frequently calcareous texture contrast soils on stony slopes and drainage floors which support succulent low shrub steppe</td>
<td>North Eastern Goldfields</td>
<td>Drainage floors susceptible to water erosion</td>
<td>High</td>
</tr>
<tr>
<td>Nubev</td>
<td>Limonitic low rises above extensive alluvial plains with texture contrast soils supporting succulent low steppe</td>
<td>North Eastern Goldfields</td>
<td>Susceptible to water erosion on wide alluvial plains, particularly in more concentrated drainages</td>
<td>High</td>
</tr>
<tr>
<td>Violet</td>
<td>Gently undulating gravelly plains on greenstones, laterite and red brown hardpan</td>
<td>Wiluna-Meekatharra Murchison and North Eastern Goldfields</td>
<td>Residual gravelly and sandy upper plains susceptible to water erosion</td>
<td>Low</td>
</tr>
<tr>
<td>Wiluna</td>
<td>Low, lateritised hills of amphibolite, schist and other greenstones with extensive lower slopes and stony plains</td>
<td>Murchison and Wiluna-Meekatharra</td>
<td>Narrow drainage floors susceptible to water erosion</td>
<td>Low to moderate</td>
</tr>
</tbody>
</table>
construction of gridlines and access roads. It is also a feature of the alluvial mining process.

Sixteen lessees reported erosion caused by unnecessary clearing of vegetation and soil, while 25 lessees reported vegetation degradation due to the removal of topsoil and/or the clearing of vegetation, and 18 lessees reported physical damage to perennial vegetation not involving clearing.

Perennial plants’ growth rates are typically low in the arid shrublands of Western Australia due to the low and erratic rainfall experienced by these areas. Regeneration to a stable plant community may thus take many years to occur. More detrimental to the ecosystem is the effect that removal of perennial vegetation has on soil stability. Vegetation provides resistance to wind and thus reduces its velocity near the ground thus reducing the susceptibility of the soil to wind erosion.

Vegetation cover also provides impedence to rain and hence reduces the area affected by raindrop entrainment of soil particles in sheet flow. Plants with a morphology which tapers toward the ground funnel rain into the soil via the plant base and subterranean root channels, reducing the amount of surface flow and its ability to erode the soil. Roots play an important role in holding soil together and hence increasing its resistance to erosion. The eroding effects of unreduced wind and water forces are combated by stony surface mantles on gibber plains.

The removal of vegetation can also provide niches for the proliferation of plants with life strategies suited to the rapid colonization of disturbed habitats. These plants play an important role in initiating the stabilization of disturbed areas, however, they are often undesirable plants in pastoral country in that they tend to exclude plants more valuable to pastoralism. Disturbed areas provide nurseries for undesirable plants from which their propagules (usually seeds) can be disseminated into adjacent pastoral country to the exclusion of less competitive but often more pastorally desirable species. *Cassia nemophila, Dodpnea lobulata, Acacia hemiteles* and *A. jennerae* are examples of such ‘undesirable’ plants in the north-eastern Goldfields.

The stripping of surface soil goes further in the degradational process in that the surface soil contains the highest levels of soil nutrients available to plants in arid environments with which this report is concerned (Friedel, 1981). It is not necessary to set bull-dozer blades below the ground or to knock over trees to achieve access to exploration gridlines. Cryptogamic crusts on soil surfaces consist of non-vascular organisms such as lichens, algae, mosses and liverworts. Cryptogams provide a protective crust on the soil surface. Lichens and algae also fix atmospheric nitrogen; when they are grazed by soil microfauna, such as mites, they are effectively introducing nutrients to the soil system. When cryptogamic crusts dry out they tend to produce cracks in the soil surface which provide ideal niches for seed germination. Reduction of cryptogamic crusting has been linked to range condition and productivity by Tongway and Smith (1989). This discussion of cryptogams further highlights the need to minimize disturbance of the soil surface.
ii) The alteration of hydrological regimes

This problem was reported in nearly a quarter of the responses. It generally involves the redistribution and channeling of surface water flow but can also involve the lowering of water tables. The alteration of surface flow characteristics is associated with the construction of tracks, haul roads, power-lines and grid lines and can also result from increased run-on due to soil and vegetation degradation in catchments.

Twenty-eight lessees reported erosion caused by the poor siting of roads, tracks or seismic lines under conditions of redistributed and concentrated flow. Four pastoralists reported lowering of the water table by the operation of mine bore-fields with consequent deterioration in pasture condition.

The reduction in run-on to a plant community will reduce its vigour, perhaps to a state where degradation occurs. This may also be reflected in the degradation of cryptogrammic crusts. In severe cases, the degradation of perennial vegetation and cryptogamic crusting may lead to accelerated wind erosion. One would also expect ephemeral plant growth to decline under conditions of considerably reduced run-off. The condition of the soil, cryptogamic crust and vegetation is highly interdependent and disturbance of one is likely to result in the destabilization and degradation of the others.

Increased run-on can also cause problems. Grid lines or tracks may become new drainages, cutting off sheet flow to lower areas and initiating gulling along the line or track.

The lowering of the watertable can result from extensive pumping from groundwater aquifers for ore treatment operations. The effects of this on Western Australia’s rangelands is not clear, however current monitoring of watertable fluctuations and vegetation at a large borefield on Austin Downs station may provide some interesting insights (Hacker, pers. comm.). Except in areas where the watertable is shallow enough for plant roots to reach it, fluctuations in watertable level most significantly affect management in terms of groundwater supply for stock. Mining influences on groundwater salt concentrations may be revealed by the monitoring exercise mentioned.

The arid shrublands and the spinifex region differ in their overall hydrological characteristics. Thus their particular susceptibilities are discussed separately below.

Large areas of sheet flow are characteristically restricted in area by the tendency of flow to channelize in all but the smoothest, flattest plains where surface resistance to flow is at a minimum (Gerrard, 1981). In the hardpan mulga wash plains of Western Australia’s arid shrublands such conditions prevail over extensive areas. Red-brown siliceous hardpan plains extend from near Kalgoorlie north and north-westwards towards the Fortescue River (Teakle, 1950). The dominant land-vegetation type is the hardpan mulga shrubland, with its typical shallow loamy soils over a red-brown siliceous hardpan (Mabbut, 1965) on extensive ‘wash plains’ subject to sheet flow. Alteration of this
hydrological regime, by either concentrating the wash into drainages or impeding its
downslope progress changes a fundamental component of the soil-water-vegetation
system. This often results in water starvation and death of perennial shrubs subjected to
reduced run on.

In the north-west spinifex region, spinifex-covered hills and mountain ranges such as the
Hamersley and Chichester Ranges, with narrow drainages broaden into extensive flood
plains near the coast. The hills are typically stony and quite resistant to erosion. Other
landforms based on Permian sedimentary rocks, such as those which characterize
Firecracker and Wandagee land systems, have received considerable attention in the
form of exploration for oil. These land systems have friable calcareous soils which are
highly susceptible to erosion (Payne et al. 1987), wherever perennial vegetation is
removed or degraded.

The shrublands west of the internally drained palaeodrainage region of Western
Australia (van de Graaf et al. 1977) are characterized by long catchments and
considerably greater discharges than the smaller and shorter palaeodrainage
catchments such as those of the Goldfields region. Thus greater rates of flow cause
erosion in the form of gullyng, which is of particular importance in these regions.
Furthermore, impedence of flow may lead to water starvation problems in the lower
catchment. Under such circumstances vegetation cover may decline and wind erosion
may accelerate.

iii) Pollution

Two major problems were identified; the release of hypersaline solutions harmful to
vegetation and the exposure of fauna to toxic substances. Hypersaline solutions are
commonly associated with sluice operations, tailings dams and test bores. If the salt-
enriched water is allowed to flow out into the land below it kills the vegetation by
increasing the salt concentration in soil water available to plants.

Buffel grass (*Cenchrus ciliaris*) has stabilized many creeks in the Ashburton and Pilbara
regions which had been rendered unstable by excessive grazing. It is important that the
protective grass cover is not damaged as it is likely to lead to further accelerated
erosion.

The treatment of ore involves a variety of chemicals some of which are highly toxic to
animals. Cyanotoxins are commonly produced in the treatment of gold ore. Their
potential effect on the fauna was illustrated by the death of about 60,000 native
budgerigars in less than a week which came to drink at treatment ponds near Laverton
in 1985. Cyanide readily forms hydrogen cyanide in alkaline conditions, and when
brought into contact with air it vaporizes. Disused treatment ponds will not therefore
usually pose a threat of cyanotoxin poisoning to stock.
Eight lessees reported pollution from the leakages of either hypersaline or toxic solutions.

Dust pollution has a minor adverse affect on vegetation as it reduces rates of photosynthesis and can block gaseous exchange pore cells (stomata) on leaves. Rain washes dust off, and hence vegetation degradation by dust pollution associated with major mine access tracks and haul roads occurs only in extreme cases and is generally restricted to small zones around the dust-producing activity.

Two lessees reported dust pollution.

7.2.3 Impact on pastoral business management

Increased expenditure and reduction of income as a result of mining activity were reported on several stations. Six stations found it necessary to remove sheep from paddocks in which mining was taking place, whilst eight stations (6 per cent) indicated they had had to reduce total stock numbers because of reduced suitable areas for stock grazing due to mining.

Fifteen stations (12 per cent) advised that grazing patterns were disrupted, whilst a requirement to spend more time checking fences, gates and waters was indicated by twenty properties.

The survey revealed that some stations derived financial benefit from the presence of mining companies. One pastoralist reported that the development and maintenance of roads on his property allowed improved access. He also advised of an improved mail service. Three stations reported having received cash compensation for loss of earnings caused by mining operations.

Thirty three per cent of replies (42 stations) indicated they received some sort of employment from mining companies at various times. The work included contract bulldozing and fencing and working with the company for wages. It is fairly common for pastoralists to obtain new watering points as a consequence of mining activity. Some mining companies allow pastoralists to tap into their water pipelines.

7.2.4 Mining activity and pastoral lease resale values

The pastoral inspectors responsible for collecting the questionnaire data reported that many pastoralists were concerned that the market value of their properties would, or had, declined as a result of mining activity.

Where there are several mines on one property the aggregation of off-site effects can impact on the perceived utility of the land for pastoral use which can have a depressing effect on lease values. One Goldfields property obtained a valuation by a licensed valuer who estimated that a 7 per cent reduction in property value had occurred as a
consequence of mining activity on that property. This issue should be resolved quickly, to the satisfaction of the pastoral and mining industries. If it is decided that compensation should be forthcoming in these circumstances, a standard procedure will need to be formulated for evaluating impacts on resale value and the proportioning of responsibility for this amount between mining concerns involved. Consultation with experts in the legal and valuation fields will be necessary.

7.3 Guidelines for the Rehabilitation of Mined Areas

A self replacing cover of vegetation should be established on all disused mine sites, open cut, underground and alluvial, and all disused roads, tracks, and grid lines. Such vegetation will stabilize the land in the long term. Where possible this established plant community should restore the former land use, usually grazing by stock.

The Department of Mines of Western Australia have issued guidelines for environmental management of mining in arid areas which addresses all stages of environmental management for open cut mines (Department of Mines, 1988). Further guidelines continue to be released by the Department of Mines, including interim guidelines on safety bund walls around abandoned open pits (1990), guidelines for waste dump design and rehabilitation (1990), guidelines for the preparation of a ‘Notice of Intent (NOI)’ and ‘Works Approved’ application for new tailings dams or extensions to existing dams (1990), guidelines for preparation of a Notice of Intent for heap leach projects (1989), and guidelines for preparation of a Notice of Intent for heap leach projects (1989). Similar publications for other mining and exploration activities are expected.

7.4 Mining Activities and the Agriculture and Related Resources Protection Act (1976-1984)

Data from a recent state-wide survey of mining activity impacts on the spread of noxious weeds conducted by the Agricultural Protection Board (APB) revealed that the initial introduction of many noxious weeds into pastoral areas can be linked with the history of mining activity and associated towns. The reports from regional APB officers indicate however, that very few cases of recent infestations can be blamed on mining activity.

The APB officers indicated that large mining companies were conscientious with respect to their responsibilities for noxious weed control. However, the smaller operators were not as diligent in their efforts.

The noxious weeds (identified by regional APB officers) in the survey area are horehound (*Marrubium vulgare*), Bathurst and Noogoora Burrs (*Xanthium spinosum* and *X. occidentale*), thorn-apple (*Datura spp.*), Mexican poppy (*Argemone ochroleuca*) and saffron thistle (*Carthamus ignatus*). Saffron thistle was the most widely reported weed, providing particular problems around Mt Magnet where five stations are currently under quarantine. Information on the control of noxious weeds is available from the Agricultural Protection Board.
7.5 **Firearms and Dogs**

Concern was expressed by six lessees regarding the effect domestic dogs have on the pastoral operation.

Little mention was made by the respondents to the survey in regard to firearms, though this is known to be an issue on mine and exploration sites.

7.6 **The Role of Land Conservation Districts**

The Soil and Land Conservation Act (1945-1985) provided for the formation of Land Conservation districts throughout Western Australia. Such Districts, with their supporting Advisory committees, have been formed over most of the area covered by this report. In some cases the committees include representatives of the mining industry and the Department of Mines.

Pastoralist members of LCD committees have considerable understanding of local climatic patterns and have experience in the rehabilitation of degraded rangelands. This experience is particularly relevant to planning mining and exploration activities to avoid land degradation and to the rehabilitation of disturbed rangelands. Mining industry participation in LCD activities will have mutual benefits for all land managers involved and will enhance the achievement of regional land conservation.

The “Report on Conservation and Rehabilitation in the Gold-Mining Industry” (WPCRMI, 1985) contained the following recommendation.

“Regional Mining environmental advisory committees should be established so that community-based environmental objectives and rehabilitation standards can be formulated for submission to the Director General of Mines”.

The recommendation has not been accepted at this time; LCDs could make positive contributions to this end.
8. References


Chamber of Mines of Western Australia (Inc) (1988). Exploration guidelines for field personnel.

Cotching, W. (in prep.). An inventory and condition survey of parts of South Broome Shire, Western Australia. Technical Bulletin, Department of Agriculture, Western Australia.


Department of Mines, Western Australia Mining Engineering Division, East Perth, Western Australia.

- Guidelines for mining project approval in Western Australia. Revised edition.
- Guidelines for environmental management of mining in arid areas.
- Guidelines for the preparation of a “Notice of Intent (NOI)” and
- “Works Approval” application for new tailings dams or extensions to existing dams.
- Interim guidelines on safety bund walls around abandoned open pits.
- Guidelines for waste dump design and rehabilitation.


Appendix 1

Recommendations Of The North Eastern Goldfields Soil Conservation District Advisory Committee Regarding Mining In Pastoral Areas

Suggested Conditions to be applied to all Tenements in Pastoral Areas

1. The tenement holder shall, prior to the commencement of any exploration or mining activity on the tenement, notify the owner/occupier of any land used for pastoral purposes. Such notification shall include a brief summary of operations to be conducted, the type and number of machinery to be utilized and the number of persons to be engaged. Further, the tenement holder shall advise the owner/occupier of any significant changes to that original notification throughout the duration of the operation.

2. In the case of alluvial mining, the tenement holder shall restore the former productivity of the land through careful planning of operations, topsoil salvage and return, contour ripping, erosion control, revegetation with suitable species and fencing to protect rehabilitated areas. All work shall be completed to the satisfaction of the Regional Mining Engineer or his nominee. (N.B. This has been extracted from the “Report on Conservation and Rehabilitation in the Gold Mining Industry”.)

3. Unless the written approval of the District Mining Engineer or Environmental Officer is first obtained, the use of scrapers, graders, bulldozers, backhoes or other mechanized equipment for surface clearing or the excavation of costeans is prohibited. Following approval, all topsoil being removed ahead of mining operations and stockpiled for replacement in accordance with the directions of the District Mining Engineer or Environmental Officer.

4. The tenement holder shall not traffic upon roads which have not been gazetted on pastoral properties without prior permission of the owner/occupier of such land.

5. The tenement holder shall take adequate precautions to prevent or control the erosion, drift or movement of sand, soil, dust or water on or from the tenement.
Suggested Requirement for Notification of Application for all Mining Tenements

1. The applicant shall provide a map to the owner/occupier of the land for which application has been made showing the location of the tenement in relation to the nearest trig point or fixed improvement.
Appendix 2

Goldmining On Rangelands Survey

STATION NAME:

Please indicate the scale of different types of mining activity on this station during the period 1980-1987 inclusive.

<table>
<thead>
<tr>
<th>EXTENSIVE</th>
<th>MINOR</th>
<th>NIL</th>
</tr>
</thead>
<tbody>
<tr>
<td>GREATER THAN</td>
<td>(&gt;100 ha)</td>
<td>(&gt;10 ha)</td>
</tr>
</tbody>
</table>

Mining

- Underground
- Open Cut
- Alluvial or Topsoil
- Metal Detecting or Other

Exploration (Gridding, Sampling, Costeans, etc)

- No soil disturbance by machinery
- Soil disturbance by machinery

How many goldmines on this station are currently in regular production?
In your opinion, what are the major impacts upon the rangelands of this activity?

What changes to your management practices have you made as a result of this activity?

Have mining operators always informed you of their presence on the station?
Yes/No
Have you been able to contact mining operators when required?

Yes/No

Have you been able to overcome any problems by direct consultation with the mining operators or their representatives?

Have you been given any assistance with the construction or maintenance of any roads, bores or similar jobs?
Have you had the opportunity to do any contract work for mining operators either on or off this station?

In your opinion, how could the present system of goldmining on rangelands be improved?

THANK YOU

NAME: ____________________________ DATE: __________________