RANGER URANIUM ENVIRONMENTAL INQUIRY

SECOND REPORT

Presiding Commissioner: Mr Justice R. W. Fox
Commissioner: Mr G. G. Kelleher
Commissioner: Professor C. B. Kerr

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RANGER URANIUM ENVIRONMENTAL INQUIRY

17th May 1977

In accordance with the *Environment Protection (Impact of Proposals) Act* 1974 and the terms of our appointment we have the honour to present this our Second and Final Report.

We have, with your agreement, and that of the Minister for Aboriginal Affairs, included in the one volume the Report which we make today to the Minister for Aboriginal Affairs pursuant to s. 11 (2) of the *Aboriginal Land Rights (Northern Territory) Act* 1976.

R. W. Fox
Presiding Commissioner

G. G. Kelleher
Commissioner

C. B. Kerr
Commissioner

The Honourable K. E. Newman, M. P.
Minister of State for Environment,
Housing and Community Development
Parliament House Canberra, A.C.T. 2600

17th May 1977

Being the Commission appointed by instrument published in the Gazette on 16 July 1975 under s. 11 of the *Environment Protection (Impact of Proposals) Act* 1974 to conduct an inquiry in relation to the proposal for the development of uranium deposits in the Northern Territory, we have, for the purposes of that inquiry, made findings that groups of Aboriginals are entitled by Aboriginal tradition to the use or occupation of a certain area of land. Those findings are set out in Chapter 15 of this Report, together with recommendations we make in connection with them.

In accordance with s. 11 (2) of the *Aboriginal Land Rights (Northern Territory) Act* 1976 we have the honour to present our Report dealing with the matters mentioned.

With your agreement and that of the Minister for Environment, Housing and Community Development the Report is presented in the same volume as the Report we present today to the Minister for Environment, Housing and Community Development pursuant to the *Environment Protection (Impact of Proposals) Act* 1974.

R. W. Fox
Presiding Commissioner

G. G. Kelleher
Commissioner

C. B. Kerr,
Commissioner

The Honourable R. I. Viner, M.P.
Minister of State for Aboriginal Affairs
Parliament House
Canberra, A.C.T. 2600

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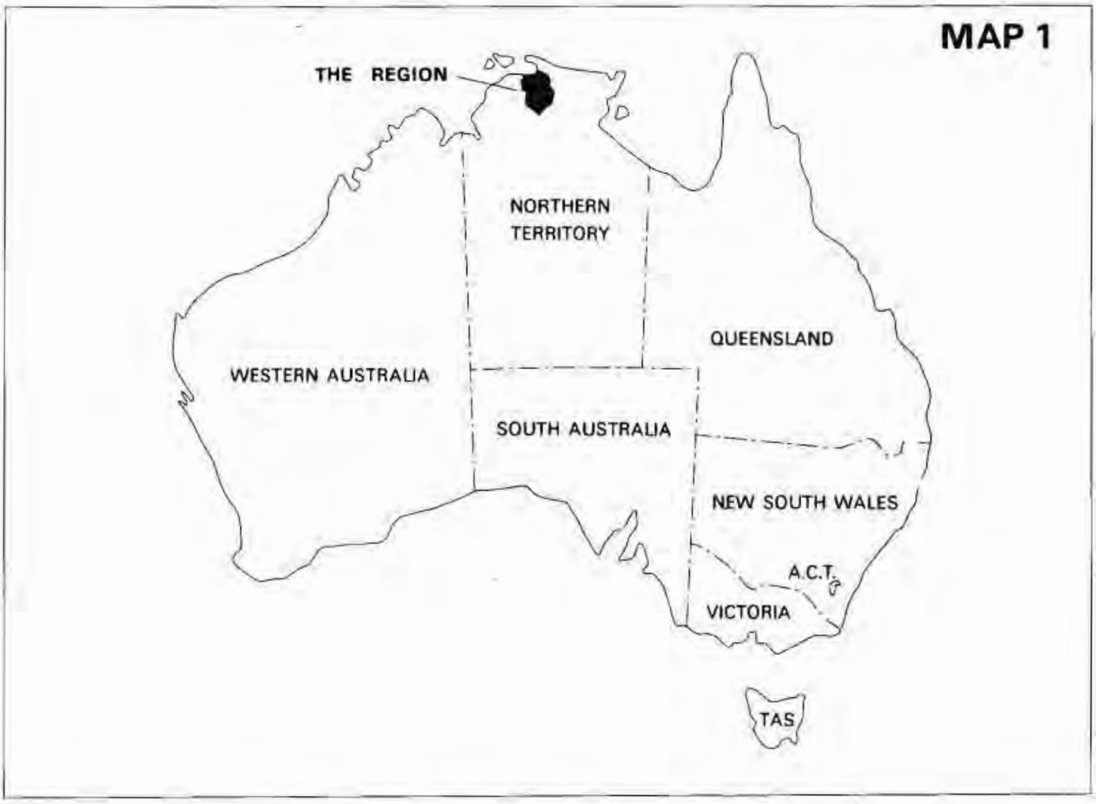

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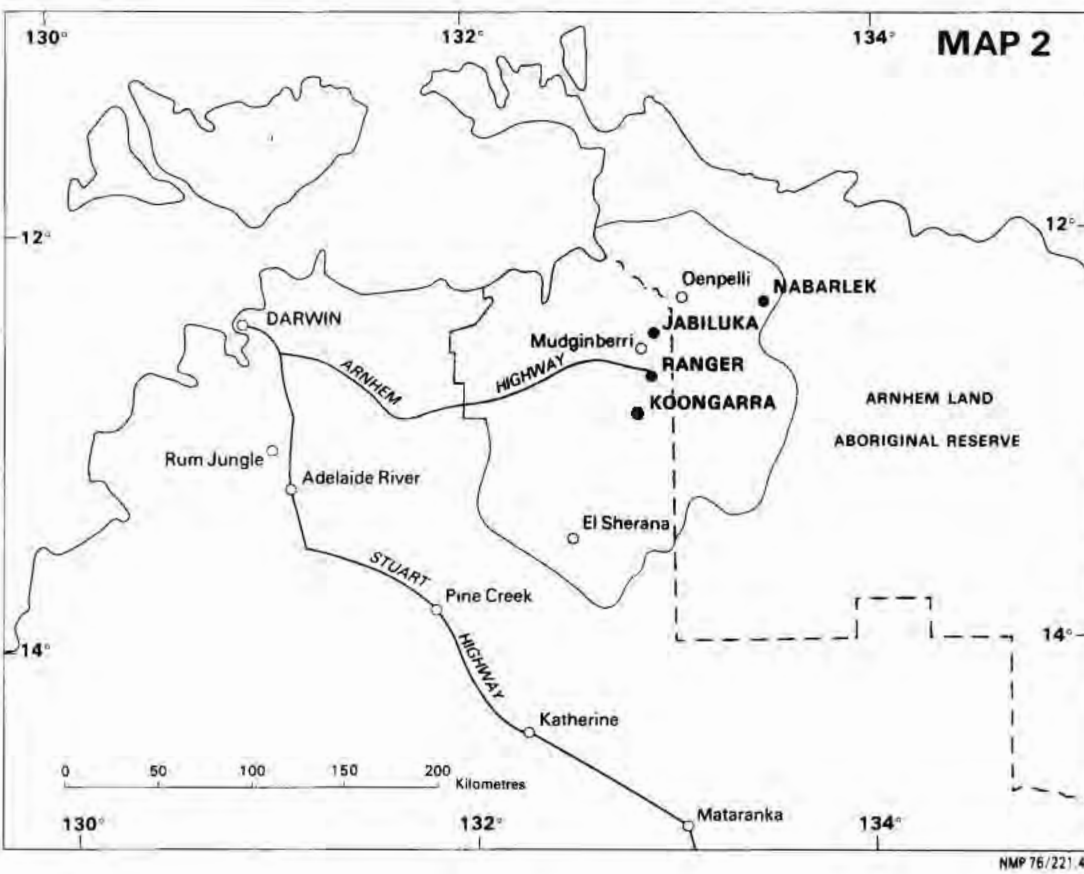


NMP 76/221.4

I INTRODUCTION

This is the Second Report of the Ranger Uranium Environmental Inquiry. The terms of reference of the Inquiry are set out in the First Report, together with formal details respecting our appointment. The Commission is required to inquire:

> in respect of all the environmental aspects of:
>
> (a) the formulation of proposals;
>
> (b) the carrying out of works and other projects;
>
> (c) the negotiation, operation and enforcement of agreements and arrangements;
>
> (d) the making of, or the participation in the making of, decisions and recommendations; and
>
> (e) the incurring of expenditure,
>
> by, or on behalf of, the Australian Government and the Australian Atomic Energy Commission and other authorities of Australia for and in relation to the development by the Australian Atomic Energy Commission in association with Ranger Uranium Mines Pty Ltd of uranium deposits in the Northern Territory of Australia.

These terms have not been altered since the institution of the Inquiry.

Evidence The public hearings of the Commission commenced on 9 September 1975. It sat for 121 days and received evidence from 303 witnesses.

A list of those who had given evidence at the time the First Report was delivered appears at Appendix A of that Report. The names of additional persons who have given evidence since is at Appendix VIII of this Report. A number of the earlier witnesses have given additional evidence related to this Report. The number of exhibits received in evidence is 419. Particulars of these are set out at Appendix IX. The transcript of evidence occupies 13 525 pages. Some fifty-three copies of each day's transcript were distributed free of cost, mostly to government departments and agencies which had requested them. We have been informed by the Australian Government Publishing Service that 10 500 copies of the First Report have been printed, and of those 2500 have been made available for free distribution and 8000 for sale. We believe the recorded cost of the Inquiry to mid April 1977 was $827 966.

The procedure followed by the Commission is governed by the *Environment Protection (Impact of Proposals) Act* 1974; it differs in important respects from that governing Royal Commissions. The Procedure is essentially semi-judicial in nature. All evidence has to be given in public, on oath or affirmation, and, subject to obtaining the leave of the Commission, every witness has a right to cross-examine every other witness. The Commission could not take account of anything said by anyone unless it was properly admitted in evidence before it. Using a power given to us, we did, however, admit as exhibits a considerable volume of documentary evidence, including many papers by informed persons.

The legislation is plainly designed to enable proposals to which it relates to be examined closely in public and to permit members of the public to express views and offer facts relevant to those proposals. Nearly all the witnesses who gave evidence asked to do so; the rest were invited by the Commission to do so in order to fill gaps in the evidence or to gain their views on particular matters.

In order to reduce the time which would otherwise be occupied at hearings, and so as to keep the evidence within the bounds of relevance and minimise unnecessary repetition, the Commission invited all witnesses to prepare statements of their intended evidence and to discuss them with counsel before giving evidence. This was done in nearly every case. An added advantage was that the principal parties (and other interested persons) were in most cases able to have a typed copy of each witness's intended evidence before it was given.

The First Report

The First Report related to a particular argument which had been raised in the course of the Inquiry. It had been submitted that, because of the nature and magnitude of the risks and problems associated with the use of uranium in the nuclear power industry, we should recommend against the Ranger proposal to mine uranium in the Northern Territory and export it. The reasons advanced were essentially negative in nature, and we dealt with each in turn so far as our terms of reference permitted. They related to five different matters:

(a) dangers associated with uranium mining and milling;

(b) dangers associated with the operation of nuclear reactors;

(c) problems associated with the safe disposal of nuclear wastes;

(d) dangers of the diversion of fissile material for terrorist purposes; and

(e) dangers of the diversion of fissile material for nuclear weapons—the problem of nuclear proliferation.

We expressed views about each of these matters, and made findings about the first four in the following terms:

- *The hazards of mining and milling uranium, if those activities are properly regulated and controlled, are not such as to justify a decision not to develop Australian uranium mines (p. 185).*

- *The hazards involved in the ordinary operations of nuclear power reactors, if those operations are properly regulated and controlled, are not such as to justify a decision not to mine and sell Australian uranium (p. 185).*

- *While we do not think that the waste situation is at present such as to justify Australia wholly refusing to export uranium, it is plain that the situation demands careful watching, and, depending on developments, regular and frequent reassessment. If, even in a few years, satisfactory disposal methods have not been established, it may well be that supplies of uranium by Australia should be restricted, or even terminated. This would in any ordinary case only be done after consultation with the purchasing country, which would probably also be the country where the wastes would be and which would therefore be more directly affected by the problem (p. 178).*

- *In our view the possibility of nuclear terrorism merits energetic consideration and action at the international level. We do not believe that this risk alone constitutes a sufficient reason for Australia declining to supply uranium. It does however provide a further reason why the export of our uranium, including what is proposed to be done with it, and where, are matters which the Government should keep under constant scrutiny and control (p. 178).*

We were, and are, of the view that the most serious danger is that referred to in (e) above: that of proliferation of nuclear weapons. We made a finding about it as follows (p. 185):

- *The nuclear power industry is unintentionally contributing to an increased risk of nuclear war. This is the most serious hazard associated with the industry. Complete evaluation of the extent of the risk and assessment of what course should be followed to reduce it involve matters of national security and international relations which are beyond the ambit of the Inquiry. We suggest that the questions involved are of such importance that they be resolved by Parliament. In Chapters 15 and 16 we have gone as far as the terms of reference and the evidence permit in examining the courses open and in making suggestions.*

We did not make a recommendation about what Australia should do about the danger. The risk was apparent and great, but international relations (including trade, diplomatic and defence considerations) were involved and a decision as to the correct strategy had to be made by those equipped to make it. We know enough of the considerations affecting resource strategy to be aware of its complexity and the impact it can have on world affairs. Our hope was that sufficient information would be given to Parliament to enable it to guide or direct the Government's actions. We nevertheless made some suggestions based on the information we had accumulated. They appear at pp. 179–81, and we set out in full what we said:

Permanent refusal to supply

'We mentioned earlier an argument that Australia should permanently refuse to supply uranium, or should at least postpone supply, with a view to persuading other countries, by our example, from entering upon or further developing nuclear power production. Although the argument probably finds its strongest support from considerations of proliferation, it can be supported by reference to all the hazards and problems of the industry.

'A total renunciation of intention to supply designed to bring an end to all nuclear power industries or all further development of them would in our view be likely to fail totally in its purpose. If the purpose were simply to draw international attention to the dangers of and associated with the industry, that purpose might be achieved, but it is most unlikely that any worthwhile action would result. On the other hand there are positive reasons against adopting such a course. Apart from financial considerations, which are not to be neglected, there are considerations to which we referred when dealing with the topic of proliferation. A total refusal to supply would place Australia in clear breach of Article IV of the NPT and could adversely affect its relation to countries which are parties to the NPT. These matters might not have been of any concern at all had we not advanced our preparations for uranium mining to the stage they have now reached, so that our readiness and ability to supply within a few years are now obvious. We are of the view that total renunciation of intention to supply is undesirable.

Postponement of supply

'When it comes to a question of a temporary postponement of supply, considerations intrude which are different and more varied. The need to take steps to impede proliferation is the matter of most serious concern. We cannot be sure that an announced intention not to mine or export for a period of, say, two to five years will not have an impact leading to more vigorous international action than might otherwise take place. Nor can we be sure of the extent of any adverse international reaction, having in mind, in particular, our NPT obligations and our relations with our close trading and strategic partners. Apart from the question whether action such as that under consideration would be successful, or is on balance desirable, there is the different consideration whether during such a delay some of the existing problems may be more satisfactorily resolved. Initiatives are in progress or can be taken which offer some chances of success in improving safeguards and helping to prevent diversion of nuclear material for war-like purposes. Australia, as a country which had no stated intention to withhold permanently its uranium, might be able to exert influence to improve matters through channels we have mentioned. There is a possibility that during this period technological advances will reduce hazards to man and the environment, especially with regard to the treatment and disposal of high-level radioactive wastes. On the evidence available to us no country with an expressed intention to buy Australian uranium will in the meantime be dependent on Australia, in the sense that supplies at reasonable cost could not be obtained elsewhere. Japan is perhaps the country most likely to need Australian uranium and it has already contracted for supply of all its requirements until 1985, almost entirely with countries other than Australia. When taken in conjunction it seems to us that these factors make delay an option which might reasonably be followed.

'The contrary argument contends that any delay would serve no useful purpose and mining should be permitted provided the recommended controls, regulations and conditions are put into effect immediately. The case for immediate development rests mainly on the positive advantages from predicted economic benefits and also on the view that Australia, as an active supplier of uranium, would be better placed to exert its influence towards reducing the problems associated with a nuclear industry. Millions of dollars have already been invested in preparatory work for uranium mines in Australia and returns on this substantial investment would be postponed by a delay. Additional costs would be involved in interest on borrowed capital, maintenance of work already completed and retention of a core of personnel for established proposals. The assessment of any losses in national income which would be caused by a delay is highly speculative. However, a two-year delay in the whole uranium industry, assuming it would otherwise have developed at the highest foreseeable rate, as discussed in Chapter 9, could cause losses to national income of some tens of millions of dollars. On the other hand, if a delay caused an increase in world uranium prices or if the assumed maximum rate of development was not achievable, losses could be small, even negligible. We recognise the importance of these factors and would not contemplate suggesting that a delay be considered if we were not convinced that the hazards associated with the nuclear industry are of overriding national and international significance.

'The essential difference between the bases for these two alternative propositions is that the case for delay places greater weight on the considerations of the environmental and human costs of nuclear development whereas the case for immediate, albeit cautious and restrained, commencement of an Australian uranium export industry places greater weight on assumed economic benefits and the view that, as a result of commencing exports, Australia's influence will be correspondingly greater.

'Because the evidence from which each line of argument is derived remains conjectural and also for reasons stated earlier when discussing the proliferation problem, we have not found a compelling basis for a conclusion on the question whether it is preferable to delay coming to a decision about mining for a period of several years or alternatively to proceed with carefully planned development of the industry. What we do conclude is that at present Australia should not commit itself to withholding for all time its uranium supplies, and that it should take the course which is determined to be the most effective and most practical in order to bring a favourable response from other states in relation to the proliferation problem.'

It will be seen that we suggested (a) that total renunciation of intention to supply was not justified, and was undesirable, (b) that the options were either to proceed to supply as soon as practicable or to delay making a decision about supplying for a period of several years. In our view, a decision on the options depended largely on what was deemed to be the best strategy in relation to the matter of proliferation. We do not wish to alter or qualify anything we have said in relation to these matters. We do not discuss the matter of proliferation in this Report.

The recommendations of the First Report covered a wide range of matters, from nuclear safety and safeguards to energy conservation, and consideration of the energy requirements and resources of developing countries. For convenience we reproduce in full at Appendix X the principal findings and recommendations on pp. 185–6 of that Report.

Aboriginal land rights legislation

When we decided that a separate First Report should be presented we recognised that inevitably it would delay the preparation and delivery of the total Report. In our First Report (p. 4) we said that we would proceed immediately to finalise and present the Second Report. By the time the First Report was delivered on 28 October 1976 it was evident that this could not be done because our recommendations were likely to be influenced considerably by the terms of the Aboriginal land rights legislation, which after having been under consideration for a long time would probably be passed by the Australian Parliament before the end of the year. We therefore announced, when delivering the First Report, that we might have to hear submissions from the parties as to the effects of the legislation on the Inquiry and on the course the Inquiry should follow. When the final form of the legislation became known, it was apparent that it would have very important consequences for the development of the Alligator Rivers Region and the mines in that area. The Commission recognised that it was not sensible for it to produce its Second Report on the eve of the passage of the legislation, which became the *Aboriginal Land Rights (Northern Territory) Act* 1976.

The operation of that Act is discussed in more detail in Chapters 14 and 15. Suffice it to say here that it provides a procedure whereby claims can be made by or on behalf of Aboriginal persons that in the Northern Territory there are traditional owners of land and Aboriginals are entitled by tradition to its use or occupation. There are two tribunals which can consider these claims. The normal tribunal is an Aboriginal Land Commissioner, to be appointed under the Act, who is to be a Judge of the Supreme Court of the Northern Territory. He is required not only to consider the claims of the Aboriginals, but also to consider related matters such as the nature and extent of the advantage that would accrue to the Aboriginals if the claims were acceded to, the possible detriment to persons or communities, including other Aboriginals, if the claims were admitted, and the effect which acceding to them would have on existing or proposed patterns of land use. Where he finds that there are traditional Aboriginal owners of an area of land, he can recommend that a Land Trust be established for a group or groups of Aboriginals who are entitled to 'the traditional use or occupation' of that land. The report and recommendation of the Aboriginal Land Commissioner are to be considered by the Minister for Aboriginal Affairs, who may in his discretion establish a Land Trust in respect of the land claimed, and this has the effect of preserving the land for Aboriginals. The Minister cannot as a rule make such a decision without an appropriate recommendation from the Aboriginal Land Commissioner, but s. 11 (2) provides that if this present Commission, for the purposes of its Inquiry, makes a finding that a group or groups of Aboriginals are entitled by Aboriginal tradition to the use or occupation of an area of land, the finding is to have effect as if it were a recommendation made to the Minister by the Aboriginal Land Commissioner. This last-mentioned provision acknowledges the importance of the Act to this Inquiry and also the fact that when acting under the *Environment Protection (Impact of Proposals) Act* 1974 we have inevitably to deal with most if not all of the matters which an Aboriginal Land Commissioner would have to explore. If s. 11 (2) had not been enacted, the probability is that useful recommendations could not have been produced by this Commission until after the Aboriginal Land Commissioner had conducted an inquiry and the Minister had made a decision on his report. Doubtless one purpose of giving this Commission a role under the *Aboriginal Land Rights (Northern Territory) Act* was to abridge the time that would otherwise have been required before final decisions concerning the Ranger proposal could be taken.

Additional evidence

The earlier history of the Commission's proceedings is set out in the First Report. In order to minimise the delay arising from the advent of the Aboriginal land rights legislation, the Commission, pursuant to the intimation it had given on 28 October 1976, announced in late November, before the Act was passed, that a further public hearing was to take place on 15 December and, as necessary, on the days following. The Act was passed on 9 December but was not assented to until 16 December. It was not to come into operation until a date to be proclaimed. In the event this was 26 January 1977 for all provisions except s. 70, which has not yet come into operation.

The Commission sat on 15, 16 and 17 December, and among other matters heard submissions concerning the effect of the Act. Land rights claims, intended to be pursued under the Act, were submitted on behalf of certain Aboriginal persons by counsel for the Northern Land Council (as constituted under earlier legislation) and the Oenpelli Council, both of which bodies had for some time been represented before the Commission. A considerable amount of evidence respecting the subject matter of those claims and other evidence relevant in determining traditional Aboriginal ownership and entitlement had been received earlier, and further evidence respecting the claims was heard on the days in question. Although the course followed was thought to be a convenient one, the claims were in fact presented prematurely because the Act requires, in effect, that they be prepared and presented with the advice of a Land Council constituted under the Act. Land Councils have very important and responsible duties under the Act, of which that is one. In the event this premature course, which was designed to save time, has not presented any difficulties because a Northern Land Council was established in accordance with the Act on 26 January 1977 and it has in substance confirmed the claims already made and continued with their prosecution.

In anticipation that the necessary steps would be taken to enable the claims already presented to be considered, the Commission gave notice by advertisement and otherwise on or about 11 January 1977 of its intention to consider them at a date to be fixed in late February, and it invited all persons wishing to contest the claims or to establish an interest in any area claimed, or otherwise wishing to be heard before the Commission, to send notice to it by 26 January. Some notices were received before that date, but the Commission in fact entertained any claims or submissions presented before the hearings concluded.

The Commission is grateful to the Northern Land Council, as now constituted, and its counsel, and to the Department of Aboriginal Affairs, for their co-operation in enabling the hearings to be resumed on 22 February 1977.

The Commission sat in Darwin from 22 to 25 February 1977. On 26 February it revisited the Jabiru area, at the request of the Northern Land Council, to examine again the question of the most satisfactory southern boundary of the Ranger mining area, having in mind its closeness to Mt Brockman and the sacred sites near it. On 27 February, at the invitation of Pancontinental, the Commission went by boat from the Mudginberri homestead to Jabiluka and again examined that site.

On 22 March 1977 the Commission sat in Sydney to deal with further evidence it thought it should hear.

Further consideration of matters in First Report

In general, the Commission in this Report does not attempt to carry any further consideration of the matters dealt with in the First Report. Evidence upon which that Report was based concluded in August 1976. There have since then been some developments of significance relevant to the First Report, but we decided that the advantage to be gained by receiving evidence and submissions about them would be outweighed by the cost and delay involved. From what we have read in the reports which we have monitored, it seems to us likely that their effect would be to confirm conclusions we have already expressed and, in particular, our warning about uncertainties likely to affect the demand for uranium. We did, in one instance, explore at a public hearing some general comments which had been made about parts of the First Report to see whether there was some further information we should have, but elaboration of the comments did not add to our existing knowledge, or require any alterations to what we had said.

Scope of this Report

In this Report the Commission deals with environmental aspects of the Ranger proposal which are of a national or local nature. Local environmental aspects were briefly summarised at pp. 4 and 5 of the First Report. It will be recalled from that Report (p. 1) that 'environment' is defined by the Act to include 'all aspects of the surroundings of man, whether affecting him as an individual or in his social groupings'.

The general area in which it is proposed that the mining take place possesses natural environmental qualities of great diversity and value, substantially unmodified by European activity. Many parts of the region are physically and ecologically vulnerable, and the local Aboriginal communities are in a state of acute social stress, largely as a result of their contact with European society. Depending on what is done, and how, the proposed mining and milling operations could have seriously adverse consequences, not only for the area of land upon which they will take place, but for *the Aboriginal people*, for *the proposed Kakadu National Park* and for *the pastoral industry at Mudginberri and Munmarlary*. These are the three aspects of the environment particularly under threat.

The Commission is not only required to report on environmental consequences, but also to make recommendations as to what should be done. It sees its particular role in this Report as one of balancing the anticipated benefits to Australians from the proposed development against its adverse environmental effects within Australia, and in seeing whether it is reasonably practicable for mining and associated activities according to the proposed or some altered plan to be carried on in a way that produces no more than an acceptable level of damage to the environment, including in this term the physical, biological and social aspects of it. All this has to be done, of course, on the basis of assessing the effects of a uranium industry if it is allowed to proceed. The fact that we explore the matter on that basis does not in itself indicate any view of ours as to the decision which will, or should, be made.

Our fundamental approach has been to establish land use patterns in which conflicts are avoided or geographically contained. We have found it necessary to explore a number of different alternatives with a view to protecting and if possible advancing the welfare of the Aboriginals in the Region. It has also been necessary to consider a number of alternatives respecting the location and operation of the Kakadu National Park, and to consider closely the prospects of the pastoral industry conducted on Mudginberri and Munmarlary. The mining activities cannot be carried on without provision for the accommodation of mine workers and their families and it has been necessary to consider the extent and location of the necessary accommodation, and to study the interaction of the mining community with the other elements of the environment already mentioned. The possibility of there being a large mining and milling operation at Jabiluka (if mining in the Region is allowed at all) has been taken into account. Associated with these developments is an expected large increase in the number of tourists coming to the area. It had been thought that accommodation for them might be provided in a central town, which would have a population, including mine workers and their families, of 10 000 or more people. We have of necessity considered the desirability of mining proceeding at Koongarra.

The scheme of the Report is first to describe the Region, from the point of view of its physical and biological characteristics, its economy and its population, with special reference to the Aboriginals, then to identify environmental values and to discuss the nature and degree of their vulnerability. Then we describe in detail the Ranger proposal, as elaborated and explained in the evidence before us, and we discuss in less detail other mining proposals. We discuss separately proposals for a national park, tourism, rural and fishing industries, and a regional centre. We consider in some detail the various environmental impacts of the proposed mining and associated activities.

It seems to the Commission that an evaluation of the various environmental considerations, and a solution to the problems they pose, can best be done by reference to a study of the uses to which the various portions of land in the region can best be put, and we have made such a study and used it in our conclusions.

We have examined the operation of the *Aboriginal Land Rights (Northern Territory) Act* 1976 and other legislation having a bearing on our Report, and we make findings and recommendations under that Act.

It will be found that we have dealt with most subjects in depth. The submissions and the evidence led us in this direction, but we would in any event have regarded it as desirable in the special circumstances of the present Inquiry to err on the side of including more detail rather than less. We hope that by adopting that course the Report will in the long run be more valuable, not only to those who have to make decisions but also to those who, in the event that mining takes place, will have to monitor those operations and supervise activities within the Region.

Aboriginal attitude

The evidence before us shows that the traditional owners of the Ranger site and the Northern Land Council (as now constituted) are opposed to the mining of uranium on that site. The Northern Land Council, as constituted before the land rights legislation was passed, had expressed the same view to us. The reasons for the opposition (which are discussed more fully in Chapter 15) would extend to any uranium mining in the Region. Some Aboriginals had at an earlier stage approved, or at least not disapproved, the proposed development, but it seems likely that they were not then as fully informed about it as they later became. Traditional consultations had not then taken place, and there was a general conviction that opposition was futile. The Aboriginals do not have confidence that their own view will prevail; they feel that uranium mining development is almost certain to take place at Jabiru, if not elsewhere in the Region as well. They feel that having got so far, the white man is not likely to stop. They have a justifiable complaint that plans for mining have been allowed to develop as far as they have without the Aboriginal people having an adequate opportunity to be heard. Having in mind, in particular, the importance to the Aboriginal people of their right of self-determination, it is not in the circumstances possible for us to say that the development would be beneficial to them. Our own assessment of the impact upon them, in which we take into account the very large amount of royalties which will accrue to them, collectively, under the land rights legislation, is to be found in Chapter 15.

There can be no compromise with the Aboriginal position; either it is treated as conclusive, or it is set aside. We are a tribunal of white men and any attempt on our part to state what is a reasonable accommodation of the various claims and interests can be regarded as white men's arrogance, or paternalism. Nevertheless this is the task we have been set. We hope, and have reason to believe, that the performance of our task will not be seen by Aboriginal people in a racial light at all. That our values are different is not to be denied, but we have nevertheless striven to understand as well as can be done their values and their viewpoint. We have given careful attention to all that has been put before us by them or on their behalf. In the end, we form the conclusion that their opposition should not be allowed to prevail.

The Commission's proposals

After consideration of all factors, we propose a solution which, if a decision is made that uranium mining is to proceed, provides a reasonably satisfactory accommodation between competing interests and the conflicting uses to which land in the Region can be put. This is subject to one qualification. The principal threat to the welfare of the Aboriginal people, and the one they most fear, is constituted by the large numbers of people who can be expected to enter the area. We make a number of recommendations designed to minimise this risk; in particular we recommend strict limitation on the size of the town and the use of the area by tourists.

If what we recommend is carried out, the impact of the Ranger proposal on the natural environment of the Region will in our opinion be kept within limits which are acceptable in the circumstances.

When arriving at recommendations, we have endeavoured to make plain the reasons for them and the principles upon which they proceed. Having in mind the great complexity of the situation, and the intimate interrelation between its various ingredients, it is our respectful but unequivocal recommendation that no part of our proposals be varied unless it is perfectly clear that alternatives will be pursued which will just as satisfactorily achieve the same purposes and satisfy the same principles.

Acknowledgements

We mentioned by name in our First Report the advisers to the Commission who were appointed by the Minister for the time being responsible for administering the *Environment Protection (Impact of Proposals) Act* 1974, and we acknowledged our indebtedness to them. We wish again to express our appreciation for the assistance provided by those of them who have had a role in the preparation of this Report. They are:

Mr C. S. Christian–Ecology and land use
Mr Chester Gray–Nuclear technology and chemical and metallurgical engineering
Mr Wilfred Gray–Aboriginal affairs
Professor Donald Greig–International law and relations
Dr Barry Hart–Water and water quality
Professor Gregory McColl–Economics
Dr Ronald Rosen–Radiation protection

Our staff, a number of whom were mentioned by name in our First Report, have continued to work long hours, with virtually no leave. We wish to say how much we have appreciated their work and loyal support. Counsel assisting the Inquiry was Mr J. Cummins of Sydney, and he was instructed by Mr B. Hill of the Commonwealth Crown Solicitor's Office. We thank them both for their conscientious assistance. We list in Appendix XI the counsel and solicitors who have at one time or another represented the parties shown. We thank them for the assistance they gave us; it was at times invaluable.

Finally we wish to thank the many witnesses who appeared before us, often at considerable personal inconvenience and for no material recompense. They obtained facts and developed arguments which made a most important contribution to the efficacy of the Inquiry.

Plate 1. Aerial view of the Ranger mine and mill site.

Plate 2. An impression of the Ranger mine and mill drawn on the same aerial photo by an artist of the National Capital Development Commission. Features are identified in Figure 1.

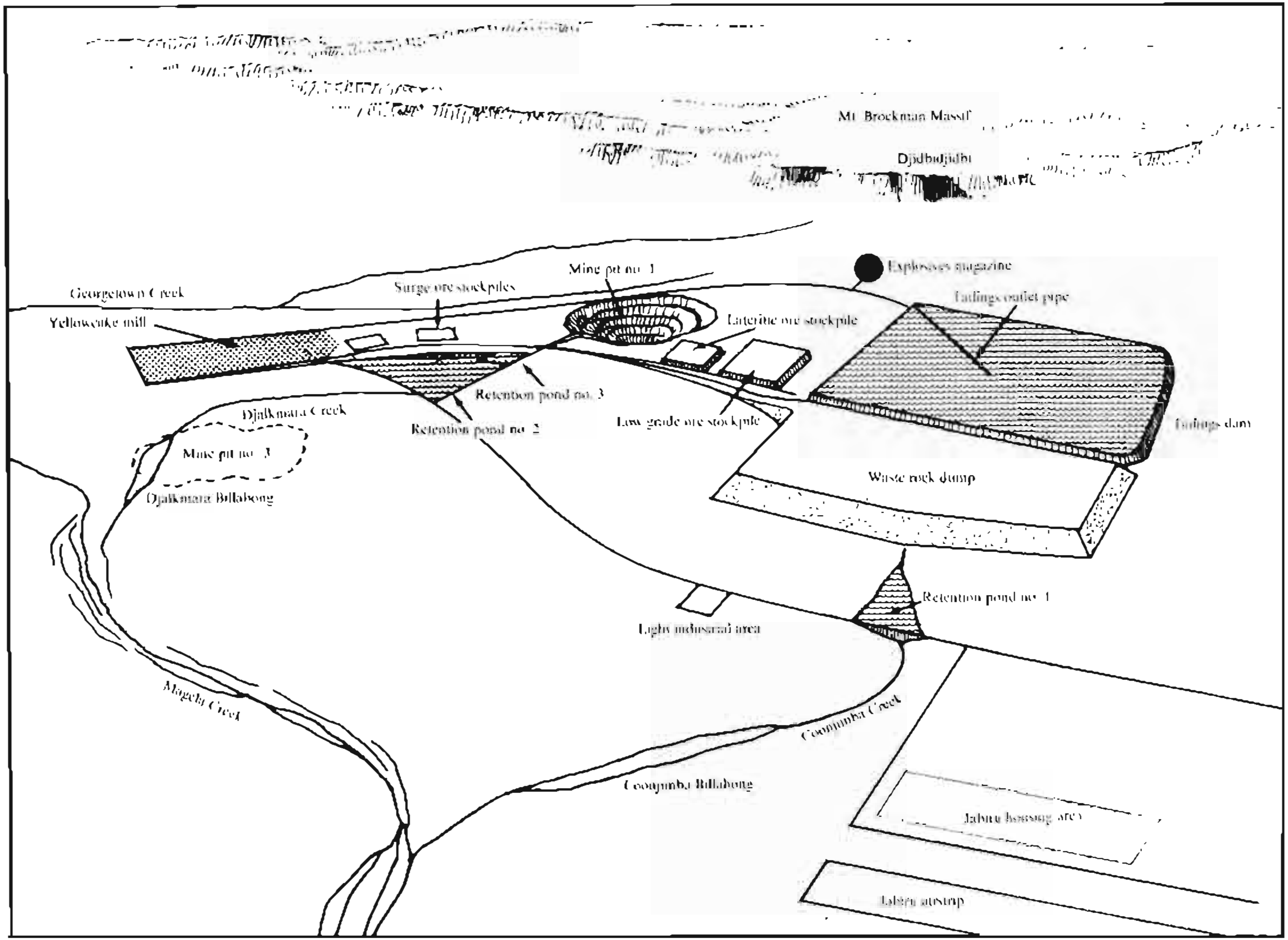
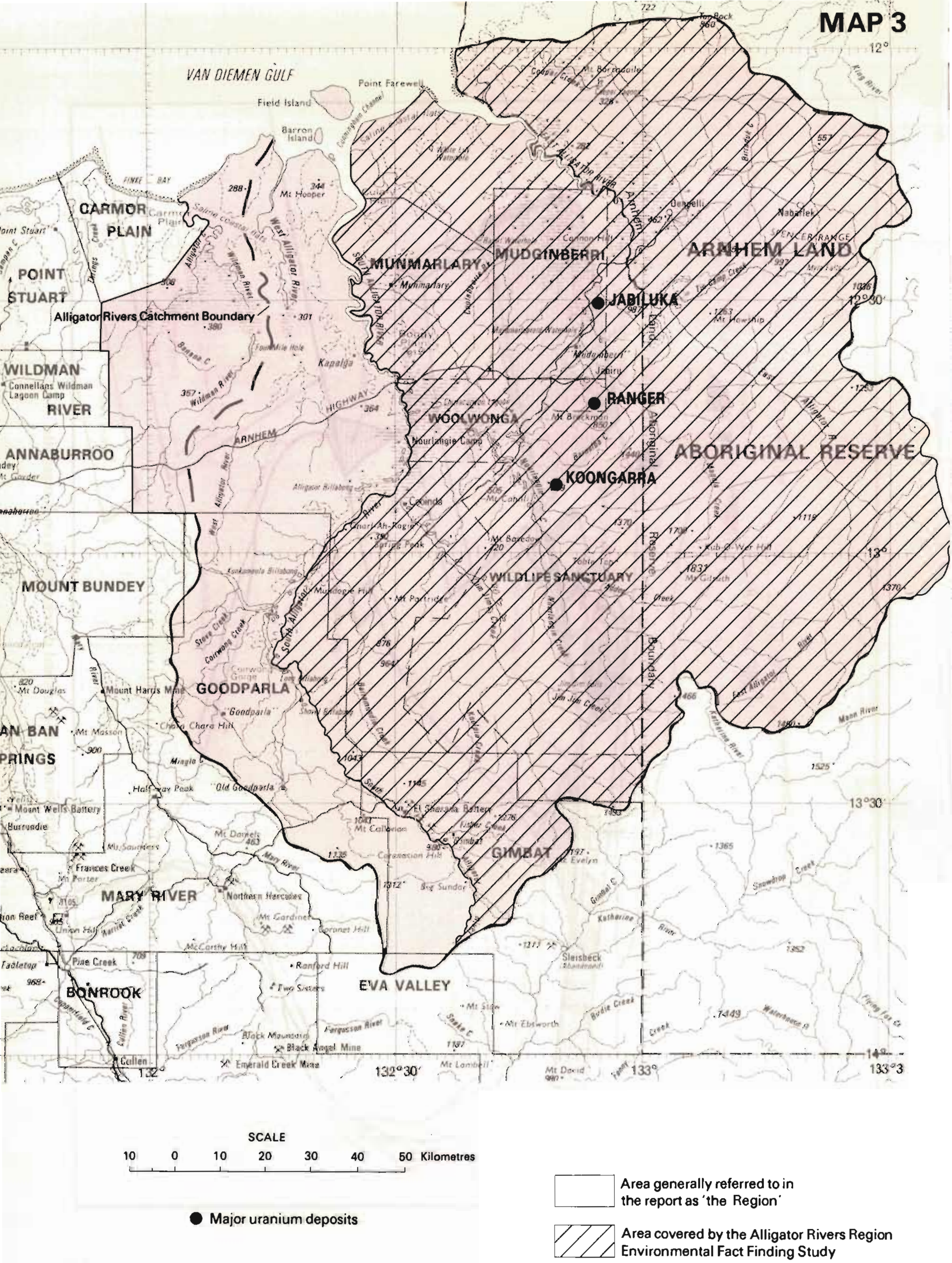


Figure 1: Identification of proposed developments on Ranger site.

MAP 3



Region Referred to in the Report

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2 GENERAL DESCRIPTION OF THE REGION

The Inquiry has mainly been concerned with the catchments of the East, South and West Alligator Rivers, and with adjacent vacant crown land in the Wildman River catchment and Field and Barron Islands (see Map 3). This is the area which is generally referred to in this Report as 'the Region', although sometimes the context will show that the term is used in a more indefinite sense.

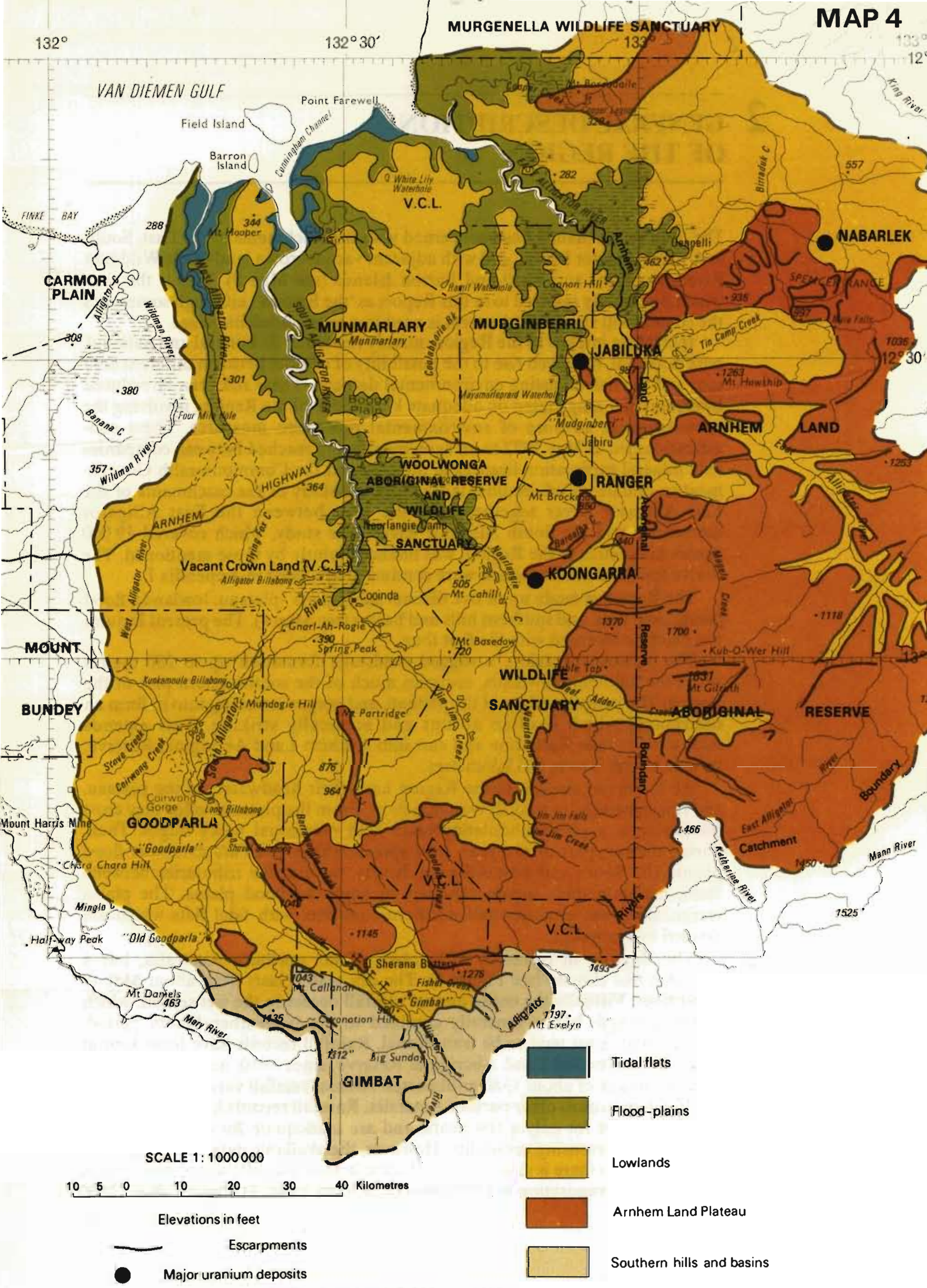
Increasing interest in the Region, mainly related to its mineral and national park potential, has given rise to the possibility of conflict between different land uses and the risk of lasting environmental damage. These risks can be reduced by careful planning, based on adequate knowledge of the Region, involving the formulation in advance of environmental protection measures. These considerations led in May 1972 to an agreement being reached between companies with mineral exploration licences in the area and the Commonwealth Government to initiate an environmental fact-finding study of the catchments of the East Alligator River together with the area between the East Alligator catchments and the South Alligator River. The study, which covered 19 000 square kilometres of the Region, was financed jointly by those mentioned. The twelve specialist studies which were conducted are listed in Appendix I.

The Region is made up of five distinct subregions–plateau, lowlands, flood plains, tidal flats, and southern hills and basins (see Map 4). The present Inquiry was chiefly concerned with the first four.

The plateau subregion, a rugged sandstone formation up to 250 metres above the adjoining lowlands, occupies much of the south-eastern part of the Region. The irregular edges of the plateau, and gorges intruding into it, form an escarpment which is often abrupt and scenically striking. This extends southward to near Katherine and east into Arnhem Land Aboriginal Reserve. Its total length is over 600 kilometres.

All the major streams in the Region have their headwaters in the plateau, and run, generally, in a north-west direction. From the plateau's edge they cross the lowlands, a gently undulating plain with occasional rocky ridges. Then, during the wet part of the year, they spread widely over the extensive flood plains. The South and East Alligator Rivers, but not the tributaries between them, maintain their stream channels through the flood plains. The plains merge, along the estuaries and northern coastline, with tidal flats which are flooded by sea water.

The Region, in common with much of far northern Australia, has a monsoon-like climate (see Figure 2). The dry season lasts from about May to September. Virtually the entire annual rainfall occurs in the wet season, which varies in length but is generally confined to the November–March period. October and April tend to be transitional. Rainfall records have been kept at Oenpelli, in Arnhem Land Aboriginal Reserve, since 1910, and they show an annual average of about 1350 millimetres. Annual rainfall varies considerably, but less than in most other parts of Australia. Rainfall records have been kept at the Ranger site for only a few years, and are inadequate for determining the average and measuring variability. However, the available data suggest that the rainfall pattern there is similar to Oenpelli's, with some differences due to local topography. Evaporation exceeds rainfall in most years, averaging about 2200



Sub-regions of the Alligator Rivers Region

NMP 76/221.1

millimetres per year. Prevailing winds are easterly to south-easterly in the dry season and northerly to north-westerly in the wet season. Like other parts of northern Australia, the Region is subject to cyclones.

The very wet–very dry season sequence causes large variations in stream flow and, together with the relatively high temperatures in both seasons, exercises a controlling influence on plant growth and wildlife habits. The three Alligator Rivers and the Wildman maintain a flow in their lower sections in the dry season. All other streams—even the main tributaries, Magela, Nourlangie, Jim Jim and Barramundi Creeks—cease to flow for the major part of their length in the last few months of most dry seasons. Permanent water is restricted to springs, waterholes and billabongs. The flood plains gradually dry out when the rains cease, leaving swamps and billabongs of varying depth and seasonal duration.

The distinctive subregions and the large seasonal changes give rise to a wide diversity of plant and animal habitats. As a consequence, the Region is rich in numbers of species of both flora and fauna. Zoologically and botanically it is representative of a large part of the far north of tropical Australia. However, because of the diversity of the native species which occur in the Region, it is regarded as one of the biologically richest in Australia. For example, more than 950 species of plants were recorded in the environmental fact-finding study, and they occur in a wide range of vegetation types, including a variety of forest, woodland and scrub communities. More than one-third of the bird species known in Australia have been sighted in the study area, and the large populations of waterfowl on the coastal flood plains are one of the Region's outstanding features. It is also rich in other vertebrate fauna. The insects are the only invertebrates studied in detail; 4500 species were collected and identified during the fact-finding study, and many more are believed to be present. Of the aquatic fauna, only the fish are well known. Forty-two species have been collected in the study area, representing about a quarter of all recorded Australian native freshwater fish. Many plant and animal species have been recorded only in that area, but this is probably due more to the limited number of studies made elsewhere in northern Australia than to their being restricted to the area.

Terrestrial and aquatic vegetation and animals have adapted to survive the rigorous changes between wet and dry seasons and the variations imposed by years of low and high rainfall. Some survive by avoiding the stresses; for example, some plant species are annuals, and some are deciduous or have distinct annual growth cycles. Many fauna species retreat to the habitats where water remains in the dry season. The survival strategies of large numbers of species, particularly of aquatic fauna, are not well understood. Some birds are migratory. Some plant and animal species, including fish and insects, which evolved when the Region's climate and environment were different are under stress; notable examples are the trees and shrubs of the semi-deciduous forests, and the pitted-shelled turtle, a rare species of great scientific interest.

The Region and surrounding areas have been occupied by Aboriginals for at least 25 000 years. Since European occupation, which began with temporary military settlements on the coast between 1827 and 1849, the Aboriginals have tended to concentrate at Oenpelli, Mudginberri and Jim Jim. Nevertheless many, perhaps most, retain traditional ties with the land and with many sites of sacred and other significance. Much of the Region is less frequently visited by them than formerly, due to a number of factors including the decimation of population over the past eighty years through disease, the utilisation by

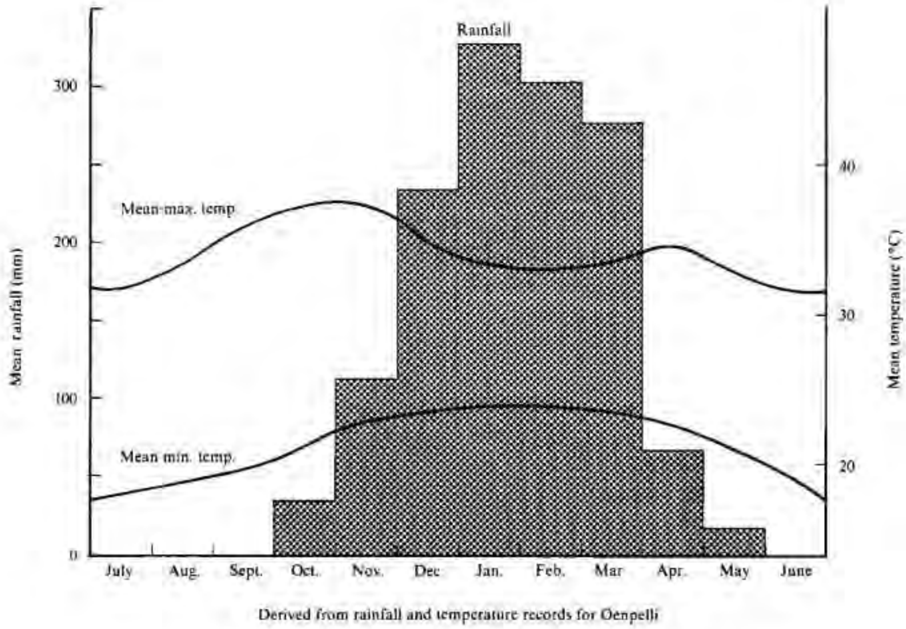


Figure 2: Regional rainfall and temperatures.

Europeans of large areas for the pastoral industry, and government policies and programs which have encouraged the Aboriginals to adopt a more sedentary lifestyle and settle on missions and pastoral properties and in towns. Although western-type foods are readily available at the centres of population, traditional foods remain an important part of the diet of most of the Aboriginals, and foraging and hunting are still widely practised in parts of the Region. The Aboriginal population of the Region has been estimated to be about 800, in a total population of about 1000.

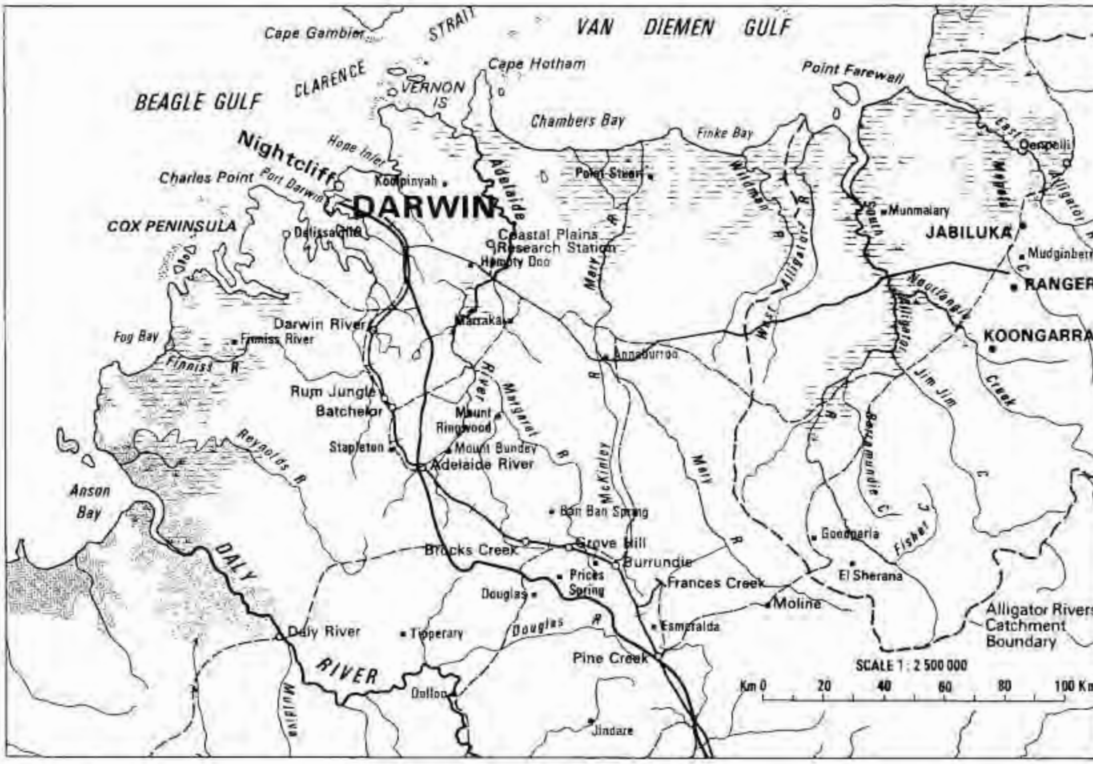
The association of wetlands, lowlands, escarpment and plateau habitats made the escarpment rock shelters particularly important to the Aboriginals before European settlement, and it is along and near the escarpment that large numbers of archaeological and art sites are found. In these respects it is one of the most important and valuable parts of Australia.

The Region includes the Woolwonga Aboriginal Reserve, declared in 1936 and redefined in 1968. This, and the Arnhem Land Aboriginal Reserve, have now become Aboriginal land under the *Aboriginal Land Rights (Northern Territory) Act* 1976.

The early European military settlements apparently had no significant impact on the Aboriginals. However, they had a lasting impact on the Region because of the exotic animals brought by the settlers. These included buffaloes and pigs, which have spread widely in and beyond the Region and have done a great deal of damage.

Early European exploitation of the Region was limited mainly to abortive pastoral activities, followed by rather intensive, but discontinuous, hunting of buffaloes for their hides from about 1880 to 1960. A major deterrent to fuller exploitation was the difficulty of travelling east of Darwin beyond the Adelaide River.

MAP 5



Coastal Flood Plain Areas with Wetland Habitats

NMP 76/221.9

Source: CSIRO Land Systems Maps: Katherine—Darwin Region and Adelaide—Alligator Area

Apart from the impact of buffaloes and pigs, which has been considerable in places, much of the country remains in a near natural state. This fact, together with the diversity of plant and animal habitats and species and its scenic values, gives the Region considerable scientific, conservation and aesthetic value.

The area of the Woolwonga Aboriginal Reserve was declared a wildlife sanctuary in 1964. It is located in the catchment of Nourlangie Creek and is regarded as the most important refuge and habitat for aquatic wildfowl in the Northern Territory.

In 1972 another wildlife sanctuary was declared in an area of 3250 square kilometres adjacent to the Arnhem Land Aboriginal Reserve and mostly south of the Ranger lease. In 1973 the then Prime Minister announced that a national park, with similar boundaries, would be established and called the Kakadu National Park. Notice of intention to submit a proposal that the area become a national park was gazetted in 1975, but it has not yet been declared a national park.

Since World War II, major changes have occurred in the Region. The buffalo resource has been further exploited, mainly for pet food and human consumption rather than for hides. Improved access has encouraged tourism and other recreational activities.

Uranium was found and mined at El Sherana, on the South Alligator River, in 1953. This was followed by several other small uranium mining enterprises in the same locality. Extensive geological studies and mineral exploration since then have led to the discovery of four major (by world standards) uranium ore body sites—at Jabiru (Ranger) and Jabiluka in the Magela drainage system, at Koongarra in the Nourlangie Creek catchment south of Ranger, and at Nabarlek on Cooper Creek in the Arnhem Land Aboriginal Reserve. Additional deposits have been recorded west of Mudginberri homestead and north of Woolwonga.

The Ranger deposits, in lowland country, are near the boundary of the present wildlife sanctuary and the 1975 Kakadu National Park proposal. The mineralised zone extends close to the foot of Mount Brockman. Aboriginal sacred sites of great significance, and art sites, exist on and adjacent to this spectacular plateau outlier. The Jabiluka uranium deposits, 25 kilometres north of Ranger, are in a valley 500–800 metres wide between the escarpment and the edge of the flood plain. These deposits are within the park proposed in 1975. Archaeological and art sites occur within about 1 kilometre of proposed developments. The Koongarra deposit is about 25 kilometres south of Ranger and is within the wildlife sanctuary and proposed park. It is on a strip of lowland country about 1 kilometre wide between a sandstone outlier and a tributary of Nourlangie Creek. Nourlangie Rock, which contains important Aboriginal art sites, is 4 kilometres from the deposit. The Nabarlek deposit is in lowland country 800–900 metres from sandstone scarps. The camp site and proposed mine adjoin an Aboriginal site of significance, a hill called Gabor (Green Ant).

Exploration for uranium has been based largely on ground examination of radiometric anomalies detected by airborne surveys. The recorded anomalies are distributed widely in the area east of the South Alligator River. The greatest concentration is in the area bounded roughly by Cannon Hill, Jabiru, Nourlangie Rock and Woolwonga Aboriginal Reserve. However, the whole Region is regarded as having prospective value for uranium.

Most anomalies have been recorded near the escarpment, where the soil and rock cover is generally thin. Deep deposits would not be revealed by airborne radiometric instruments as these do not detect radiation from ores covered by more than 1 or 2 metres of soil or rock. The most easily identifiable deposits have probably been discovered; recognition of deeper deposits would require other methods of exploration based on geological studies, radon gas detection and pattern drilling, or new techniques.

Two pastoral leases north of the Ranger site, Mudginberri and Munmarlary, were granted in 1969. They are mainly on lowland and flood plain country. Parts of two other pastoral leases, Gimbat and Goodparla, extend into the southern part of the Region. Parts of another three, Mt Bundey, Wildman River and Annaburroo, are in the upper catchments of the Wildman River.

All parts of the Region, apart from the Aboriginal Reserves and the areas which are the subject of pastoral or special purpose leases, are the subject of Aboriginal land rights claims made before this Commission. Notice has been given that Aboriginal land claims will probably be made for the land which is the subject of the Mudginberri and Munmarlary pastoral leases if they are resumed.

An impetus to development, exploration and tourism in the Region has been provided by the completion in 1974 of the Arnhem Highway to Jabiru. The Region depends on Darwin for a port and on road transport to it. The main rivers, though navigable by small boats for some distance, do not have suitable estuaries or offshore conditions for major port purposes.

The main types of land in the Region also occur over wide areas outside it. The plateau country extends into Arnhem Land Aboriginal Reserve and southward to Katherine. The lowland land type occurs in various slightly modified forms over large areas of the Top End of the Northern Territory and elsewhere in northern Australia. Similar flood plains are associated with the Mary and Adelaide Rivers between the Wildman River and Darwin, with the Daly, Finniss and Reynolds Rivers west of Darwin, and also with rivers east of the Region. Tidal flats like those in the Region exist around much of the Northern Territory coastline.

Nevertheless, the Region has a uniqueness which stems from the combination of the following features:

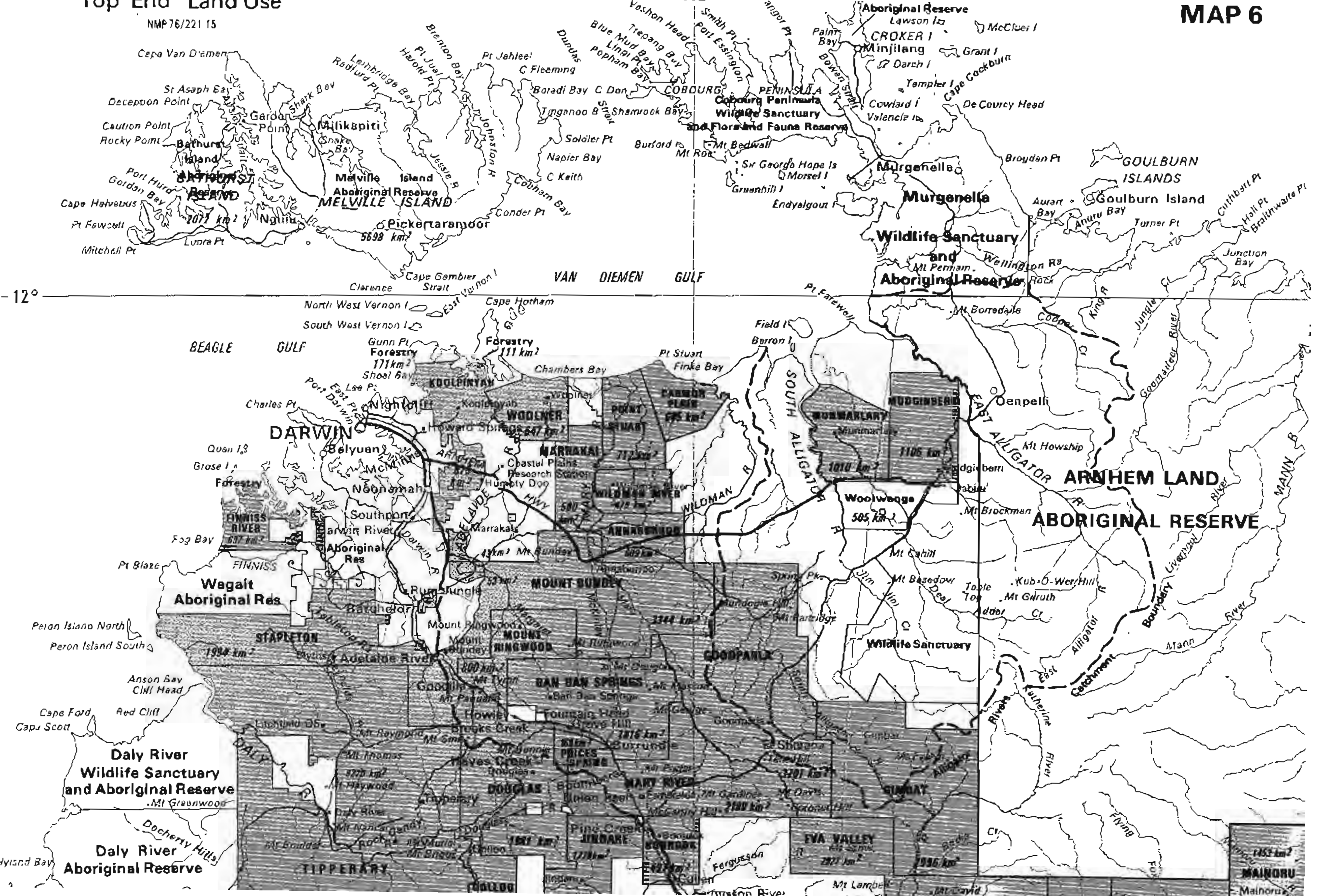
- the wide range of biological habitats and their richness in species;
- the association in close proximity in parts of the Region of plateau, lowlands, flood plains and rivers;
- the fact that Aboriginal people in the Region continue to have strong traditional links with the land;
- the impressive examples of Aboriginal art and the presence of important archaeological sites;
- the discovery of major uranium ore bodies in the Region;
- the presence of buffaloes which have become established and have been hunted for hides (1880–1960) and meat (since World War II);
- the high conservation value of the Region which, despite the impact of buffaloes and pigs, retains most of its natural features.

Some features of the Region are described in more detail in later chapters. Further detail can also be found in the *Review Report* of the Fact-finding Study and the specialist reports of the Study's twelve projects (see Appendix I).

"Top End" Land Use

NMP 76/221 15

MAP 6



3 ECONOMY OF THE NORTHERN TERRITORY AND THE REGION

In this chapter we describe in general terms the demographic and economic characteristics of the Northern Territory and of the Darwin area. We also outline the present distribution of land uses in the Region; the lack of comprehensive economic data relating specifically to the Region prevents us giving a general description of its economy. Economic aspects of particular land uses are discussed in later chapters.

Population The population of the Northern Territory has grown rapidly since the end of World War II (see Table 1). Between 1961, when all Aboriginals were first included in census data, and the census taken on 30 June 1976, the total recorded population of the Territory increased from 44 481 to 97 090. The latter figure is less than the total reached before Christmas Day 1974 when Cyclone Tracy devastated the Darwin area. Darwin's population, which trebled between mid 1961 and mid 1974 to an estimated figure of 46 656, fell to about 11 000 in January 1975 as a result of the post-cyclone evacuation. The figure had risen again to 42 818 by the time of the 1976 census.

As detailed data from the 1976 census are not yet available, earlier statistical material is used as the basis for most of the discussion which follows. This appears to be a realistic approach, since events in 1975 and 1976 have been

Table 1

Population of Australia, the Northern Territory and Darwin, 1947 to 1976

	Australia		*Northern Territory*		*Greater Darwin*
Date	*(millions)*	*Average annual rate of increase*	*Number*	*Average annual rate of increase*	*Number*
Census at 30 June					
1947	7.579[(a)]	..	10 868[(a)]	...	5 208[(a)]
1954	8.987[(a)]	2.50	16 469[(a)]	6.10	8 071[(a)]
1961	10.548	2.30	44 481	..	15 477
1966	11.661	2.00	56 504	4.90	21 671
1971	12.928	2.10	86 390	8.90	37 060
1976	13.916	1.50	97 090	2.40	42 818
Estimates at 30 June					
1972	13.172	1.89	91 666	6.11	39 851
1973	13.379	1.57	95 629	4.32	42 843
1974	13.598	1.64	101 233	5.86	46 656
1975	13.711	0.83	87 584	−13.48	32 630
1976	13.916[(b)]	1.50	97 090[(b)]	10.85	42 818[(b)]

Source: Australian Bureau of Statistics.

(a) Excluding full-blooded Aboriginals (11 788 Aboriginals were enumerated in the Census in the Northern Territory at 30 June 1954, and it is estimated that a further 5369 were not enumerated).

(b) Census at 30 June.

strongly influenced by the short-term effects of Cyclone Tracy. Long-term demographic and economic trends in the Territory will be determined principally by more permanent factors, although the effects of the cyclone may continue to influence events for some time.

Largely because of a substantial inflow of immigrants from other parts of Australia, the Territory's population has grown much faster than that of the nation as a whole in recent decades. Direct immigration from other countries has contributed only a small part of this growth. A comparison of figures showing the natural increase within the area (the excess of births over deaths) with census data shows that net immigration accounted for about two-thirds of the population increase between mid 1971 and mid 1974. Also, a relatively small proportion of the population at the date of the 1971 census was resident in the Territory at the time of the previous census in 1966; in Darwin, for example, the figure was only about 22 per cent.

Another characteristic of the population of the Northern Territory is the relatively high proportion in younger age groups. At the 1971 census, 32.8 per cent of the Territory's population was under 15 years of age, compared with 29 per cent in Australia as a whole. About 46 per cent of the Territory's population was in the 15 to 39 age group, compared with 36 per cent for the whole of Australia. In addition, the ratio of men to women was much greater in the Territory than in the rest of Australia. The Bureau of Statistics has estimated that at 31 December 1973 there were about 118 males to every 100 females in the area, compared with a ratio of 100.65 : 100 for Australia as a whole. The transient nature of a high proportion of the population contributes to these characteristics. One estimate given to the Commission suggests that three-quarters of the labour force comprise people who are not permanent residents of the Territory.

The future growth of the Northern Territory's population will almost certainly depend heavily on the future rate of inflow of people from other parts of Australia.

The National Population Inquiry projected in 1975, on the basis of recent trends, that if no net immigration occurs the Territory's population will grow to 156 000 by the year 2001. Its projections for Australia's population at the beginning of next century are 15.9 million people in the absence of net immigration from abroad and about 17.6 million if the direct and indirect effects of a net immigration rate of 50 000 per year are added. Based on past experience, the Territory's share of immigration from abroad will add only about 3000 to its population in 2001 (see Table 2). However, a continuation of the 1966–71 rate of migration from the rest of Australia would add more than 76 000 people. Adding both these projections of increase from immigration to the estimated natural increase gives a projected population figure for the Territory in 2001 of about 242 000.

Taking into account the mobility of the Territory's population, it is clear that future population levels may vary within wide limits. A major determinant of levels actually achieved will be the number of employment opportunities which are created, since this will largely determine the extent to which people are attracted from other parts of Australia.

Labour force The main employers of the Northern Territory labour force are primary, construction and service industries (see Table 3; greater detail is provided in Appendix II Table A). Statistics derived from the 1971 census show that

Table 2

Projected population of Northern Territory (thousands)

Year	*Natural increase only*	*Natural increase plus share of assumed overseas immigration*	*Natural increase plus continuance of internal immigration*	*Natural increase plus share of assumed overseas immigration and continuance of internal migration*
1971	86.4	86.4	86.4	86.4
1981	111.5	112.1	127.8	129.1
1991	132.8	134.5	175.7	180.1
2001	155.8	158.9	232.0	241.6
Increase 1971 to 2001	69.4	72.5	145.6	155.2

Source: *Population and Australia: A Demographic Analysis and Projection*, First Report of the National Population Inquiry, AGPS, 1975.

manufacturing activities then accounted for less than 5 per cent of the total workforce, compared with nearly 23 per cent in Australia as a whole. About 10 per cent of the Territory workforce was employed in mining, representing about 5 per cent of the total number engaged in mining in Australia. Construction activities were a much more important avenue for employment in the Territory than in Australia generally, reflecting the high rate of population growth and demand for housing and other buildings. In the service industries, public administration and community services, taken together, also were responsible for a much greater proportion of total employment in the Territory, about 30 per cent compared with about 16 per cent in the whole country. Public administration, including defence, accounted for 11 per cent of total employment, compared with about 5 per cent for Australia as a whole. On the other hand, commercial services (including wholesale and retail trade, finance, real estate

Table 3

Percentage of employed population in different industries

Industry	*Australia 30 June 1971*	*Northern Territory 30 June 1971*	*Greater Darwin 30 June 1971*	*Greater Darwin 17 September 1975*
Agriculture, forestry, fishing, hunting	7.3	8.0	1.5	0.7
Mining	1.4	9.8	1.6	0.4
Manufacturing, electricity, gas, water	24.5	5.8	7.4	5.5
Construction	7.7	13.4	13.0	20.1
Commercial services	32.4	20.6	31.2	30.9
Public administration, defence, community services	15.9	29.7	32.6	34.3
Other	9.1	10.9	12.7	5.0
Total employed	98.3	98.2	100.0	96.9
Unemployed	1.7	1.8	..	3.1
Total labour force	5 330 488	32 295	17 041	18 656

Source: Australian Bureau of Statistics.

and business services) contributed much less to total employment than they did in Australia as a whole.

The proportion of the total workforce engaged in public administration and community services was higher in the Darwin area than in the Northern Territory as a whole. In addition, commercial activities including transport, storage and communication were relatively more important in the city area than in the rest of the Territory. Manufacturing accounted for only a marginally greater proportion of the city's labour force than that of the Territory as a whole.

Reconstruction after Cyclone Tracy has raised the contribution of building and construction to total employment opportunities. It seems likely that the proportion of the workforce engaged in these activities will fall now that reconstruction is virtually complete. However, if a fast rate of population growth is maintained, these activities will continue as major employers.

Unemployment

Because of the effects of Cyclone Tracy, it is necessary to draw most conclusions about unemployment trends in the Northern Territory from data relating to periods before December 1974. Both the Darwin area and the Territory as a whole appear to have experienced slightly higher rates of unemployment than the average for Australia during the high levels of economic activity experienced in 1973–74. However, apart from seasonal influences, the percentage of the estimated labour force unemployed has followed similar cyclical trends to those experienced in the rest of Australia.

The data for 1975 and 1976 are obviously affected by the impact of the cyclone. The evacuation of Darwin greatly reduced the size of the labour force, and then the reconstruction program created new employment opportunities in construction and related areas. The most recent figures can possibly be taken to represent a return to a more normal situation. With 5.4 per cent of the workforce unemployed in December 1976, compared with a national average of 4.4 per cent, the unemployment rate in the Territory is again somewhat higher than in Australia generally.

Except in periods of high levels of economic activity, it appears that the largest components of registered unemployed normally comprise unskilled and semi-skilled workers, followed by clerical and administrative workers and people seeking work in service occupations.

Data on unemployment in the Territory, and related information, are summarised in Appendix II, Table B. A number of well-known deficiencies need to be borne in mind in interpreting the unemployment data, including variations in the extent to which unemployed people actually register with the authorities. These deficiencies may be particularly important in the Northern Territory because of the high rate of migration between it and the rest of Australia and fluctuations associated with the wet and dry seasons.

Northern Territory industries

Rural

Only about 0.01 per cent of the total area of rural holdings in the Northern Territory is devoted to the growing of crops (see Appendix II, Table C). The area used for growing pastures and grasses is about ten times greater, but about 99.8 per cent of total holdings is either used for grazing or not used for productive purposes.

The number of cattle grazed has exceeded one million head in recent years. A marked increase has occurred in the last two years because of favourable weather and unfavourable market conditions for beef which reduced slaughtering and exports. The number of domesticated buffaloes has declined in recent years, numbering about 3000 at 31 March 1976.

The gross value of rural production declined from about $25 million in 1973–74 to less than $12 million in 1975–76, principally because of the downturn in beef prices. Since other activities make a relatively small contribution to the value of rural output, prospects for the rural economy of the Territory are closely related to the fortunes of the pastoral industry.

Fishing Prawn and other fishing has made an important contribution to the Territory's economy in recent years. The gross value of production has fluctuated considerably, reaching $8 million in 1975–76 compared with about $3.7 million in 1974–75 and $6.5 million in 1973–74.

Mining The important contribution of mining industries to the Northern Territory economy is illustrated by the data in Table 4. The quantity of bauxite mined at Gove has risen rapidly in recent years, from about 200 000 tonnes in 1970–71 to more than 4 million tonnes in 1974–75. The other activity of major significance is the production of manganese ore on Groote Eylandt. Production of copper from Tennant Creek has been an important source of income to the Territory, but fluctuations in the world demand for copper have led to the temporary closure of the mine and smelter. Iron ore production at Frances Creek, which contributed to exports from 1967 to 1974, has now ceased.

Manufacturing The number of establishments engaged in manufacturing activities grew rapidly in the early 1970s; between 1969–70 and 1973–74 the number of people employed in them rose from 944 to 2450 and the value of transactions more than quadrupled (see Appendix II, Table D). Minerals and metal manufacture, including alumina production, copper smelting and other activities associated with the major mining projects, accounted in 1974–75 for about two-thirds of the employment in manufacturing activities and an even greater proportion of the value of transactions. Industries producing food and beverages, including abattoirs, were responsible for a major part of the balance of manufacturing output. The main products of the other manufacturing industries were furniture, paper products and building materials intended principally for local consumption.

Retail and wholesale trade The growth in population has been associated with a continuing increase in the number of retail and service establishments in the Territory. As shown in Appendix II, Table D, the turnover of these establishments exceeded $162

Table 4

Mining industry in the Northern Territory

						Quantities of minerals produced (thousand tonnes)			
Year	*No. of establishments*	*Persons employed*	*Wages and salaries $m*	*Turnover $m*	*Value added $m*	*Bauxite*	*Copper concentrate*	*Iron ore*	*Manganese ore*
1970–71	24	1495	8.7	41.3	22.2	209	27	1248	641
1971–72	26	1587	10.1	47.7	35.8	861	29	934	1052
1972–73	15	1473	10.8	66.0	49.1	1415	35	885	1265
1973–74	15	1495	12.9	87.7	70.2	3246	59	735	1619
1974–75	15	1180	15.9	91.6	69.2	4231	58	..	1410

Source: Australian Bureau of Statistics.

million in 1973–74 and they provided employment for 6338 people, more than twice as many as manufacturing industry and more than five times as many as mining. The category of retailers recording the highest turnover was motor vehicle dealers, including petrol and tyre retailers ($48 million), followed by food stores ($42 million), department and general stores ($15 million), clothing, fabrics and furniture ($9 million) and household appliances and hardware ($9 million). Among service industries, licensed hotels and motels were of greatest significance ($18 million), while cafés and restaurants ($5 million) and licensed clubs ($5 million) were also important.

Summary

Data relating to economic activities other than those discussed above are not available in detail. However, it is clear that most employment opportunities in the Territory are in public administration and the provision of goods and services required by local residents. The principal export industries–grazing, mining and their associated activities–provide direct employment for a relatively small part of the total workforce.

No official estimates are available of the income generated by economic activity in the Territory. An estimate made by the Commission, details of which are given in Appendix V, suggests that the total income accruing to people living in the Territory in 1973–74 was about $400 million (expressed in January 1976 prices).

Present land use in the Region

The only activities in the Region currently of economic importance are the pastoral industry and tourism (see Chapters 9 and 11). Land has been allocated for a variety of uses west of the Arnhem Land Aboriginal Reserve; the main ones are shown in Map 7 and described below. All tenures are leasehold.

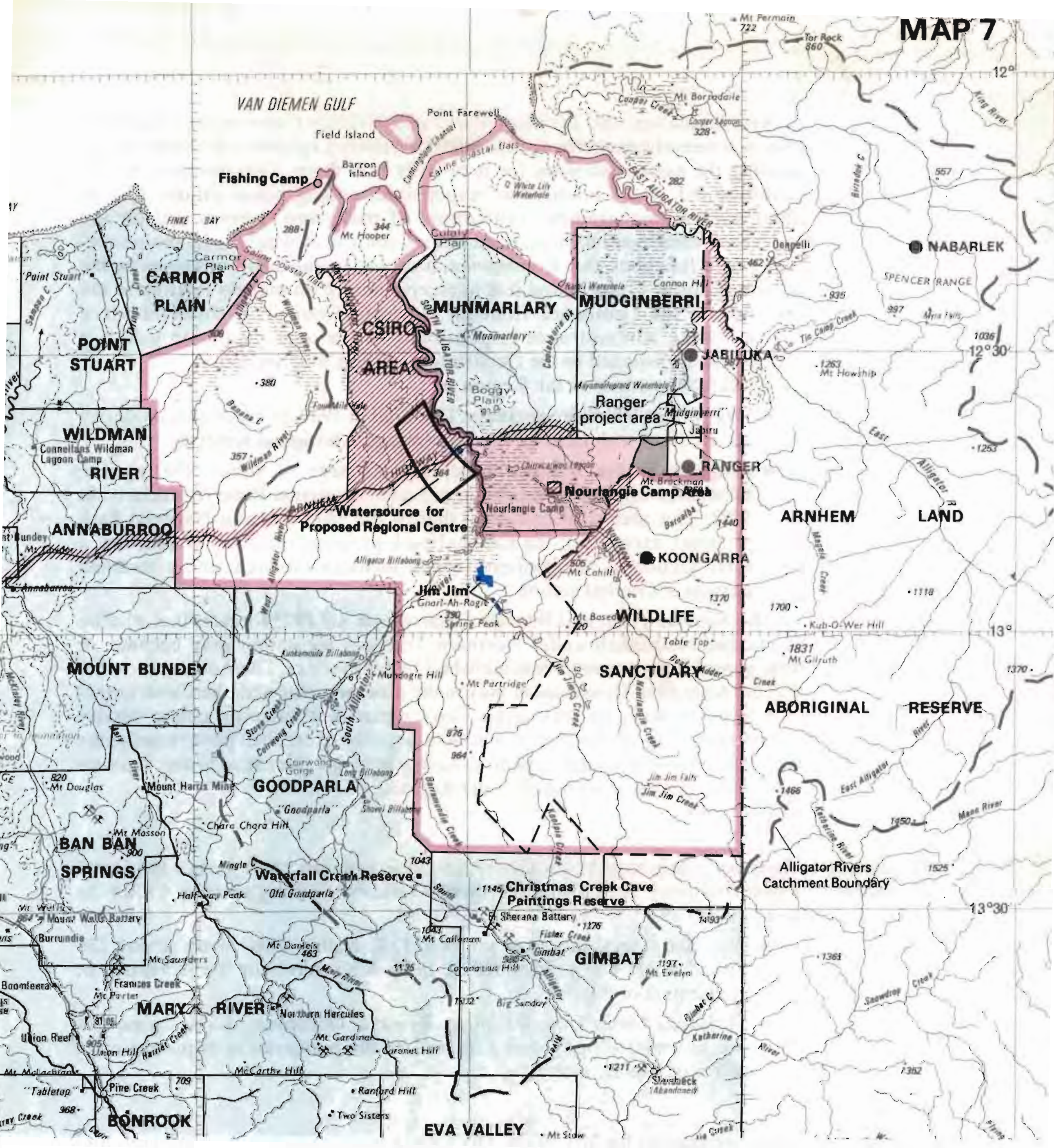
Woolwonga Aboriginal Reserve

This was declared in 1936 and revised in 1968. It covers 505 square kilometres. Aboriginal Reserves in the Northern Territory are reserved for the use and benefit of the Territory's Aboriginal inhabitants. Control is under the Director, Northern Territory Division, Department of Aboriginal Affairs, Darwin. Entry is normally prohibited to all non-Aboriginals except those, including public servants and police in the course of their duties, specifically exempted under the provisions of the Territory's Social Welfare Ordinance. Non-exempt persons may enter the reserves if they first obtain a permit; these are only issued with the approval of the Aboriginal communities involved. Legislation complementary to the *Aboriginal Land Rights Act* 1976, to be introduced into the Legislative Assembly of the Northern Territory, will affect entry into Aboriginal reserves (see Chapter 14).

Wildlife sanctuaries

People are not allowed to enter wildlife sanctuaries without approval, and firearms and traps are prohibited.

To date, sanctuaries have been declared or specified under the *Wildlife Conservation and Control Ordinance* 1962–1976. That Ordinance provides for the Administrator of the Northern Territory to appoint a Chief Inspector of Wildlife who, subject to the direction of the Administrator, is responsible for the administration of the Ordinance. Following the entry into force of the *Northern Territory (Administration) Act* 1976 on 1 January 1977, responsibility for administering that Ordinance rests with the Department of the Chief Secretary in the emerging public service of the Northern Territory.



Boundary of aboriginal land claims	Proposed town area
Special purpose lease	Woolwonga Aboriginal Reserve and Wildlife Sanctuary—now aboriginal land under Act of 1976
Protected areas under the Wildlife Conservation and Control Ordinance	Nourlangie Camp area now part of Woolwonga aboriginal land under Act of 1976
Pastoral lease	

SCALE

10 0 10 20 30 40 50 Kilometres

Present Land Use and Aboriginal Land Claims

NMP 76/221.17

New legislation, the Territory *Parks and Wildlife Conservation Ordinance* 1976, was recently passed by the Northern Territory Legislative Assembly and is awaiting the assent necessary for it to enter into force. This provides for the establishment of a Commission responsible, among other things, for the administration, management and control of parks and reserves and for the protection, conservation, management and control of wildlife. In the performance of its functions, that Commission is subject to any directions given by the Administrator in Council, and it is to receive advice on matters relating to the operation of the Ordinance from an Advisory Council. If this Ordinance receives assent, administrative responsibility for its implementation will, it is understood, be assigned to the Department of the Chief Secretary.

Wildlife sanctuaries in the Region are:

- Woolwonga Wildlife Sanctuary. Declared in 1969, its external boundaries are identical with those of the Woolwonga Aboriginal Reserve.
- Alligator Rivers Wildlife Sanctuary, an area of about 3290 square kilometres adjacent to the Arnhem Land Aboriginal Reserve, declared in 1972. This area corresponds to that of the 1975 Kakadu National Park proposal, except that the national park proposal includes, in addition, a small section of Mudginberri, which includes Jabiluka, and a resumed portion of Gimbat station.

The *National Parks and Wildlife Conservation Act* 1975 foresees that wildlife sanctuaries established under Northern Territory legislation may become, or form part of, a park or reserve established under that Act. The Act also provides that the Australian Government may make arrangements with the Government of a State or with an Australian Government authority or public service department for the performance of functions or the exercise of powers under the Act. This provision would appear to have particular relevance to any national park which may be established in the Region.

Scenic and historic reserves

These are proclaimed by the Governor-General under provisions of the *Crown Lands Ordinance* 1931 of the Northern Territory. Existing reserves within the Region are:

- Waterfall Creek (also known as U.D.P. Falls). This covers about 236 hectares, and was proclaimed in 1971 as a reserve for the recreation or amusement of the public.
- Christmas Creek Cave Paintings Reserve. Occupying 4.5 hectares, this was proclaimed in 1974 as a reserve for the preservation or protection of places of historic interest.

Pastoral leases

These are granted for fifty years. The Crown reserves rights to all minerals and the power of resumption:

- Mudginberri – 1106 square kilometres, lease granted in 1969. Seventy-six square kilometres are proposed for inclusion in Kakadu National Park under the 1975 proposal.
- Munmarlary – 1010 square kilometres, lease granted in 1969.
- Approximately 1161 square kilometres of Gimbat station – lease granted in 1962. The remaining 1835 square kilometres of Gimbat station are outside the Region. A 324 square kilometres area within the Region,

formerly part of this station, was acquired recently by the Commonwealth Government for inclusion in the proposed Kakadu National Park.

- Approximately 2345 square kilometres of Goodparla station – issued in 1961. The remaining 1356 square kilometres of this station are outside the Region.

The total area currently held as pastoral leases in the Region is 5622 square kilometres.

Mineral exploration and mining tenements

Exploration licences, which give their holders exclusive rights to explore for but not recover gold or minerals, covered a large part of the Region in 1973, including nearly all the area between the South and East Alligator Rivers. Since then, the number of licences and the area covered have been considerably reduced as a result of expiration, surrender, or refusal of renewal. The present position respecting most of the Region is shown in Map 15. No exploration licences remain within the boundaries of the land in the 1975 Kakadu National Park proposal.

Mining leases (gold-mining leases, mineral leases and special mineral leases) authorise the extraction of minerals. Mineral leases generally have a maximum area of 40 acres (16.1 hectares). Those which are current are located outside the boundaries of the 1975 park proposal in two general areas, one to the north of Woolwonga and the other to the south and west of the proposed park boundaries. The minerals which can be mined under them include uranium, copper, lead, nickel, zinc and cobalt. At present no mining operations are being carried on pursuant to these leases. Special mineral leases are used for major mining development projects requiring more than 40 acres, and up to a maximum area of 25 square miles (about 6500 hectares). Applications for special mineral leases have been made in respect of the Jabiru (Ranger 1), Jabiluka, Koongarra and Nabarlek uranium deposits (see map 15 and comments in Chapter 14). A number of gold-mining leases have been granted in the Region. So far as the Commission is aware, none are at present being worked.

Mineral claims and dredging claims are less secure forms of tenure authorising the extraction of minerals, but are only available to holders of miners rights. A small number of mineral claims and dredging claims have been granted in the Region. Tenements authorising activities other than extraction are also available to holders of miners rights, and a number of these have been granted in the Region, for example in relation to the Border Store at Cahill's Crossing (see Chapter 14).

Reserves from mining

Mining reserves are reservations of land from occupation under the Mining Ordinance and are designed to prevent both exploration and mining. A large proportion of the Region is now under mining reserves.

Town area

An area of vacant crown land between Woolwonga, Mudginberri, the Alligator Rivers Wildlife Sanctuary and the Ranger special mineral lease application has been under consideration for several years as a possible site for construction of the proposed regional centre. However, no area has yet been gazetted for this purpose.

Other land use in the area includes:

- a tourist camp and motel at Cooinda, also known as Jim Jim (Special Purpose Lease Numbers 146 and 147, each of which is due to expire in June 1994);
- a service station and roadhouse near Kapalga (Special Purpose Lease No. 397, which is due to expire in July 2025);
- a fishing base camp near the mouth of the West Alligator River (Occupation Licence No. 964, an annual licence current to 31 October 1977);
- a research area set aside for CSIRO north of Kapalga and between the West and South Alligator Rivers. This land has been declared a 'protected area' under the Wildlife Conservation and Control Ordinance (N.T. Gazette No. 28 of 9 July 1976).

Apart from the 'protected area' referred to above, 'protected areas' under the Wildlife Conservation and Control Ordinance in the Region include an area 1 mile each side of the Arnhem Highway as far east as the western border of Mudginberri station and areas near Nourlangie Creek and Cahill's Crossing.

Plate 3. A frieze of x-ray paintings of human figures and legendary beings in the Nourlangie Creek catchment area (photo: C. Christian).

4 ABORIGINALS OF THE REGION

The Region has been occupied by Aboriginals for at least 25 000 years, and probably much longer. The rivers and wetlands of the flood plains, the open forests and woodlands of the lowlands, and the sandstone gorges and plateaux provide a great variety of habitats and food resources. Before European settlement, the Aboriginals' lifestyle was dictated to a large extent by the wet–dry seasonal regime. Different parts of the Region provided food resources at different times and the seasons governed the ease of movement from place to place. The rock shelters and caves of the escarpments of the main plateau and outlying sandstone massifs provided protected shelters conveniently placed for exploiting all habitats. The Region is naturally productive, and a large portion of it was occupied until recently by a relatively large population of Aboriginals.

Relationship with the land

Of all the relationships traditional Aboriginal man has with anybody or anything, the most important is that which binds him to a particular tract of land which he refers to as 'his country'. This is a religious bond. The people have a spiritual relationship with the species and the physical features of their environment, expressed through the concept of the 'dreaming'.

Before the dreaming, according to Aboriginal lore, the land existed but was without shape or life. Then 'spirit beings', or 'dreamtime heroes', travelled over the land creating the natural environment as it now exists—the physical features and all living things including the people. The spirit beings also, according to tradition, gave the people their own tracts of land along with their languages and social institutions. Particular features of the landscape are believed to retain part of the spiritual essence of the dreamtime heroes who created them.

The spiritual relationship between the Aboriginals and the land is given emphasis in the belief that for a child to be born a spirit must first enter the mother's womb to give the child life. The spirit derives from one of the various sites associated with the dreamtime heroes. Consequently, there is a direct personal link between the spirit being, the child and the place from which the spirit came. That place is the source of the person's life force and he or she is inseparably connected with it. The spirit is part of the land, and therefore the land is very much a part of the Aboriginal. This relationship is not broken, even on death, as the Aboriginal's spirit returns to the site from which it first came.

While sites associated with the spirit beings are particularly important, all the land has religious significance for the Aboriginals; they believe it was formed and given life by the same dreamtime heroes who gave life to the people. They traditionally recognise and maintain a binding social relationship between themselves and the other natural species within their environment. This relationship and the kind of spiritual identification it involves is called totemic.

The personal and spiritual links with the land are expressed through membership of local descent groups, sometimes referred to as clans. The term local descent group was used by Mr Justice Woodward in the First Report of the Aboriginal Land Rights Commission (para. 37) to mean 'a subdivision of a dialect group larger than a family but based on family links through a common male ancestry, although those links may be back beyond living memory'. Such groups are referred to within the Alligator Rivers Region as gunmugugur.

Each gunmugugur has a spiritual relationship with particular sites and areas of land, the total of which is called an 'estate'. Each member of a gunmugugur is related to a particular estate jointly with every other member of the same gunmugugur regardless of sex, age, status or any other criterion. The relationship gives to the gunmugugur certain collective rights and responsibilities in respect of the estate and the sites it contains. Individuals have specific responsibilities and rights which, taken together, make up those of the gunmugugur. The members can be described, in European terms, as 'owners' of their estate. The entitlement of each gunmugugur to its own estate is understood as deriving from the dictates of the dreamtime heroes.

Traditionally, ownership of such an estate could not be taken away, given away, lost or abandoned. There was no reason to motivate, or mechanism which would enable, clan members to give it away or other clans to try to force them to do so. Gunmugugur did die out and the Aboriginal people, in order to meet the reality of this occurrence, evolved a means to ensure that an estate which became 'vacant' was succeeded to by an extant clan. A more detailed discussion of this subject is taken up in Chapter 15 under the heading *Succession*.

The senior adult members of a gunmugugur have, traditionally, special rights in making decisions about the use of land which they possess. However, such rights do not exclude the need for those leaders to consult with the members of other gunmugugur possessing land either adjacent to or near their own. In Western Arnhem Land, as in many other parts of the Northern Territory, a person has a 'managerial' interest in his maternal uncle's estate. Such an interest involves certain ritual responsibilities. In some cases traditional owners cannot visit certain important religious sites within their own estate without the prior approval of the 'managers', who are themselves members of a different gunmugugur.

There is also an economic relationship between the Aboriginals and the land. The people were hunters and gatherers, relying on the natural resources of the land and, where applicable, the rivers and the sea. The economic grouping was the horde or band, which was distinct from the religious unit, the gunmugugur. A horde might include a nucleus of members of the one gunmugugur (clan) but, as gunmugugur are exogamous (marriage partners must be found from other gunmugugur), it would also include people from other gunmugugur such as wives, mothers' brothers, mothers' mothers and so on. There would be a general coming and going of the people making up the membership of the horde.

Hordes of various sizes travelled over tracts of land which included the estates of more than one gunmugugur. The total area over which a horde travelled and which it exploited to satisfy both its economic and social needs is called a range.

The range over which the band travelled was variable and was largely determined by the membership at any time of the horde, the state of social relations existing between neighbours and the economic and social requirements of each horde.

The way in which the people of the Region exploited the land was dictated largely by the seasons. Foods such as fish, mussels, lily-roots and wildfowl were hunted and gathered during the dry season, when the coastal plains and estuarine waters were accessible. During the wet season the people retreated from the flooded plains to the margins of the escarpment, where they subsisted on a diet of yams, various marsupials, reptiles and other animals.

Sacred sites The sites with particular spiritual associations are commonly referred to as sacred sites. These may differ considerably in physical characteristics—they can be waterholes, rock formations, caves, shelters, hills or gorges—and in their degree of religious significance. Some contain rock and stone arrangements and rock paintings, but many have no marks at all to distinguish them from areas without special significance. Conversely, not all sites which have rock paintings or stone arrangements are necessarily of religious significance.

The religious sites are, in many cases, connected by what the Aboriginals believe to be the tracks or pathways made by the dreamtime heroes during their wanderings over the land at the time of creation. Traditionally, the Aboriginal people followed these routes as part of their ritual observances.

The sacred sites within the Region associated with spirit beings or dreamtime heroes are divided into two basic categories—those subject to secrecy, taboo, prohibition and danger (described as Djang Nadjamun), and those without these associations (described simply as Djang). Sites in both categories are found within the Region.

The Commission's attention was drawn to two sites of spiritual importance which it was stated were already endangered by activities associated with the Ranger company's program of mineral exploration. Both are associated with the Mt Brockman escarpment. The sites, known as Djidbidjidbi and Dadbe, were said to be Djang Nadjamun, and it was stated that Djidbidjidbi had already been intruded upon by non-Aboriginal people.

Alternating dark red/black and whitish vertical water flow marks on a perpendicular cliff face at the north-western tip of the Mt Brockman massif are said to represent the blood of the rainbow snake, a mythical being with great religious significance for many of the Aboriginal groups living in Western Arnhem Land. A very large boulder, about 10 metres high, which lies on the scree slope near the base of the cliff has a number of paintings, some of them faded, on several faces. The Djidbidjidbi sacred site comprises the high cliffs and the boulder-strewn area in front, including the painted boulder.

Dadbe is a rock hole on top of the cliffs, a short distance south-east of Djidbidjidbi. Said never to go dry, it is the permanent residence of the rainbow snake.

Sites connected with the rainbow snake are considered dangerous and are prohibited to most people. The commission was told that Aboriginals had expressed fears that splitting (killing) of the rocks either by prospectors' picks or the use of gelignite in the vicinity of Djidbidjidbi and Dadbe could bring on great disaster both for the Aboriginals and the white population in the Jabiru–Mudginberri area.

Archaeology and art A large number of sites provide evidence of Aboriginal occupation of the Region in the past. Archaeological material is well preserved and provides an opportunity for the study of lifestyles of the Aboriginal people in a varied environment over many thousands of years. There are more than 120 known archaeological sites within the Region, of which fifteen have been excavated.

These excavations have revealed evidence of the earliest human settlement in tropical Australia. Important discoveries include the world's oldest evidence for the technology of grinding stone for axes and an ochre-impregnated grindstone which establishes that pigments were being prepared at least 18 000 years ago, a date comparable with the Palaeolithic cave paintings of Western Europe. Other grindstones recovered from the same site provide inferential evidence for the earliest preparation in Australia of food by grinding.

It was stated that, important as these findings are, the amount of archaeological research carried out within the Region has been very limited. If research were to be increased it is anticipated that more findings of scientific importance would be made.

The information obtainable from occupation sites (i.e. sites used by Aboriginal people as shelters and camping sites) is supplemented by the more numerous and more widely distributed examples of Aboriginal art throughout the sandstone areas. The art consists mainly of ochre paintings, of which there are two main forms. The oldest, called Mimi art, consists of stick-like figures in one colour composed in tableaux illustrating hunting and other scenes. Much can be learned about prehistorical activities from this art. The other main form is multicoloured x-ray type paintings in which internal structures, as well as external shapes, are illustrated. Paintings played an important part in the traditional and daily life of the people, and many were painted and repainted as parts of rituals. Some represent activities or legends of periods in the distant past. Paintings of dreamtime figures have a sacred significance, as have others which record the people's belief in totemic beings and their power to invoke particular acts or to encourage the maintenance of food animals so that hunting may be successful.

The general locations of archaeological and art sites are indicated in Map 8. Archaeological sites of occupation are usually important art sites also, but art sites occur much more widely and are much more numerous. More than 380 art sites have been recorded and about 1000 more are known. Many are of excellent quality. From both the archaeological and art points of view, the Region is highly important.

Apart from their traditional and scientific values, archaeological and art sites could have considerable tourist and educational interest and be valuable components of a national park. The rock art is amongst the best in Australia, if not the world. Unfortunately, serious deterioration of both kinds of sites is occurring. Causes of damage include activities of buffaloes and pigs, water drainage and weathering, growth of plants, termite and wasp nests, pilfering of bones and artefacts and vandalism. Evidence was given that archaeological occupation sites composed of discarded wastes are generally not areas of major concern to Aboriginals, unless human bones within them are disturbed. As the traditional life of Aboriginals has been interrupted and partly destroyed by European occupation, they have tended to congregate around a few centres. A result is that little effort is now made to repaint paintings which have persisted through centuries because there were traditional responsibilities to repaint them.

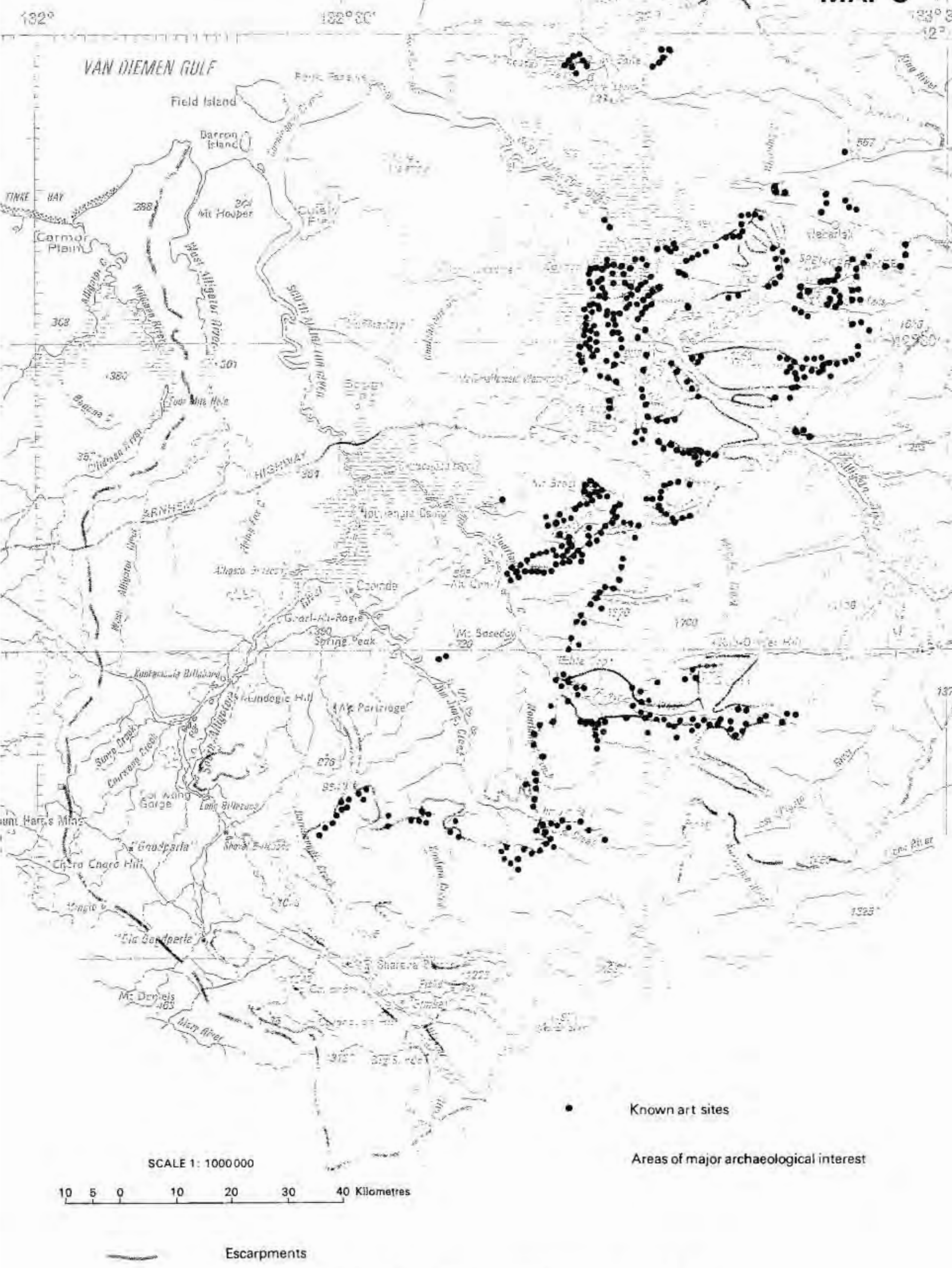
However, since archaeology has revealed information about their prehistory, Aboriginals have begun to appreciate the value of these sites in a new way. The belief was expressed during the Inquiry that, given the opportunity and responsibility, Aboriginal groups would again protect and preserve their art and archaeological heritage. This is discussed in Chapter 10.

Contact with non-Aboriginals

The evidence indicates that the Aboriginals in the Region have remained in physical and cultural isolation from other cultural groups until relatively very recent times.

Their first known contacts with outsiders were with fishermen from Macassa who made regular trips to the coastal waters of Arnhem Land for more than two centuries up to 1906 when a customs control point was established. They came in search of trepang, a sea slug, which the Macassans processed for sale to China

MAP 8



Aboriginal Archaeological Areas and Art Sites

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where it was highly prized for soup and as an aphrodisiac. A number of old Macassan camp sites have been discovered on the shores of the Cobourg Peninsula. The visitors brought with them such things as fish hooks, cloth, rice, metal knives, axes, the dugout canoe, tobacco and alcohol, all of which the Aboriginals readily adopted whenever they became available. Although these material aspects of Macassan culture did influence the lives of those who came in contact with them, it is believed that the fundamental basis of Aboriginal society remained undisturbed.

Two attempts to establish European settlements on the Cobourg Peninsula, north of the Region, were made in the first half of the nineteenth century—at Raffles Bay (1827–29) and Port Essington (1838–49), and there is little doubt that contact took place between the Aboriginals and European settlers. Ludwig Leichhardt, during his mammoth journey from Moreton Bay to Port Essington in 1845, claimed to have met a few Aboriginals in the East Alligator River area who could speak some English, which he assumed they had learned as a result of contact with the early settlers. However, as both settlements were short lived, it is unlikely that there was major disruption to the Aboriginals' way of life.

In 1863 the Northern Territory was annexed by South Australia, and the port of Palmerston, now Darwin, was established in 1869. With the building of the overland telegraph between 1870 and 1872, and the development of Pine Creek goldfields at about the same time, the population of Europeans and Asiatics grew quickly, as did the frequency of contact between Aboriginals and the new settlers. Some of the Aboriginals came from the Region, drawn no doubt by curiosity and a desire for tobacco and alcohol.

During the 1880s European intrusion into western Arnhem Land became more common, with the advent of buffalo hunting. Buffalo hunters operated mainly in the area between the South and East Alligator Rivers, from mobile camps comprising one or two Europeans and a number of Aboriginal assistants and their relatives. The best known of these hunters was Mr Paddy Cahill, who eventually took up a pastoral lease at Oenpelli in 1906 and remained there until 1916.

The contact between the Aboriginals and the colonisers during the latter part of the nineteenth century and the first two decades of the twentieth century proved to be of major consequence to the Aboriginal people of western Arnhem Land. Their numbers decreased in a dramatic way, due largely to the spread of diseases including tuberculosis and leprosy. An official report at the turn of the century records that of 190 members of one particular group 130 died over a six-year period.

As a response to the deleterious effects of contact on the Aboriginal population, the West Arnhem Land Reserve was proclaimed in 1920. This was incorporated into the larger Arnhem Land Reserve in 1931, an area now of 96 089 square kilometres.

In 1925 the Church Missionary Society established a mission at Oenpelli. As a result the Aboriginals were confronted, for the first time, with a deliberate program of social change. This program has continued for some fifty-one years and has had a major influence on the lives of the Aboriginal people in the area. The mission, with an initial staff of two Europeans, commenced operations by establishing a church and a school.

From the mid 1920s to the mid 1960s a pattern of migration developed around Oenpelli. Initially Aboriginals, primarily from areas to the east, visited the mission for brief periods and then returned to their own land to continue their nomadic existence. Gradually, however, the visits became more prolonged. The groups moving in from the east and south-east were not opposed by the traditional owners of the land around Oenpelli, and these visitors soon constituted the majority of the people living at the mission.

Early contact motivated many people whose traditional estates of land lay between the East and South Alligator Rivers to move west to the centres of population established along the Pine Creek to Darwin railway, and some chose to remain there. Later, during World War II, many descendants of these same groups were housed in Army camps along the Stuart Highway, and chose to remain in that vicinity after 1945. As a consequence of the population movements, many of the people now living in the Region do not claim to be the traditional owners of land within the area. However, a number of residents of the Region do lay claim to tracts of land there, as do a number of Aboriginals living outside the Region. Some residents and non-residents claim entitlement by Aboriginal tradition to use and occupancy of the land, without claiming ownership.

More recently, increased contact between the Aboriginals and non-Aboriginals has resulted from the development of the Mudginberri and Munmarlary pastoral leases, from increased activity associated with mineral exploration and mining developments within the Region, and from the increased number of tourists now coming into the Region as a result of the upgrading of the Arnhem Highway, which places Darwin only four hours' travelling time from the East Alligator River.

The Aboriginals today

Today about 800 Aboriginals live in the Alligator Rivers Region, about 600 of them at or near Oenpelli. It is estimated that about sixty-five Aboriginals live at Mudginberri and forty-four in the vicinity of Jim Jim. A family group lives at Nourlangie, and there is another group at the Pensioners Camp close to Cahill's Crossing on the East Alligator River. The Commission was told that up to fifty-four Aboriginal people have lived at Jabiru, but that numbers there have decreased in recent times. There are no Aboriginals known to live in the catchment of the Wildman River.

In addition to the 800 or so permanent residents, there are a number of Aboriginals who travel to the Region every year, especially during the dry season. They come from centres such as Katherine, Pine Creek, Darwin, Croker Island, Goulburn Island and Maningrida.

The people living at Oenpelli are from a number of groups, but are collectively referred to today as the Gunwinggu people. Gunwinggu is the name of the language spoken by a group who migrated to Oenpelli from areas further to the east. Some of the groups residing at Oenpelli are related to one another by marriage, but many of them speak different dialects and languages.

The civic affairs of Oenpelli are directed by the Gunbalanya Shire Council under the Chairmanship of Mr Silas Maralngurra. The Council is made up of representatives of the various groups living at Oenpelli. Over the past four years, government policies have encouraged Aboriginal Councils to assume greater responsibility for decision making on matters affecting the administration and control of communities. Whereas previously government funding of the Oenpelli community was channelled principally through the Church Missionary Society, the recipient of these funds is now the Gunbalanya Council. This entails the management and control of large sums of money by the Aboriginal people and an increase in the degree to which they are required to be involved in the administration of fiscal matters. The Council is the major employer of Aboriginals in the town, and it also employs a number of advisers.

The increasing responsibilities of Oenpelli's Gunbalanya Council, along with increased pressures for decisions to be taken in respect of mining, building programs, town management, social affairs and programs being developed by other government agencies, have placed considerable strain on its members. Doubt was expressed to the Commission about the effectiveness of this Council at present, owing to the fact that many of its members do not attend meetings or involve themselves in council matters. Two reasons given for this breakdown were that members were withdrawing from a source of pressure which was becoming an increasing burden for them and that some members, along with a large part of the Oenpelli community, were preoccupied with drinking alcohol. The reality appears to be that the European staff members continue to carry a large degree of responsibility for decision making and administration at Oenpelli.

The Aboriginals living at Mudginberri have no formal council and have little say in matters relating to the running of the station. An attempt has been made to establish an incorporated association there, mainly for the purpose of receiving government grants. However, due to the movement of people from Mudginberri during the latter part of 1976, the association no longer operates.

Traditional institutions continue to play an important role in the Aboriginals' conduct of their social affairs. The Commission received a considerable amount of evidence indicating that for the most part the Aboriginal people in the Region continue to regard the land in accordance with their traditions. The people, especially the middle-aged and elderly, continue to express their concern for the land and the sacred sites it contains, and they retain a belief in the religious relationship which binds them to the land. Practices associated with religion and ritual observance have been to some extent subdued, but knowledge of and belief in traditional religion continues to manifest itself in the lives of the people, particularly during times of crisis.

Concern was expressed by Aboriginal witnesses about the possibility of sacred sites being entered and desecrated by people who might be attracted to the Region as a result of the proposed mining ventures. They said desecration of certain sites had already occurred, causing disquiet amongst the Aboriginal population. There is no doubt that they feel deeply about such matters, and that to a very large extent their traditional beliefs and values continue to have real meaning to them.

Evidence was also received which indicated that the Aboriginal people in the Region continue to rely to a significant extent on natural sources of food. Aboriginal witnesses said that, although they ate western-type foods purchased from stores or canteens, they continued to consume substantial amounts of their traditional foods because they could not afford to live solely on bought foods, western foods were not always available, especially during the wet season, and they had a distinct preference for certain varieties of 'bush tucker'.

Today game is seldom hunted by traditional methods. The Aboriginals use rifles and shotguns and travel in motor vehicles. Although the new methods give the Aboriginals greater mobility and access to traditional hunting areas, there is no evidence to suggest that their use of firearms and vehicles is having a detrimental effect on the fauna populations of the Region. This arises principally from the fact that the Aboriginals are dispersed over a wide area and limit their hunting activities mainly to obtaining their own food supplies.

Employment

Oenpelli provides the greatest range of employment opportunities for the Region's Aboriginal people. A number of non-government organisations and government agencies operate within the community, all of which can provide employment for the Aboriginals. Non-government organisations, some of them subsidised by government grants, include the Oenpelli Housing Association, the Gunbalanya Shire Council, the Oenpelli store, the Church Missionary Society and the Gunbalanya Meat Supply. Government agencies include the Departments of Health and Education. Under-utilised opportunities exist for employment as slaughtermen, pastoral workers, builders, mechanics, municipal workers, bus and truck drivers, clerks, shop assistants, storemen, market gardeners, plant operators, teachers and teaching assistants.

At the Mudginberri pastoral station opportunities exist for slaughtermen and meat packers, stockmen, vehicle and truck drivers and general labourers. The mining companies, Ranger, Pancontinental and Queensland Mines, currently provide some employment opportunities. In general, Aboriginals prefer work in connection with vehicles and moving plant to other work.

Mr P. Carroll, of the Oenpelli Mission, gave us figures showing that, as at 30 June 1971, 81 per cent of the Oenpelli workforce were employed, at least part time. The situation is now very different. The evidence shows that only a small minority of the potential workforce seeks any form of stable employment. Most remain unemployed. A number of witnesses, both black and white, stated that the reason for this situation was not that the Aboriginal people lacked the skills needed to perform employment tasks but that the large majority of those who could work showed no disposition to do so and instead spent most of their time in acquiring and drinking alcohol or recovering from its effects. Other witnesses suggested that some Aboriginals were not motivated to engage in regular work in European-type enterprises but were more interested in developing their own ventures in decentralised communities (these are discussed later in this chapter). Mr Carroll told us that Aboriginals were not particularly keen to work for wages, and nearly always gave the performance of ceremonials a higher priority. He also regarded consumption of alcohol as a principal reason for the decline in employment.

Education

Primary schools, run by the Department of Education, operate at Oenpelli, Jabiru and Mudginberri. Most of the Aboriginal children attending school do so at Oenpelli, where some 200 to 240 children are enrolled. The Commission was told that over the past two to three years there has been a falling away in attendance and that average attendance figures for the Oenpelli school are now only about one-quarter of the enrolment figures.

A great deal of concern was expressed by witnesses about declining school attendance, and various explanations were offered. Some witnesses suggested that the school curriculum was not relevant to the economic and social realities of the Aboriginal students, or that the school leavers saw no 'pay-off' from going to school. Others suggested that the decline was largely due to the impact of alcohol on the Oenpelli community. One witness who held such a view gave evidence to the effect that during a period in July 1975 'the daily attendance during the week was eleven teachers and seven children'. The children, he thought, were too tired to attend school as a result of night-time disturbances caused by excessive alcohol consumption or because they were taken into the bush by their parents to escape the disturbances. Another view was that the fall in attendance figures may be due principally to the growing trend in Arnhem Land for Aboriginals to move away from established population centres. It is probable that all these factors contribute to declining school attendance.

The Commission received no evidence on the numbers of Aboriginal children attending the schools at Jabiru and Mudginberri, but they would be very few.

Some students, after completing their primary education, attend Kormilda Residential College in Darwin where Aboriginal children receive post-primary education up to a standard which enables them to enter a high school in Darwin. In 1973 thirteen boys from Oenpelli attended Kormilda. In the first term of 1974 twenty-four boys and four girls attended, but only six boys remained by the end of the third term. Of these, only two attended high school in Darwin. In 1975 accommodation was limited at Kormilda due to Cyclone Tracy, and only high school students were enrolled. Three children from Oenpelli, one girl and two boys, attended high school during 1975. Very few children from Oenpelli have completed their secondary education.

The evidence indicates that vocational training courses available to Aboriginal school leavers are extremely limited. The Commission was not made aware of any formal program into which Aboriginal school leavers could be channelled to pursue training in any trade. The only training currently available seems to be that provided on the job and, given the low level of employment among Aboriginals in the Region, the reality is that very few, if any, Aboriginal youths are at present undertaking any form of vocational training. The Commission is not aware of any Aboriginal in the Region who has completed a recognised apprenticeship, or of any currently employed as an apprentice.

Health

Health facilities available to the Aboriginal people within the Region consist of a health centre at Oenpelli and a temporary clinic in a house at Jabiru, where a registered nursing sister is stationed. In addition, the area is serviced regularly by the Northern Territory Aerial Medical Service.

The Commission was told that a sixteen-bed hospital had been planned for Oenpelli, but the settlement's health complex would now be developed only as 'a primary treatment facility' and any patients requiring full hospital treatment would continue to be evacuated to Darwin. The present Oenpelli facility is manned by one Aboriginal health supervisor and a team of Aboriginal nursing aides. No fully qualified nursing personnel are employed there, but regular visits are made by a doctor and nursing sisters from Darwin or Maningrida attached to the Northern Territory Aerial Medical Service. The Jabiru and Mudginberri facilities provide only primary treatment, and people requiring hospital treatment are evacuated to Darwin.

No substantive evidence on morbidity or mortality rates for the various communities was received. However, the Commission was told that Oenpelli has a relatively high incidence of leprosy compared with other parts of the Northern Territory. Approximately 25 per cent of the Aboriginal population has been treated for leprosy over the years that the Church Missionary Society and Department of Health have been operating in the area. Frequent checks are made by the Department of Health to evaluate the health of those previously treated and to detect new cases.

Decentralised communities

A number of witnesses referred to a growing trend for groups of Aboriginals to move away from established centres of population administered by government or mission authorities, mainly those on Aboriginal Reserves, and to establish themselves in country with which they have traditional affiliation. These 'decentralised' groups attempt to resume a more independent existence free from the social tensions and stresses of the larger multitribal communities. Mr

Carroll provided us with a history of this development in West Arnhem Land. He said that, in the dry season, there are currently about 200 Aboriginals in outstations within 16 kilometres of Oenpelli and another 200 if those in the vicinity with links with Maningrida are taken into account.

In the Region six groups have settled in permanent camps away from the established centres of population. In addition a number of temporary outstations have been established which are evacuated in the wet season. Two of these latter are between Oenpelli and the East Alligator River. Some of the groups use Oenpelli as their base and supply centre and are serviced by light aircraft and vehicles from Oenpelli. The Aboriginals living in these smaller communities have shown that they are able to establish greater control and enforce discipline within the group more readily than in the larger and less traditional communities found on settlements and missions. Those living in decentralised communities also rely more heavily upon traditional foods for their subsistence, although flour, sugar, tea and tobacco are supplied in some quantity.

The decentralised groups depend for their income largely on social service payments such as age pensions and family allowance payments, contributions from relatives who are earning wages, and the sale of artefacts, fish or meat. The Federal Government has provided establishment grants to some of these communities to assist them in building living quarters and obtaining facilities such as water reticulation, transport and radio communications.

Alcohol

Evidence placed before the Commission left no doubt that excessive consumption of alcohol by a large proportion of the Aboriginal people in the Region is having a deleterious effect on their general welfare. The Commission was left with the clear impression that the future of these people will depend in large part on removing or substantially reducing the causes of this problem.

The Commission's attention was drawn to the many inquiries conducted and reports written over the years in relation to alcohol and its abuse within the Northern Territory. There are in fact references to twenty-one such reports contained in the library of the Department of Aboriginal Affairs in Darwin.

A particular report whose importance was emphasised is that of a Board of Inquiry on the Liquor Laws of the Northern Territory. This report, known as the Adams Report, was completed in 1973. One of the Board's conclusions was 'that in particular the health, living conditions and economic circumstances of the Aboriginal section of the population are being adversely affected by excessive consumption of intoxicating liquor'. The Board of Inquiry made a number of recommendations which it believed would assist in the amelioration of the serious situation it found to exist. These recommendations have not been implemented.

It is clear from the evidence that, in recent times, the increased income of the Aboriginals, resulting from the payment of award wages and the increase in social service benefits, has been a factor in the escalation of the alcohol problem.

Aboriginals in the Region obtain alcohol mainly from the Border Store at Cahill's Crossing which is immediately adjacent to the Arnhem Land Reserve, from the Cooinda Motel at Jim Jim, and from Darwin via charter aircraft and road vehicle. Of these three outlets, the Border Store seems to supply the largest quantity of alcohol, in the form of beer, to the Aboriginal population. Located only 17 kilometres from Oenpelli, it is the closest outlet to the largest population centre. The store has been licensed to sell alcohol since 1969.

Plate 4. Oenpelli early in the wet season (photo: P. J. Carroll).

The Commission was told that operation of the Border Store has had a very serious impact on the welfare of all Aboriginal communities in the Region. The Oenpelli Council opposed the granting of the store's licence in 1969, but its objection was overruled by the Northern Territory Licensing Court in Darwin. A subsequent objection by the Oenpelli Council to renewal of the licence was also overruled in 1974.

The Licensing Ordinance was amended in November 1976 to add a ground of objection to the renewal of a storekeeper's licence, 'that the quiet and good order of the neighbourhood in which the premises are situated has been, or will be, disturbed by the renewal of the Licence'. This might give a greater opportunity to future objectors to renewal of the Border Store licence.

The Commission received evidence which indicated that, as a result of alcohol being taken back to Oenpelli by Aboriginals, drunken and disorderly behaviour ensued, and the resulting violence, noise and bad language disrupted and upset the community. We were told that women and children were apathetic and demoralised as a result of nights of sleeplessness and drunken brawls. In the past six years five people had died as a result of events stemming from excessive drinking. Many others had been injured and required evacuation to Darwin. Motor vehicles and other property had been extensively damaged, and a general air of despondency had overcome the community.

During the wet season, access to the Border Store from Oenpelli is cut off by flooding of the East Alligator River. The Commission was told that problems associated with alcohol decrease significantly during this period.

Following an amendment to the Northern Territory Licensing Ordinance in 1963, Aboriginals were granted the same legal rights as other Australians in respect of the consumption of liquor. It remained an offence, however, to take liquor on to an Aboriginal reserve unless a permit to do so had been obtained from a Welfare Officer who had been declared under the Licensing Ordinance to be a person in charge of the reserve. The Commission was told by a representative of the Department of Aboriginal Affairs that, for a period of time, there was discrimination against Aboriginals in the administration of the permit system. It was common for Europeans employed on or visiting reserves to be granted permits, but only on rare occasions were Aboriginals granted permits even though a number of applications were received from Aboriginal people. More recently, with government policies emphasising 'self-determination' and 'self-management', the decision to allow alcohol on to reserves has to a greater degree become the responsibility of the Aboriginal people. The actual authority for the issue of permits continues to rest with the Welfare Officer in charge of the reserve, but permits are now issued only on the advice and with the approval of the Aboriginal Councils.

During the 1975–76 wet season the Aboriginal people, through their Council, applied to the Department of Aboriginal Affairs for a permit which would allow them to take alcohol on to the Aboriginal Reserve at Oenpelli. This was granted, and alcohol was taken to Oenpelli by aircraft chartered by the people themselves. However, because of the cost and method of transport, the amount of alcohol available to the people was still considerably less than that available during the dry season.

The evidence points strongly to the conclusion that alcohol abuse is a major cause of the low employment and school attendance figures for Aboriginals in the Alligator Rivers Region. So far as employment is concerned the Commission was told that, if it were not for the alcohol problem, the Aboriginal people at Mudginberri could constitute 80 per cent of the station's total workforce as opposed to the present 12 per cent.

Evidence received suggests that attempts have been made by Aboriginal communities to combat the problems associated with alcohol. In the Gove area arrangements have been made, on occasions, between leaders of the Aboriginal community at Yirrkala and the licensee of the hotel at Nhulunbuy whereby temporary restrictions have been placed on the sale of liquor to Aboriginals during important Aboriginal ceremonies, most notably those associated with death.

The Aboriginal Council at Croker Island has placed a ban on the importation of any liquor on to the island. This restriction applies to all people, black and white. Although the ban caused initial adverse reaction on the part of certain non-Aboriginal bodies whose members or employees were required to work on the island, the ban is still in effect and accepted by those living and working there.

Dr H. C. Coombs, who was at the time of giving evidence Chairman of the Council for Aboriginal Affairs, told the Commission that his Council had been approached by Aboriginal leaders at Yirrkala seeking increased authority, and increased backing from the law enforcement authorities of white society, to enable them to impose greater discipline in relation to alcohol on their own people. Dr Coombs said certain proposals were now being studied by the Department of Aboriginal Affairs and the Attorney-General's Department.

Those giving expert testimony were unanimous in their belief that, whatever action was taken to mitigate the deleterious effects of alcohol, the initiative in some part at least should come from the local communities themselves. This is not to say that the responsibility for resolving these problems rests solely with the Aboriginal communities. It will be necessary to support the various initiatives taken by Aboriginal groups, and to minimise pressures arising from contact between Aboriginals and white Australians, if the Aboriginals are to have any success in dealing with this most disruptive and debilitating social problem.

More recently a report entitled *Alcohol Problems of Aboriginals—Northern Territory Aspects* (1976) by the House of Representatives Standing Committee on Aboriginal Affairs again drew attention to the very serious problems associated with alcohol abuse currently facing the Aboriginal people. The Committee stated (p. xi): 'Alcohol is the greatest present threat to the Aboriginals of the Northern Territory and unless strong immediate action is taken they could destroy themselves'.

Conclusions

The Aboriginals are the largest ethnic group in the Region, and the only one considering the area their permanent and only home. Most continue to hold values and beliefs consistent with traditional Aboriginal society and continue to recognise a religious relationship with the land. The Aboriginals continue to hunt game and gather foods, but their lifestyle is more sedentary than in traditional times.

While there are many unutilised employment opportunities in the area, only a small minority of the employable adults are in fact employed; the preoccupation of many with the consumption of alcohol is a major factor contributing to the low employment rate.

Primary schools are available, but are poorly attended by Aboriginal children. This is due in part to the results of alcohol abuse and the movement of Aboriginals away from established settlements, and may possibly be due to some extent to inappropriate curricula.

Increasing numbers of the people are moving away from the established centres of population to set up their own communities in areas with which they have traditional affiliations. This trend is expected to continue.

The Aboriginals are faced with programs involving rapid social change, and these are causing a great deal of concern and difficulty for the people. The Gunbalanya Council is on the verge of breakdown, and increasing numbers of people are seeking refuge from the growing tensions and pressures either by withdrawing from contact situations (decentralisation) or by seeking relief through the consumption of alcohol.

The Aboriginals of the Region are a depressed group whose standards of living are far below those acceptable to the wider Australian society. They are a community whose lives have been, and are still being, disrupted by the intrusions of an alien people. They feel the pressures of the white man's activities in relation to their land. In the face of mining exploration, and the threat of much further development, they feel helpless and lost. Their culture and their traditional social organisation do not enable them to cope with the many problems and questions to which this development gives rise. They feel harassed by all the people who have descended upon them in recent times in connection with mining proposals. Their custom is to arrive at important decisions after long deliberation among themselves, sometimes over a period of months or even years. In relation to matters outside tribal tradition, they have not delegated authority to make decisions to any one or more persons. They do not consider the proposed developments as being advantageous to them, as their concerns and values are different from those held by the white man. Their position is perhaps best described in the following words of an Aboriginal leader, Mr Silas Roberts, who was chairman of the Northern Land Council before the Aboriginal Land Rights Act was proclaimed and who is now chairman of the Council of the same name constituted under the Act:

> It is true that the people who are belonging to a particular area are really part of that area and if that area is destroyed they are also destroyed. In my travels throughout Australia, I have met many Aborigines from other parts who have lost their culture. They have always lost their land and by losing their land they have lost part of themselves. By way of example, they are like Christians who have lost their soul and don't know where they are—just wandering. We in the Northern Territory seem to be the only ones who have kept our culture.
>
> We are worried that we are losing a little bit, a little bit, all of the time. We keep our ceremony, our culture, but we are always worried. We still perform our ceremonies.
>
> We are very worried that the results of this Inquiry will open the doors to other companies who also want to dig up uranium on our sacred land. There are so many I find it hard to remember them all but I can remember Ormac, Queensland Mines, Union Carbide, Reynolds Mining, B.H.P. and Pancontinental. We think if they all get in there and start digging we'll have towns all over the place and we'll be pushed into the sea. We want a fair go to develop. We are human beings, we want to live properly and grow strong.
>
> We see white men as always pushing. We know white men think differently from us, and they are not all bad. But even this Commission is pushing in its own way. I must explain this because it is very important that our difficulty in this is understood. The trouble is the Aborigines did not run their business the same as the white men. We did not and do not reach decisions in the same way. Our people are not as free to make decisions and give evidence as white men seem to be. If you add to this that most Aborigines are very frightened of white men; you will have a lot of trouble getting much straight talk from Aboriginal people and you will have a lot of trouble getting them to come back to give evidence more than once. These problems are always faced by our field officers. Let me explain a little bit more. We have got to make decisions in respect to land our own way.
>
> It is a long hard road to final answer. Sometimes a person or group will say 'yes' then talk a little bit more and then say 'no'. Then more talk might take place after a few months and still no final answer. Then all the people who really belong to that country will go over it all again until everyone is sure of his answer and then the answer is given. That may be years after the first talks if the question is a hard one.

Plate 5. Hunting scene on a wall of a shelter near Obiri Rock (photo: C. Christian).

Plate 6. A wet season storm over the South Alligator River flood plain near the Arnhem Highway (photo: G. Kelleher).

Plate 7. The Arnhem Land plateau escarpment, near Jim Jim Falls (photo: Australian Information Service).

5 NATURAL FEATURES OF THE REGION

One of the most notable features of the Region is the great variety, in a relatively small area, of land forms, vegetation and animal life. Each of the main subregions, the plateau, lowlands, flood plains and tidal flats (see Map 4), is quite unlike the others, and there is considerable variation within them. The climate increases the diversity–large areas, most notably the flood plains and lowlands, take on a quite different appearance when the wet season follows the months without rain.

This diversity, as well as making the Region so interesting, complicates the problem of assessing the impact of any man-made disturbance to the environment. For example, assessment of the effects of pollutants discharged into streams has to take account of the fact that streams which flood over the surrounding countryside in the wet season stop flowing towards the end of the dry season. Studies in recent years, notably the Alligator Rivers Region Environmental Fact-finding Study, have built up extensive inventories of the Region's plants, animals, soils, rock types and so on. But much less is known about the interactions between them, which constitute the regional ecology and which could be disturbed by developments.

We begin this chapter by briefly describing the natural features of the Region as a whole. Then we look in more detail at Magela Creek and its catchments, the area where any impacts from water pollution from the Ranger development would be felt, and assess the adequacy of existing information for predicting the effects of this pollution. The chapter ends with an outline of the possible ecological effects of the developments proposed for the Region.

The plateau This is a massive sandstone formation, nearly 2000 million years old. It once covered a much larger area, but erosion over the millenia has caused its escarpment to retreat gradually in a south-easterly direction to its present position, leaving some outliers.

Much of the plateau is made up of bare rock or thin soils with a scanty cover of spinifex and shrubs. There are also areas of deep sandy soil supporting tall forests of eucalypts, and rugged areas in which grows an interesting type of rain forest, thought to be a relic of a past climatic era.

The plateau contains some spectacularly scenic areas, with rock pools, deep gorges and waterfalls. Many of its sandstone cliffs and caves have been used by Aboriginals as galleries for their paintings.

The lowlands The retreat of the plateau with erosion uncovered some ancient rock formations which now outcrop or underlie the soils of much of the lowlands. The major uranium deposits so far discovered in the Region are associated with two of these, known as the Koolpin and Cahill (or Koolpin Equivalent) Formations (see Map 9). The present land surface has been formed by erosion, deposition of eroded materials and other processes including widespread leaching to form laterite.

The lowlands are somewhat monotonous scenically. Most parts are undulating, and there are low hills and ridges. Most of the soils are sandy or loamy, and are highly susceptible to erosion if disturbed. A few have a cover of gravel or rocks which protects them from erosion. The lowland vegetation is mostly open eucalypt forest or woodland, or scrub. Tall grasses, reaching heights of 2 metres or more in the wet season, are the main ground cover over large areas. Fire passes through much of the lowlands each dry season, and most of the vegetation is adapted to regular burning.

The flood plains These were probably formed by material deposited in river estuaries, which then emerged from the water as a result of a rise in the land surface or a drop in sea level. Heavy clay covers most of these plains, and deep cracks form when it dries out after the floods retreat.

Small variations in surface height result in considerable variety in the flood plain vegetation. The highest parts, flooded for shorter periods each year than lower areas, are covered with sedges and grasses. The lowest parts, most of which are at the edges of the plains, are permanently inundated. Many support paperbark forest. Between these two are swampy areas where a variety of aquatic plants, including sedges, reeds, waterlilies, large and small algae, wild rice and other grasses, grow profusely in the wet season.

The flood plains are the main habitat for the Region's abundant waterfowl. They also provide pastures and wallowing grounds for buffaloes, and many swampy areas have been heavily overgrazed. The buffaloes use the higher sedge and grass areas more as a refuge than as a grazing ground because the sedges are generally unpalatable to them. The buffaloes' preference for the grasses in these areas has probably altered the balance between sedges and grasses, favouring the sedges.

The flood plains have much scenic value in both the wet and dry seasons. In the wet season the vast expanses of water and the lush growth and variety of the vegetation are notable features. In the dry season vast numbers of birds congregate around the remaining wet areas. More than 120 species, mostly water, sea and wading birds, have been recorded.

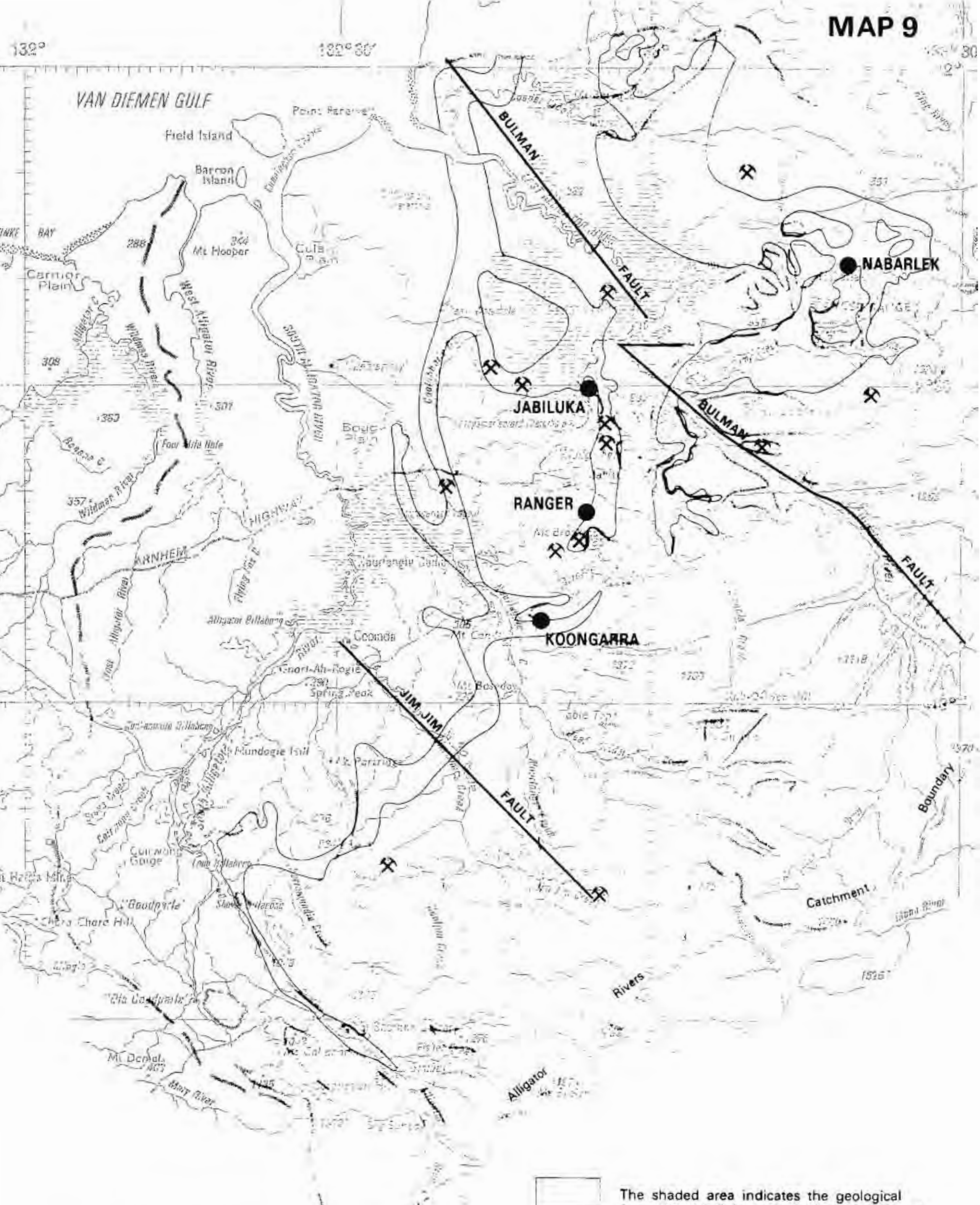
The tidal flats These consist of marine clays and muds and some low beach ridges with coarse sandy soils. Most parts are regularly inundated by sea water. Their vegetation is mostly sedge and salt-tolerant, fleshy samphire, but there are also areas of mangroves, and a rare and interesting type of semi-deciduous forest grows in some parts which are not inundated.

Vegetation The Alligator Rivers Region Environmental Fact-finding Study recorded 954 species of plants, an unusually high number for a region the size of the study area. Many more probably remain unrecorded, because species in less accessible parts, particularly the plateau and some permanently wet areas, were not collected as thoroughly as those of other areas.

Some species were not known previously, but they are not necessarily restricted to the Region. More than half the species are found only in Australia, and about one-third of those are confined to the Northern Territory. The aquatic plants are particularly diverse and interesting.

The Region is notable for its present relative freedom from introduced species, especially in aquatic habitats. The introduced species *Hyptis suaveolens*, commonly called horehound, is probably the main weed in the lowlands. It has become established in areas where vegetation has been disturbed. Depending on one's point of view, the Para grass planted on the flood plains and the Townsville Stylo planted in lowland pasture areas may be regarded as weeds or as pasture-improving species.

MAP 9



SCALE 1 : 1 000 000

10 5 0 10 20 30 40 Kilometres

Uranium prospect sites

Escarpments

Major uranium deposits

The shaded area indicates the geological formation (Koolpin or equivalent) considered to have prospective value for uranium

The darker sections, in which the most important discoveries are located, are considered to have the greatest prospective value

Elevations in feet

Prospective Areas for Uranium Exploration

NMP 78/221.13

Two particularly interesting plant communities, both restricted to small areas, are the rain forests and semi-deciduous forests near the coast. Both are relics of earlier times.

The Region's main vegetation groups are listed in Table 5, and their distribution across the subregions is shown in Figure 3.

Animal life

The Commission was told that the native mammals, birds, reptiles and frogs of the Region are the biologically richest groups in the Northern Territory and are matched in Australia only in some areas of north-eastern Queensland. Fifty-one species of native mammals were identified during the Fact-finding Study, and 273 birds, seventy-five reptiles and twenty-two frogs.

Some species are very rare. Many are found only in northern Australia and some only in Arnhem Land. Few species, if any, are restricted to the Region, but some subspecies or forms may be.

The swamps, rain forests, mangrove areas and escarpments are the most notable areas for diversity of bird life and for species restricted to the Region and adjoining areas. The swamps are also important for frogs and reptiles. Small creeks and rock holes around the escarpment are refuges for frogs and reptiles during the dry season in the way that the swamps, especially in the South Alligator River catchment, are for water birds. Escarpment areas are also the homes and foraging grounds of many mammals.

Table 5

The Main Vegetation Communities in the Region

Plateau	Sandstone scrub—mixed, with many legumes and myrtaceous species. Sandstone woodland—eucalypt woodland with sandstone scrub understorey. Sandstone rain forest—dominated by a newly recorded myrtaceous tree species, but often mixed with other non-eucalypts. Occupies a total of about 500 square kilometres in patches. Thought to be a relic community.
Lowlands	Woodlands—variable, mostly but not always eucalypt dominant, mixed, open or dwarf; tall grasses and scattered shrubs. Tall open forests—mostly eucalypt dominant, but with small areas of mixed open forest dominated by non-eucalypts; tall grasses, scattered shrubs and low trees. Savannah and grasslands—eucalypts, with irregular patches of non-eucalypt trees and areas of annual or perennial grasses. Mixed scrub—mostly non-eucalypt, pandanus scrub and leguminous-myrtaceous scrub.
Flood plain	Sedgeland—dominated by a number of sedge species with varying proportions of grass. Herbaceous swamp vegetation—numerous aquatic herbaceous and grass species, unstable and in patchy mixtures according to flood depth etc., susceptible to buffalo damage. Paperbark forest—occurs in depressions and along lowland freshwater river channels. Patchy and fragmented.
Tidal flats	Mangrove scrub—extends as scattered occurrences along the coast and for short distances up East Alligator River, Cooper Creek and South Alligator River, West Alligator River, and Wildman River. Samphire (fleshy, salt-tolerant plants)—with sedges and grasses, occupying flats along the coast and parts of the estuaries.
Streams and water bodies	Mixed communities along stream channels—various assemblages of species, particularly luxuriant and important ecologically near springs and streams emerging from the escarpment, notably along Baroalba Creek.

Source: Exhibit 58.

The wildlife of the Region includes six introduced animals—buffaloes, pigs, cattle, dingoes and domestic dogs and cats. The feral cat population is small, and the great abundance of small mammals in the Region is probably due in part to this fact. Numbers of some ground-frequenting mammals and birds have declined as a result of buffaloes grazing and trampling their habitats.

The commercial significance of the Region's land animals is very limited, except for the buffalo. No native mammals have skins of value and there are not enough kangaroos to support a pet-meat industry or extensive sport shooting; moreover, the red kangaroo, which can only be taken under licence, and the agile wallaby are protected under the *Wildlife Conservation and Control Ordinance* 1962–1976.

A number of rare bird species could be endangered if trapping were permitted in the Region. Also any extensive hunting of waterfowl could seriously affect the survival of local populations, particularly of the magpie goose which, together with certain other geese and ducks, is protected for part of the year under the Wildlife Conservation and Control Ordinance. The South Alligator River swamplands are the dry season refuge for the major part of the entire Australian population of this bird.

A total of forty-three native fish species, a quarter of all Australian fishes, was recorded in the Fact-finding Study. By comparison, the whole Murray–Darling river system has only twenty-seven species. Ten of the Region's fishes have value as food and five for sport fishing. The silver barramundi is outstanding for both and is fished commercially in the river estuaries. Studies have indicated scope for expansion of commercial fishing, but safe harvest levels have not been established.

Biological information on the fish species is limited. Some are restricted to very localised areas, while others make use of the greater part of the length of rivers and streams. Silver barramundi, for example, spawn in the brackish estuaries during the wet season and migrate up to the freshwater reaches before the wet season flow subsides.

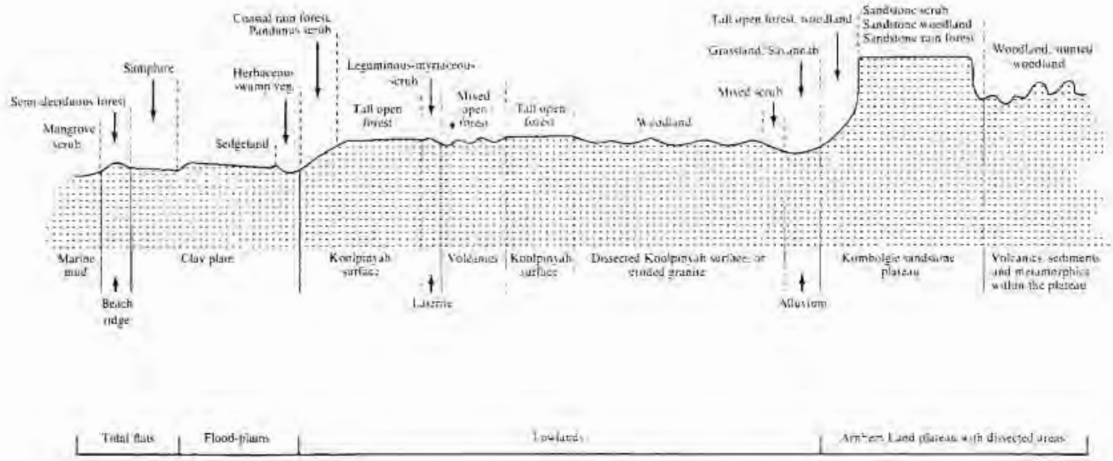


Figure 3: Cross section showing the relationship of vegetation to land type in the Region.

Plate 8. Harney's marsupial mouse (*Antechinus bilarni*), a small mammal found mainly around the foot of the escarpment (photo: E. Slater, CSIRO).

Some fish species have adapted to depletion of oxygen resulting from high water temperatures; to ensure that their eggs receive adequate oxygen, some lay them on floating vegetation while others carry them in their mouths. One fish, the spangled grunter, reputedly lies dormant in the mud of dried-up streams in the dry season.

The Region's aquatic reptiles include both the freshwater and saltwater crocodile (despite the river names, alligators do not occur in Australia). Following large reductions in their numbers as a result of shooting, the crocodiles are now protected and their numbers are increasing.

Insects The Region's insects could be important as indicators of environmental change. Changes in numbers of, for example, dragon flies associated with main streams, flies whose larvae inhabit large waterholes and butterflies whose larvae inhabit stagnant water bodies could indicate the presence of water pollutants.

About 4500 insect species have been recognised in collections made during the Fact-finding Study, and further identification and collection are expected to reveal a total of over 10 000 species. Knowledge of the roles of all these insects in food chains, nutrient recycling processes and so on is very limited.

The insects include more than seventy blood-sucking species. Among these are several malaria host mosquitoes, so the possibility exists that malaria could spread within the Region if it were allowed in. Other mosquitoes can carry Australian encephalitis and Ross River and dengue fever viruses.

Termites are present in large numbers; the mounds of some species are a feature of the lowland countryside.

Rivers and creeks In the wet season the flow of the Region's rivers and their tributaries fluctuates widely, with peak flows following periods of heavy rain. Flow declines and eventually stops in the dry season, except in the lower sections of the rivers and their estuaries and in upstream sections fed by springs or seepage. Some water remains until the next wet season in rock pools in the plateau and in waterholes, billabongs and swamps in the lowlands and flood plains.

The number of waterholes and billabongs which persist through the dry season varies from year to year. In particularly wet years some streams keep flowing throughout their courses. An indication of the variation in flow comes from measurements made in the East and South Alligator Rivers which indicate that the amount of water flowing to the estuaries can vary between years by as much as a factor of five.

The permanent upper sections of the streams usually have sandy or rocky bottoms, and in places are bordered by dense vegetation which adds substantial amounts of organic matter to the water. The stream courses in the lowlands vary in form and vegetation, but most commonly they are channel complexes linking billabongs and overflowing in the wet season over plains and swamps in broad valleys. Paperbark forests are common along the main channels, and grassland and savannah woodland on the adjacent plains of the drainage valleys.

The flood plains are inundated each year for periods varying, with location and rainfall, from about three to nine months. These plains are mainly treeless, except near the margins. A dense growth of reeds, water grasses, herbs and other plants emerges each wet season from perennial root stock or seed retained in the soil after the previous inundation.

The river and creek water is generally very soft and slightly acidic. Natural levels of heavy metals and suspended solids are low. Changes in water quality occur in the water bodies remaining after flow ceases, and stress conditions for aquatic organisms sometimes develop. Existing information on the development of stress conditions in Magela Creek water bodies is discussed later in this chapter under the heading *Water quality deterioration in the dry season.*

Underground water Types of underground water storage located in the Region include joints or cracks in the basement rock, porous limestone-type rock which can hold large quantities of water, and shallow aquifers in weathered rock, in old sand deposits and in sand along stream channels. Aquifers are likely to play an increasingly important role as a source of fresh water if development proceeds, and knowledge of the characteristics of the different types is necessary if they are to be successfully exploited and protected from contamination.

Accumulations of water in faults in the basement rock have been the main source of pastoral water supplies. Water quality in many of these aquifers is good, which suggests that they are recharged locally from the surface. In some very localised areas groundwater radioactivity is above World Health Organisation standards for drinking water.

The highest yielding aquifers so far found in the Region are associated with the limestone-type rock. The most productive of these, near Kapalga just west of the South Alligator River, is the proposed source of water for the regional township. Aquifers of this type have not been found east of the South Alligator River. Higher than normal chloride concentrations in some bores near the river have been interpreted as meaning that some contamination of the aquifer from the river occurs, and as offering a warning of the possible effects on this source of water if mine or other contaminants should enter the South Alligator drainage system.

The Region's plateau sandstone is sufficiently porous in places to act as an aquifer which discharges as springs at the foot of the escarpment. Old sand beds beneath the surface form aquifers in some other areas; information on their occurrence and potential as water sources is very limited. Seepage from the shallow aquifers in weathered rock, sand sheets and sandy drainages probably extends the period of flow of streams and the life of some billabongs in the dry season.

The Magela drainage system

Any contaminants from the proposed mining and processing operations at Jabiru or Jabiluka released into and remaining in surface waters or shallow aquifers would be confined to the Magela drainage system (see Map 10). The destination of contaminants entering deep groundwater is less certain, but it is unlikely that they would migrate far beyond the area covered by this system.

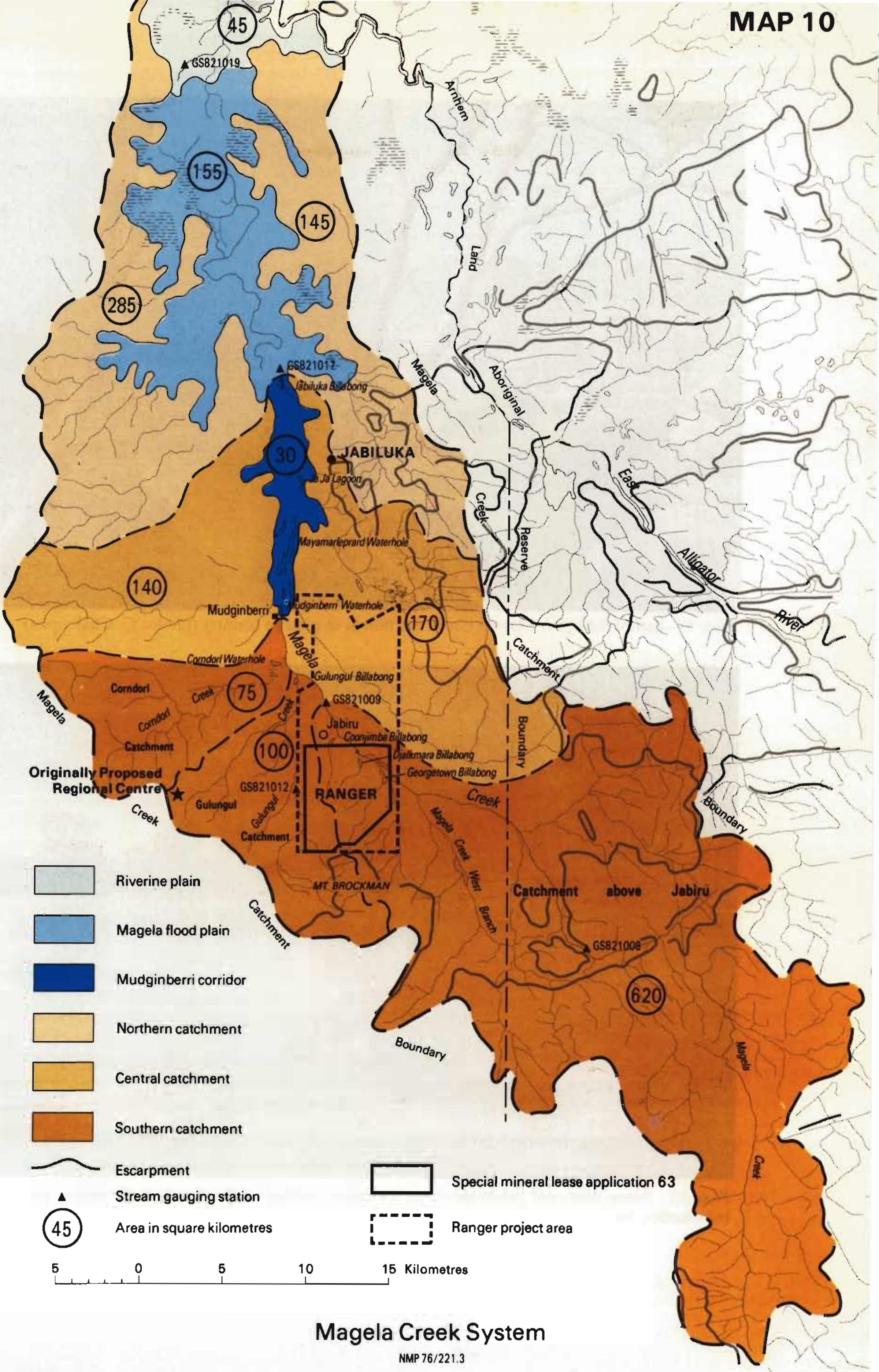
The Magela system comprises:

- The southern catchments of Magela Creek and its tributaries upstream of Mudginberri homestead. These cover about 1000 square kilometres, and include the Ranger mine site. Magela Creek and three small tributaries, Georgetown, Djalkmara and Coonjimba Creeks, pass through the area of the special mineral lease application. Another tributary, Gulungul Creek, has two branches, of which one receives drainage from the western side of this area and the other drains part of the site of the proposed regional centre. These four tributaries, and Corndorl Creek which drains an area north-west of Ranger, including part of the regional centre site, are the main drainages which join Magela Creek in this section.
- Mudginberri corridor, a series of stream channels, waterholes and flood plains between Mudginberri homestead and the main Magela flood plains. The southern section mostly comprises paperbark-lined channels and billabongs, and the northern part more open plains. Mudginberri corridor covers about 30 square kilometres, and receives additional water from catchments to the east and west of it totalling about 300 square kilometres.
- The coastal flood plains, covering more than 200 square kilometres and made up of the Magela freshwater flood plains and the riverine plain along the East Alligator River. The freshwater plains comprise, broadly, an area of poorly drained paperbark country in the south, a wider plain of better drained sedgeland in the centre, and another large area of poorly drained paperbark country merging with the riverine plain (see Map 11). There are small areas of swamp in each section. The riverine plain has clay soils and a vegetation of sedge and scattered patches of mangroves. A substantial amount of water drains on to the flood plains from surrounding lowland catchments, which have an area of about 450 square kilometres.
- The estuary of the East Alligator River. The Magela system contributes about one-tenth of the total flow of the estuary.

A distinctive feature, and a scenic highlight, of the Magela system is the proximity of its flood plains north of Mudginberri Billabong to plateau outliers and their escarpments. The only comparable area in the Region is near Oenpelli, in the Arnhem Land Aboriginal Reserve.

Otherwise the Magela flood plains are not especially notable. They are less used as a dry season refuge by birds than other parts of the Region, particularly

MAP 10



Magela Creek System

NMP 76/221.3

Plate 9. Part of the upper Magela Creek catchment in plateau country (photo: G. Chaloupka).

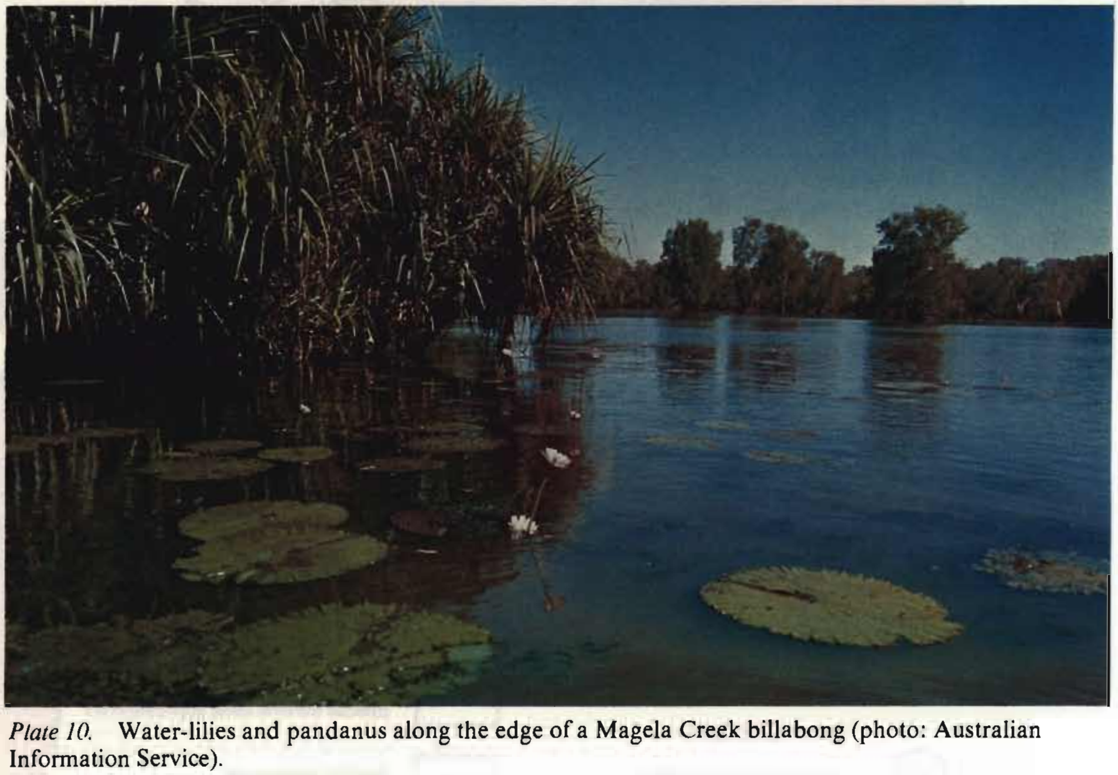


Plate 10. Water-lilies and pandanus along the edge of a Magela Creek billabong (photo: Australian Information Service).

the Nourlangie Creek flood plains in Woolwonga Wildlife Sanctuary, and observations indicate that their vegetation is less diverse than that of the South Alligator River plains. Open swamps with herb vegetation make up a much smaller proportion of the Magela plains than of other flood plains in the Region.

The plateau and lowland sections of Magela Creek and its catchments are generally similar to those of other streams and catchments in the Region and in comparable areas outside it.

Hydrology of the Magela system

The hydrology of the system can be described only in broad terms because limited stream flow data exist. Wet season flow comprises a series of peak floods superimposed on a base flow which begins in an average year about mid December and ceases about the end of June. In a wet year flow may commence in November and finish in August.

The low-lying areas along the main stream channel are usually flooded between January and April to a depth of up to about a metre. By May sedges and grasses have usually begun to emerge from the retreating water. At the end of the dry season only some billabongs still contain water.

The total flow past Jabiru is about 250 million cubic metres in an average year. In a wet year it may exceed three times this volume and in a dry year it may be less than a quarter.

The contributions of catchments downstream of Jabiru to the quantity of water entering the flood plains, including rainfall on the plains themselves, probably amount to about one or two times the flow of Magela Creek at Jabiru.

On entering the plains, water from Magela Creek spreads widely. About 200 square kilometres are flooded in most years and it is estimated that, on average, the area flooded may extend to more than 300 square kilometres once in ten years and to nearly 500 square kilometres once in 100 years. The flood plain sedge areas are generally under water for three to six months and the swamps for six months or more. The deeper depressions remain inundated throughout the year.

Depressions around the margin of the plain may receive water first from run-off from adjacent catchments or from spillover from the main streams, depending on the timing of rainfall in the northern and southern sections of the Magela system. The way water originating from different sources is distributed on the plain is not known in detail.

Water enters the East Alligator River from the Magela plains by a number of channels. The river, which has an average annual flow of about 5000 million cubic metres at the estuary, enters Van Diemen Gulf 35–40 kilometres to the north-west. The gulf has an average depth of less than 10 metres. Not enough information about the local oceanography exists to enable the way river water diffuses into the sea to be determined.

Seepage to deep aquifers

Some water from Magela Creek and its tributaries is probably lost to deep aquifers associated with faults in the basement rock. Several major fault lines have been identified within the catchment. Some small fractures have been studied at the Ranger site, and it has been inferred from geological studies that others exist in the area, following Magela and Gulungul Creeks. The evidence indicates that water movement in these aquifers is slow and restricted. Water may drain from some of them into streams.

Water quality

The initial chemical quality of stream water into which additional contaminants are discharged is important in determining the eventual fate and significance of the discharged material. Particularly relevant in the Magela system are the levels of heavy metals and radioactive materials, and other water quality characteristics which influence the availability of these to organisms. The naturally occurring metals identified as most significant in Magela Creek are copper, lead, zinc, uranium and radium, but others may also be important. Data on concentrations of these materials are of variable quality. Table 6 gives the ranges of concentrations recorded, together with the quantities of the metals that would be carried downstream by an average annual flow of 250 million cubic metres of water if concentrations remained at the levels shown. The figures can be regarded as giving only an indication of the quantities present.

The data available are not adequate to show how concentrations vary during a year or between years of different flows.

The level of suspended materials, mainly silt, is usually low (10–40 milligrams per litre), but may be higher (possibly 100 milligrams per litre) in periods of high flow.

The evidence does not suggest that major changes in quality occur as water moves downstream to the flood plains, but interpretation is complicated by the effects of rain on the plain and the contributions of contaminants from other catchments.

Information is not available on the chemical form of the metals in Magela Creek water, a major factor influencing their toxic effects. The softness and slight acidity of the water, together with the low level of suspended solids, would tend to keep heavy metals in solution and so readily available to organisms. However, soluble organic materials, which the evidence suggests are also present, could act in the opposite manner by binding them in a less readily available form. Transport of the metals by adsorption on suspended materials is likely to be less important than in other river systems because of the lack of a major source of clay materials in the catchments.

Water quality deterioration in the dry season

The section of Magela Creek between Jabiru and the flood plains contains a number of billabongs that retain some water through most dry seasons. These include Mudginberri, Mayamarleprard, Ja Ja and Jabiluka Billabongs (see Map 10). Some billabongs in tributary streams, including Georgetown and Coon-

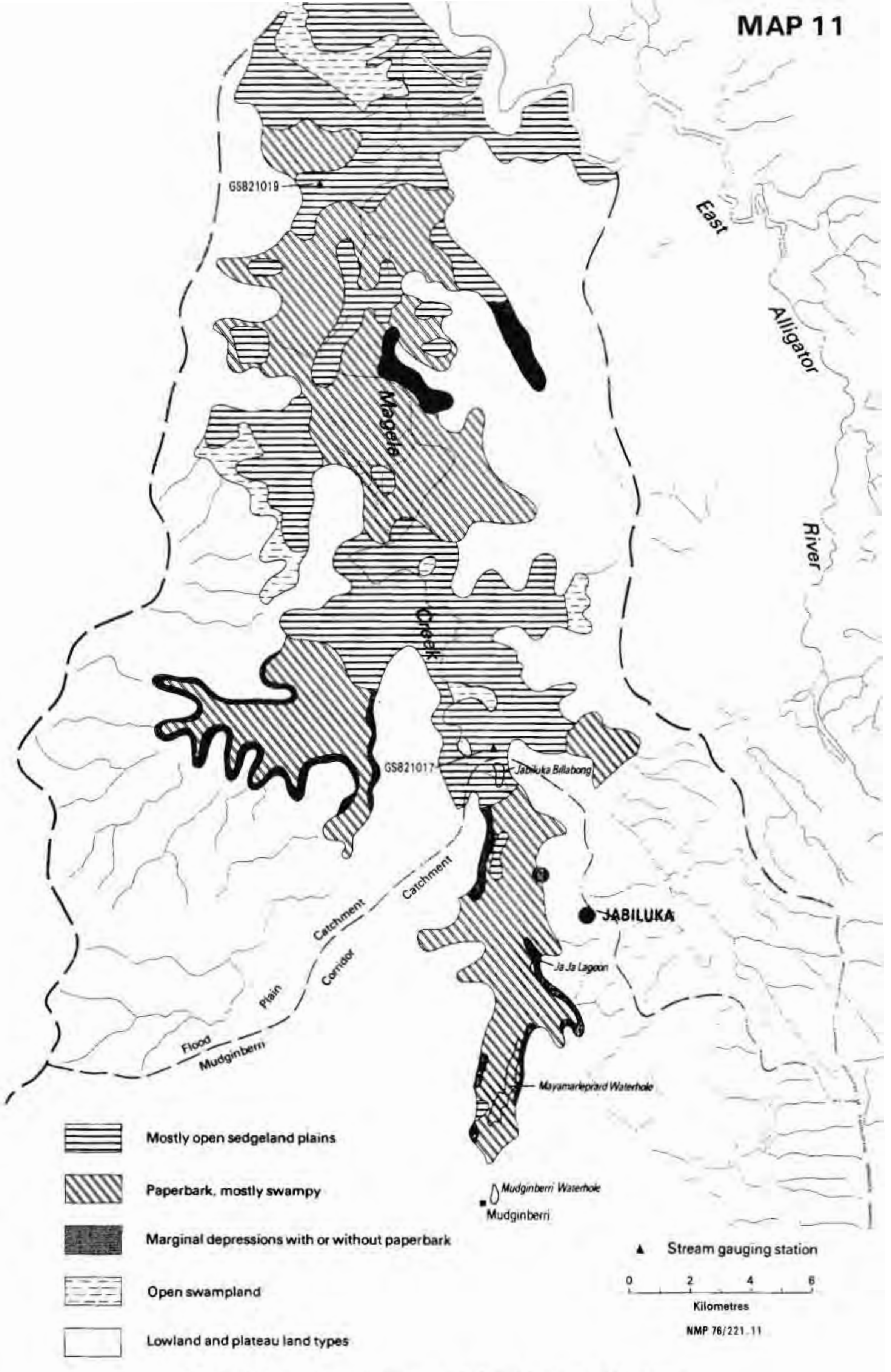
Table 6

Heavy metal levels in Magela Creek at Jabiru

Contaminant	*Concentration*	*Total load in average annual flow of 250 million m³*
Cadmium	0.05–0.5 μg/l	12.5–125 kg
Copper	0.5 –5 μg/l	125–1250 kg
Lead	0.5 –3 μg/l	125–750 kg
Zinc	1–15 μg/l	250–3750 kg
Uranium	0.1–5 μg/l	25–1250 kg
Radium	0.1–0.5 pCi/l	0.025–0.125 Ci

Sources: Evidence of D. R. Davy and R. K. Carruthers.

MAP 11



Flood Plain Land Types of the Magela System

Plate 11. South Alligator River flood plain in the dry season with magpie geese overhead (photo: G. Chaloupka).

Plate 12. A typical permanently wet depression with paperbark vegetation at the edge of a flood plain (photo: R. Story, CSIRO).

jimba Billabongs in the proposed Ranger special mineral lease area and Gulungul and Corndorl Billabongs nearby, are also seldom dry.

On the flood plains water persists in some sections of channel and in various billabongs, swamps and depressions at the edge of the plains.

These surviving water bodies play a vital role in the ecology of the area. They provide water through the dry season for land animals and very large numbers of water birds, and they sustain some fish species and other aquatic organisms.

The amount of water remaining, and the number of water bodies containing it, varies markedly from year to year, depending on annual rainfall and the length of the wet season. This variation is illustrated by stream flow figures for the Magela at Jabiru which show that, between 1972 and 1975, the number of days of flow per year ranged from eighty-nine to 170. None of those years was unusually dry.

Oenpelli rainfall data for 1912–72 have been used to estimate roughly the period between the time when a water body would start to decrease in depth after the wet season and when it would begin to refill. This period was calculated to vary from twenty-two to thirty-four weeks. The estimates were made by comparing weekly rainfall figures with estimated evaporation, ignoring seepage and runoff. The depth of water that would have evaporated in different years during that period was calculated to range between 847 and 1349 millimetres.

Because of this variation, and because of the differing characteristics of persistent water bodies, the extent to which water quality deteriorates in the dry season must vary greatly from year to year and in different parts of the Magela system. The details of this variation are not known, but two types of billabongs which respond differently to the annual drying out have been identified.

One type has steep banks and sandy bottoms. These billabongs, including Mudginberri and Mayamarleprard, are usually in main channels and appear to be well flushed each year by the main creek flow. Their water tends to remain cooler, clearer and of better quality than that of the other type. They probably receive seepage from surrounding sandy aquifers for some time after Magela Creek stops flowing, and may later lose water by seepage.

Georgetown, Djalkmara, Coonjimba, Gulungul and Corndorl are among billabongs of the second type, which have shelving banks and clay or silt bottoms with accumulations of organic matter. Seepage inflow or outflow is likely to be small. These billabongs are usually shallower, and are often more turbid, than the other. Algae commonly grow in them in the dry season and form surface blooms.

Most are near the mouths of tributaries or in depressions behind levee banks beside main channels. Depending on rainfall in the catchments, water flows in the wet season through these billabongs to the main stream or 'backflow' occurs from the main stream to the billabongs and tributaries. Backflow tends to deposit fine sediments and organic matters in the billabongs, whereas flow down the tributaries tends to flush them out. The Commission has little information on the flow conditions in different catchments likely to result in backflow, when and for how long such conditions exist, or the balance between backflow deposition and flushing of material from these billabongs.

Studies of both types of billabong in the Magela system have revealed a number of general trends in water quality as the dry season progresses. These changes, which directly or indirectly influence the survival of organisms, are

Plate 13. Mudginberri billabong, a permanent billabong in Magela Creek with steep banks and a sandy bottom (photo: J. Pendarvis).

Plate 14. A portion of Magela Creek's Mudginberri corridor in the wet season, with typical paperbark vegetation (photo: R. Lehane).

usually more pronounced in the second type and in smaller billabongs. They vary with the length of the dry season. The main changes are as follows:

- Water temperature increases, often to more than 40°C.
- Acidity increases to moderately high values (for example, to pH 4.2); this trend is probably coupled with the increasing concentration of brown humic materials (dissolved organic acids) due to evaporation and perhaps seepage inflows, and the generally low capacity of the water to resist acidity changes.
- The concentration of dissolved material increases; a fivefold increase has been recorded.
- Concentrations of sodium, potassium and chloride increase, but calcium and magnesium concentrations appear to stay relatively constant.
- Nitrate levels may increase by a factor of ten, from about 2 milligrams per litre.
- Anaerobic conditions (absence of free oxygen) may be established, at least among the sediments near the bottom. When these sediments become anaerobic, insoluble iron and, significantly, toxic heavy metals associated with it can change into a soluble form and diffuse into the water at the bottom of the billabong.
- The limited data available on heavy metal changes in the dry season suggest that, at least in the smaller backflow billabongs, increases in copper, lead and zinc concentrations do occur. Some of the levels reported for copper and zinc are close to what would be lethal levels for some fish species in an unacclimatised condition if all the metal were in a toxic form. Little trend towards higher heavy metal concentrations was recorded in a study of Ja Ja and Jabiluka water holes during the 1975 dry season, possibly because this was short and occurred between two very wet seasons.
- Concentrations of uranium in backflow billabongs have been observed to increase dramatically during the last few weeks of the dry season. For example, one record indicates a change from 0.04 micrograms per litre in the water in July to 100 micrograms per litre in October, which is slightly below derived 'safe levels' (see Chapter 6). Significant increases have also been recorded in radium-226 concentrations.
- The normally clear water of the wet season becomes very turbid during the dry season in the shallower billabongs, due to lowered water levels and disturbance of the bottom sediments by buffaloes and geese. Although few quantitative data are available, increases in suspended material from less than 50 to as high as 3000 milligrams per litre have been recorded.

This natural deterioration of water quality during the dry season imposes stress on aquatic organisms in various ways—through high temperatures, low oxygen levels, high turbidity and perhaps high levels of metals in the water. As water recedes, the scope for organisms to move and select other habitats is reduced. Dead fish have been observed in the dry season, but the factors responsible for the deaths are not known.

Many interrelated physical, chemical and biological processes influence the effects of toxic contaminants in the billabongs (see Appendix IV). Turbid conditions and the presence of organic matter tend to lock up heavy metals in an inactivated, non-toxic form. However, the development of more acidic or oxygen-depleted conditions later in the dry season could result in these metals going into solution. Also they could be concentrated by evaporation.

The factors determining their chemical form, and therefore their level of toxicity, are not well understood. There is a general paucity of information about complex aquatic systems, and specific data for the Magela system are very limited.

The fate of natural contaminants

If the present fate of natural contaminants in the Magela system were known, it would be easier to assess the impact of additional contamination from the proposed Ranger and Jabiluka operations. However, knowledge of the fate of these contaminants is very limited, despite considerable investigation over recent years.

Several features of the lowland section of Magela Creek would tend to limit the retention of contaminants there. One is the fact that a few peak flood flows of relatively fast-moving water (0.6–0.8 metres per second) account for about three-quarters of the annual flow past Jabiru in average years, and would probably flush most of the contaminants through. At flow rates like these, it would take about one day for water to travel from Jabiru to the main Magela flood plains. Also a large proportion of the soils in this part of the drainage are sandy, with a low capacity to hold heavy metals. The finer sediments of the associated billabongs and swamps have a higher capacity, but their areas are small and they would be unlikely to hold more than a very small proportion of the total amount of contaminants.

Mudginberri corridor could trap contaminants. Stream flow, supplemented by other drainages, is quite rapid in flood periods and would tend to carry dissolved or suspended materials through the corridor. However, the black organic clay soils common in areas like the southern part of the corridor probably have a high capacity to retain heavy metals, and the presence of hydrogen sulphide in some of them could cause heavy metals to be deposited and retained in insoluble forms. The AAEC has reported studies of radioactive metals which indicate that there is some loss of uranium from Magela Creek water before it enters the Magela flood plain further north. This suggests that some uranium, at least, may be trapped, but the role of the corridor cannot be determined without further study. Its soils should be examined to determine whether it is an area of natural accumulation.

The soils of the flood plains are heavy clays with moderate organic content, which intrinsically have a high capacity to incorporate heavy metals in an inactive form. However, although the Magela system has been carrying these metals for probably several thousand years at least, their levels in the flood plain soils are in fact low compared with the normal range of concentrations in soils. The reason for this is not known. In contrast, high concentrations of contaminants have been measured in the top 5 centimetres of similar soils of the Finniss River flood plain, which has been flooded by water whose contaminant levels have been greatly increased by the now abandoned Rum Jungle mines.

Two independent estimates of the percentages of the water entering the plains which is discharged to the East Alligator River were presented to the Commission. One, based on a water balance model, suggests an outflow of about 70 per cent in years of average rainfall, but zero output in very dry years. The other, based on the limited hydrological data available, indicates a discharge in average years of 90 per cent, falling to about 50 per cent in low rainfall years. So it appears that, in most years, a substantial proportion of the water entering the plains is discharged to the river. No evidence exists on the proportion of dissolved substances and fine sediments discharged with it.

The evidence indicates that water moves very slowly over the plains because of their flatness, wide expanse and flow-retarding vegetation. This would encourage deposition of suspended material. About 4500 tonnes of suspended material are estimated to pass Jabiru annually. Some of this is almost certainly carried through to the sea, but if it were all deposited on the plains the build-up of material would amount to less than 0.1 millimetre even if concentrated on the central quarter of the flooded areas. This accumulation could easily be obscured by soil-mixing processes.

The behaviour of the East Alligator River contributes to the slowing of outflow from the plains. When flood levels are high on the plains, the river level is also likely to be high. Also, high tides and north-westerly winds that occur in the wet season tend to impede river flow, and as a result water frequently backs up the creeks which act as outlets from the plains. River water may sometimes overflow on to the northern section of the plains.

Of the dissolved material not transported through to the sea, some would be adsorbed on to soil particles as the water passed over the plains or seeped into the soil, some would be left on the surface as the water evaporated, and some would remain in the residual water bodies. Plants and animals could take some of this material up from the soil or water (see *Biological uptake*, below).

The natural contaminants in the flood plain soil appear to be fairly evenly distributed from the surface to a depth of 1–3 metres. It has been postulated that this is because rain early in the wet season washes material which has accumulated on the surface into the cracks which form each year in the soil. The evidence suggests that vertical mixing may be less complete in the moist soils of some billabongs on the flood plain.

Once saturated, further movement of water into the soil is likely to be very slow. The soil needs to absorb the equivalent of about 150 millimetres of rainfall before swelling closes the cracks and the soil is saturated. If this were provided by rain falling on the plains before flooding from Magela Creek occurred, the likelihood of entry of contaminants in creek water would be reduced.

Biological uptake

Heavy metals can be removed from soil or water by various organisms. In the Magela system, the main biological removal mechanism is probably the annual growth of vegetation on the flood plains. The limited data available suggest that pasture grasses in the area contain zinc at a concentration averaging about 7 micrograms per gram (or 7 parts per million), and about 5 micrograms per gram of copper. An estimate of the total annual growth on the flood plain is about 10 tonnes of dry matter per hectare. If this is correct, and if the concentration figures are representative, about 70 grams of zinc and 50 grams of copper per hectare are cycled through the vegetation each year. On average 1 metre depth of flood plain soil contains about 90 kilograms of zinc and about 25 kilograms of copper per hectare, at concentrations of about 7 and 2 micrograms per gram respectively, so only a very small proportion is cycled through the vegetation each year. It is not known how much of the annual uptake in vegetation is derived from the soil directly and how much from floodwaters.

Plate 15. Jabiluka billabong at the northern end of Mudginberri corridor. The instrument tower is part of gauging station GS821017 (photo: R. Lehane).

Plate 16. The Magela flood plains during a typical wet season flood (photo: G. Chaloupka).

Some species take up greater quantities of toxic heavy metals than others. For example, pandanus has been shown in the Region to have higher levels of copper and zinc than most plants tested there. High levels of uranium have been measured in several eucalypt species. And evidence exists of a relationship between the uranium content of paperbark leaves and the level of uranium in the nearby soil.

It may prove possible to use these plants as indicators of excessive concentrations of heavy metals. However, much additional research would first be needed. Details of the differing uptake of different parts of plants and plants of different ages would have to be determined. Also more information would be needed about the time species take to respond to environmental change.

Annual species, including various aquatic plants, may be more useful than perennial species for detecting contamination in the short term. The limited data available indicate that grass-sedge samples from the contaminated Finniss River flood plain have higher copper and zinc concentrations than samples from the natural environment in the Magela system, and that the concentrations at different locations are correlated with levels of these elements in the soils. Also substantially higher concentrations have been recorded in algae samples from the polluted part of the Finniss than from upstream of it.

Some plant and animal species can store various contaminants in their tissues, without harm to themselves, at concentrations dangerous to other organisms feeding on them. Well-known examples are mercury in fish and zinc in oysters at concentrations harmful to humans. However, successive concentration of elements in each step in the food chain does not necessarily occur, and in many instances there is a reduction. Very little information exists about biological concentration in food chains in the Magela system.

Need for more information

Clearly large gaps exist in knowledge of the Region, and the Commission accepts the contention of a number of biologists who gave evidence that existing information is not sufficient to enable the ecological effects of mining, especially long-term effects on aquatic ecosystems, to be predicted. The deficiencies are not confined to the problems already discussed in this chapter, but include information on the life history and biology of species, the sensitivity of species to contaminants and interactions between species.

The desirable objective would be to gain an understanding of the Region sufficient to enable any man-made changes to be detected quickly. The evidence shows clearly, however, that the techniques of the environmental and ecological sciences are not yet adequate to achieve this objective. Whatever information is obtained, in the short term it is inevitable that gaps and doubts will remain.

This is not an argument against seeking more information. We support the proposition that, if mining or other developments are to proceed, as much information as possible should be obtained beforehand. However, because of the uncertainties, we also adopt the view that, to protect the ecological value of the Region, the best practicable technology should be used in avoiding or minimising the release of contaminants. Standards for any contaminant releases should be strictly defined, and the most comprehensive monitoring program possible should be instituted to detect environmental changes. The plan of operations should be sufficiently flexible to enable adjustments to be made if deleterious impacts are detected.

The Commission proposes that, if a decision to proceed with mining is made, a multidisciplinary technical and scientific group be formed to advise on the design of an information-gathering program. Emphasis should be placed on gathering information helpful in designing a monitoring program rather than attempting to predict the effects of developments. People from a variety of scientific disciplines, including hydrology, hydrochemistry, botany, zoology, soil science and ecology, would need to be involved in this program and a research approach would be essential in some fields.

They would face great difficulties in establishing baseline biological data against which changes could be assessed. The variability between years is such that many years of measurement would be required to record natural fluctuations in such things as water quality and species composition and populations. Moreover, the ecology of the Region has already been substantially modified in places by human activities including the introduction of exotic animals and plants. One witness proposed a three-year program costing $1 million a year to study certain biological aspects of aquatic ecosystems, but he agreed that even this would provide little information of value for resolving the problems before the Commission.

Even if a decision were made to commence mining as soon as possible, there would be a period during which further investigations could be carried out. We believe that the information sought should include:

- more complete knowledge of the contaminants in the ore bodies;
- additional biological data, e.g. fuller inventories of species of aquatic plants and animals, including lower organisms, and information for selected species on aspects such as survival strategies, reproduction, and natural population sizes and their fluctuations;
- contaminant levels in selected organisms (plants and animals) and in separate parts of organisms;
- data on the sensitivity of selected species to single and combined contaminants, and to different chemical forms of contaminants;
- further information on the hydrology of the Magela system, and on the natural distribution and local accumulation of contaminants;
- information on the physical–chemical processes operating within drainages and identification of the parameters most useful for measuring change, especially as the dry season advances;
- information on sampling procedures necessary for obtaining significant statistical information; and
- extension of present information to cover all sensitive areas of the Magela system.

The evidence indicates that investigations before mining could not:

- indicate accurately the physical effects of contaminant releases;
- indicate responses of biological populations to the environmental changes that would be produced; or
- provide sufficient information to predict long-term effects.

Possible developments other than uranium mining and milling, notably intensification of pastoral activities and the creation of a regional township, would also add contaminants to watercourses. It could prove difficult to distinguish any environmental changes resulting from these developments from

Plate 17. Buffaloes in lowland country (photo: J. Estbergs, CSIRO).

Plate 18. Coastal plains erosion following destruction of vegetation by buffaloes (photo: J. Estbergs, CSIRO).

those produced by the uranium operations. The monitoring program should be designed to enable, as far as possible, the sources of environmental impact to be identified.

Possible impacts of proposed developments

The characteristics of the Region outlined in this chapter will have a major influence on the nature and magnitude of the effects of any man-made disturbances to the environment. Possible developments in the Region, other than the Ranger project, include uranium mining at Jabiluka, Koongarra, Nabarlek and other as yet unidentified sites, intensification of the pastoral and tourist industries, reservation of an area or areas for a national park, and the development of a town and regional services. In an attempt to present an overall view of the possible impact, we describe the main potential environmental effects briefly below. The different land uses are considered in detail in later chapters.

The Ranger project during its period of operation

Construction and operation of the mine and mill would have a variety of ecological effects within the special mineral lease, along service routes and access roads and tracks, and in local drainage systems. Ecological effects could emanate from the occupation of space, removal of vegetation and disturbances of the soil surface which would lead to erosion and sedimentation of streams, destruction of fauna habitats, and changes in local water flow and seepage patterns to degrees depending on the extent of the disturbances and the success of control measures.

A much larger area could be affected by discharges of contaminated water. Effects could result along the whole Magela drainage system downstream of Jabiru, including the flood plains and the East Alligator River estuary, and possibly in underground water storages. Contaminated water seeping from the tailings dam and retention ponds could affect areas within and near the mineral lease as well as the lower course of Magela Creek and underground storages. Whether particular areas would, in fact, be affected is uncertain and would depend to a large extent on the environmental control measures adopted. We consider these aspects in detail in Chapters 6 and 7.

Air pollution—mainly sulphur dioxide emissions from the acid plant and radon and dust from mining and milling operations—would generally decrease with distance from the source and have its main influence within the mineral lease. The area affected at any time would be determined by the winds.

The impact of people on the environment, during construction and mining, would be strongly influenced by the scheme of regional management adopted.

The Ranger project after mining operations

The Ranger company proposes, after mining ceases, to revegetate disturbed areas, with the exception of the mine pits which would become lakes. Revegetation would establish wildlife habitats, but these would not be the same as those on the site before mining. The extent to which dust was blown from the dumps and other areas would largely depend on the success of revegetation.

Seepage from the tailings dam would continue indefinitely unless the tailings were placed in the mine pits. The main areas affected would be Gulungul Creek and drainages within the lease area, but contaminated water would also continue to be carried through the Magela system. Placing the tailings in the pits would probably produce a hydrological situation after mining not very different from that before mining.

Radon emissions from the tailings, if left in the dam, would depend on the thickness and composition of the covering layer. If the tailings were returned to the pits, and kept below groundwater level, radon emissions would be very greatly reduced.

Other uranium projects The possible developments at Nabarlek, Jabiluka and Koongarra were not examined in detail during the Inquiry, but it can be assumed that their ecological effects would be similar in kind to Ranger's. These effects would vary according to the size of the project and its rate of production, its location, the nature of the site and the ore body, whether processing were conducted at or near the mine site, and the processing, water management and tailings disposal systems adopted.

Jabiluka is on the edge of the Magela flood plain downstream from Jabiru, and hence any contaminants discharged in water would be additive to those reaching that area from Jabiru. Koongarra and Nabarlek are in separate catchment areas and drainage systems. Other impacts, including air pollution and the effects of increased population, would generally increase with the number of mines operating and their output.

Regional centre The major source of ecological interference arising from the proposed township is likely to be the activities of the increased number of people in a sparsely populated area. Subject to any controls which were instituted, these activities would probably include hunting, fishing, shooting, picnicking, sightseeing and exploration, including the use of four-wheel-drive vehicles off roads and tracks. They would also probably include the collection of fauna and flora, accidental or deliberate lighting of fires, uncontrolled disposal of wastes, and vandalism. The size and extent of the impact would depend on the degree of control exercised by regional authorities, the extent to which various activities were planned, and the influence of community attitudes.

Ecological effects on the town area, and access roads and service routes, would flow from the occupation of space and disturbance of vegetation and the soil surface. Disposal of sewage and other wastes, and runoff and drainage which would be likely to include fertiliser leached from gardens and other chemical contaminants, would affect some areas. If the town were built at the site proposed in a study commissioned by the former Department of National Development, treated sewage effluent and drainage would enter Corndorl Creek and the main Magela drainage system.

Construction sites, roadside drainages and off-road tracks would provide increased habitats for insects which can spread human diseases, such as malaria-carrying mosquitoes. Unless stringent controls were applied, domestic pets, particularly cats, would multiply and spread widely in the Region, affecting wildlife populations. Introduced plants could also spread from the centre.

Pastoral industry The Commission was told that intensification of pastoral development on Mudginberri and Munmarlary stations was planned, involving the domestication and containment in fenced paddocks of 30 000 buffaloes under controlled management. If this plan were implemented, it would produce ecological interference through grazing and trampling of vegetation and interference with wildlife habitats throughout the pastoral leases. The effects would vary in intensity with rates of stocking, forms of management and mustering, and rainfall variations.

The increased stock numbers would probably also increase damage in and around, and pollution of, water bodies and drainages in the lowland country and on the flood plains. However the planned reduction in numbers of uncontrolled livestock and better management according to grazing capacity should to some extent offset the impact of the increased buffalo numbers.

Fertilising of improved pastures and the use of other agricultural chemicals could contribute to water pollution. Other sources of ecological effects include fencing, access road construction, cultivation of land and the disposal of wastes from the abattoir and holding paddocks.

Transport and other services

If mining proceeds, there will be a substantial increase in traffic on the Arnhem Highway. The provision of power and communication services would require the erection of transmission lines beside the Arnhem Highway or along other routes from Darwin.

6 THE RANGER PROPOSAL

In this chapter we assess, to the extent that the evidence makes possible, the impact of the Ranger proposal on the mine site and surrounding areas. The chapter begins with a general description of the proposal and a discussion of some possible hazards faced by people on the site. Assessments follow of water pollution, air pollution and radiation risks during mining operations, and of continuing environmental hazards after closure of the mine. The chapter ends with a discussion of the likely economic impact of the proposal.

The ore deposits

The Ranger uranium ore deposits are located at Jabiru, about 220 kilometres east of Darwin in the Magela Creek catchment between the South and East Alligator Rivers. The Commission was told that the deposits contain an estimated 100 000 tonnes of U_3O_8, divided nearly equally between two ore bodies designated Nos 1 and 3. Six other radiometric anomalies in the area have not yet been tested in detail, and may contain additional recoverable uranium. One of these, designated No. 2 anomaly, is about 3 kilometres south of No. 1 ore body and is known to extend to within a few hundred metres of Mt Brockman. The others were not considered during this Inquiry. Ranger Uranium Mines Pty Ltd proposes to mine and treat ore initially from No. 1 ore body at a rate sufficient to produce 3000 tonnes of U_3O_8 (2540 tonnes of uranium) per year in yellowcake. Mining of No. 3 ore body would follow. If and when the market for uranium expands, capacity could be increased to 6000 tonnes of U_3O_8 (5100 tonnes of uranium) per year.

No. 1 ore body has been extensively tested to determine the uranium content, and is estimated to contain approximately 20 million tonnes of uranium ore at an average mined grade delivered to the treatment plant of 0.25 per cent U_3O_8, i.e. 2.5 kilograms of U_3O_8 per tonne of ore. The relatively shallow formation of No. 1 ore body makes open cut mining the most economic method of extracting the ore. It is anticipated that, if mining goes ahead, some 60 million tonnes of waste rock will need to be extracted along with ore. The completed pit would be roughly conical, approximately 700 metres in diameter and 175 metres deep, and would cover an area of about 46 hectares.

Under the proposal, ore with a U_3O_8 content of less than 0.05 per cent would not be fed to the mill during the initial years of operation. Instead, ore in the grade range 0.02 to 0.05 per cent would be stockpiled in a low grade ore dump, where it would be available for future recovery if this proved economic. The company suggested that it may prove practicable to extract the uranium from this low grade ore by the 'heap leaching' method in which acid is allowed to trickle down through the ore, dissolving the uranium as it goes, and is collected in a sump at the base of the heap. Mineralised material with a U_3O_8 content between 0.02 and 0.01 per cent may also be stockpiled. The Commission did not receive information on the economic feasibility of the heap leaching process or on its environmental impact.

No. 3 ore body has not been delineated in as much detail as No. 1 ore body. It is estimated to contain about 23 million tonnes of ore with an average grade of about 0.22 per cent U_3O_8. The Commission was told that some 19 million tonnes could be removed by open cut mining, producing a pit 190 metres deep covering an area of 55 hectares. The company anticipates that the remaining 4 million tonnes would be mined by underground methods to a depth of 420 metres. Since No. 3 ore body consists of the same types of rock as No. 1 ore body, it is not expected that any changes in the treatment plant would be required when this ore body comes into production.

Finance and administration

Ranger Uranium Mines Pty Ltd is the Managing Agent for the Peko–EZ Ranger Joint Venture. It is wholly owned in equal shares by Peko Mines Ltd, a wholly owned subsidiary of Peko-Wallsend Ltd, and Electrolytic Zinc Company of Australasia Ltd, a wholly owned subsidiary of EZ Industries Ltd. Peko Mines Ltd and Electrolytic Zinc Company of Australasia Ltd entered into contracts in late 1972 and early 1973 to supply two Japanese utilities with a total of 2540 tonnes of uranium in the years 1977–86. These contracts, which it was expected would be fulfilled from the Ranger mine, received the approval of the Government in November 1972.

On 30 October 1974 a memorandum was signed to which the two companies and the Government were parties. It was recited that because regulations authorising the Minister to issue licences for mining the uranium had been disallowed by the Senate, the Government had made different arrangements for mining it—through the Atomic Energy Commission. The memorandum, which has been called the Lodge Agreement, provided that the mining, milling and delivery operations would be undertaken by Ranger. Control of that company was to change; EZ Ltd and Peko Mines Ltd were each to appoint one director and the Atomic Energy Commission the other two. It was provided that the AAEC was to act as agent for the Government in negotiating further sales of yellowcake. The Ranger participants agreed to make available to the AAEC sales information at their disposal, and were to be able to introduce particular sales proposals to it. Deliveries to Japanese utilities under contracts approved before 2 December 1972 were to be made from the output of the Ranger mine.

Under the memorandum, the AAEC was to finance 72½ per cent of the costs of the mine, mill and necessary infrastructure, and EZ Ltd and Peko Mines Ltd the remaining 27½ per cent. Evidence given to the Commission by the joint venturers estimated that the capital cost of plant to produce 3000 tonnes of U_3O_8 per year would be $118 million at January 1976 prices. The AAEC share of this would therefore have been $85.6 million. EZ and Peko were to receive 50 per cent of the net proceeds of the venture, net proceeds being calculated as sales revenue less proportionate costs of mining, milling and selling yellowcake. (These provisions ensured that, at the rates of company tax then prevailing, the Commonwealth and the companies would receive shares of the revenue after tax in proportion to their financial contributions.)

In a statement tabled in the House of Representatives on 31 October 1974, the then Minister for Minerals and Energy said the Government had indicated that arrangements would be made for the AAEC to participate in other uranium projects at appropriate times. He also stated that the Government had decided that companies which had undertaken exploration leading to the discovery of mineable uranium deposits would receive the net proceeds from 50 per cent of the uranium oxide obtained from the deposits. The Minister added that: 'Because deposits explored by Queensland Mines, Noranda and Pancontinental will be developed later, the Government will consider separately the question of some earlier return for their shareholders.'

The arrangements made between the previous Government and Peko Mines Ltd and EZ Ltd in the agreement of 30 October 1974 were elaborated and supplemented in a Memorandum of Understanding signed on 28 October 1975. Under the memorandum, contracts giving effect to it, to which Australia was or would become a party, were not to become effective until affirmed by the Government following consideration of the Report of this Commission and a report by the Interim Aboriginal Land Commissioner on claims by Aboriginals in respect of land within the Ranger Project Area (which was defined in the memorandum). The intention to procure the last-mentioned report was not proceeded with and no such report has been made. The report of this Commission (see Chapters 14 and 15) may possibly be regarded as a sufficient substitute.

The material provisions of the Memorandum of Understanding can for present purposes be sufficiently summarised as follows:

(a) The joint venturers were to deliver the uranium concentrate produced to the AAEC, as agent for the Commonwealth Government (cl. 5 (c)).

(b) The Commonwealth was to grant any necessary and appropriate authorities under the Atomic Energy Act, the initial authority to be for a period of twenty-one years (cl. 2 (e) (i)).

(c) The Commonwealth was to ensure that Peko and EZ were treated with respect to their participation in the joint venture, for the purposes of taxation, as if they were carrying on 'prescribed mining operations' (cl. 2 (e) (ii)).

(d) No royalties were to be imposed of a kind similar to those which would have been imposed under the Northern Territory Mining Ordinance (cl. 2 (h)).

(e) Ranger Uranium Mines Pty Ltd was to manage the project, including its planning, development, construction, operation and maintenance, and have possession and control (but not ownership) of the assets of the joint venture (cl. 3).

(f) A Ranger Project Committee, responsible for fundamental policy decisions (including cessation, curtailment or suspension of construction or operations, and major expansion of treatment plant capacity) was to have four members, two appointed by the AAEC and one each by Peko and EZ. Decisions of this committee were to require a unanimous vote (cl. 4 (a)).

(g) Subject to adjustments in respect of yellowcake required to meet contracts already made, or to replenish drawings by the companies from the Commonwealth stockpile, each company was to receive the net annual proceeds of 25 per cent of sales from the venture (cl. 6 (c), cl. 6 (d) and cl. 9).

(h) No allowances for interest charges on capital, or for depreciation of capital assets provided by the joint venturers, were to be made in calculating the net proceeds of sale of yellowcake (cl. 6 (e)).

(i) All sales of yellowcake from the project mine were to be effected by the AAEC as agent for the Commonwealth. The AAEC was required to sell output at least at world market prices with the object of maximising profitability and cash flow on a continuing basis'. The AAEC was to attempt to sell sufficient output, prior to commencing construction, to assist the companies to finance their capital contributions (cl. 7 (a)). This clause also stated that: 'By the time the treatment plant commences commercial production, the planned plant capacity shall, as far as practicable, have already been contracted for sale.'

(j) The AAEC was to determine the level of the uranium stockpile to be held, the quantity not to exceed the nominal capacity of the plant for three months of continuous operation unless otherwise agreed (cl. 8 (a)). If the AAEC was unable to sell on 'reasonable terms and conditions', the parties would confer in the Project Committee regarding continuance of operations (cl. 8 (b)). If the AAEC withheld supplies from the market for commercial reasons, the companies could, if this caused holdings to exceed the maximum level specified in cl. 8 (a), request that their share of production be sold at prevailing world prices. In such a case the Minister was to make the final decision, giving due consideration to financial hardship the companies might suffer (cl. 8 (c)).

(k) If uranium which had already been produced were withheld from sale in the national interest, an arbitrator would be appointed to determine the compensation (if any) to be paid to offset the effects on the companies' finances (cl. 8 (d)). The compensation was not to exceed the world market price for the uranium.

(l) In the event that one of the companies wished to assign its interest in the venture, the other company was to have a pre-emptive right of purchase. If the other company did not wish to exercise this right, the interest might be assigned to the Commonwealth or to a corporation nominated by the Commonwealth. If the AAEC wished to assign its interest, the companies had a pre-emptive right of purchase (cl. 10).

The Commission was informed that the present Government has considered an alternative arrangement under which the Australian Industries Development Corporation might take over the AAEC's role in financing the project. In this event, we were told, the AIDC would probably borrow funds in accordance with its normal practice. The AIDC would later relinquish its interest in the venture. The Commission was also informed that the Government had given some consideration to alternative marketing arrangements for Australian uranium generally. The Commission was told that the Government did not intend to give further consideration to, or make any final policy decisions regarding, these or other matters, including the management and marketing functions of the AAEC with regard to Ranger, until the Commission had presented its report.

The Ranger area

The Ranger Project Area, covering about 83 square kilometres, includes the area around the ore bodies Ranger proposes to mine and extends about 8 kilometres further north to include the south-eastern corner of Mudginberri pastoral lease. It is the area specified for the project in the Memorandum of Understanding of October 1975 between the Australian Government at that time and the Ranger joint venturers. The *Aboriginal Land Rights (Northern Territory) Act* 1976 exempts the Ranger Project Area from certain provisions of the Act (see Chapter 14). The southern boundary of the area runs close to Mt Brockman, and a small portion of the sandstone massif just north-east of Mt Brockman is included within it. The remainder of the Project Area is in the lowland subregion.

Ranger has applied for a Special Mineral Lease (S.M.L.) covering 28.7 square kilometres in the southern part of the Ranger Project Area; the mining activities are planned to occur within this area. In the remainder of this Chapter we frequently refer to the 'mine area'; by this we mean the area covered by the S.M.L. application.

The southern boundaries of the project area and proposed lease are close to the Aboriginal sacred sites, Djidbidjidbi and Dadbe, at Mt Brockman. It was suggested during the Inquiry that the proposed lease boundary was too close to these sites. This matter is considered in Chapter 15.

Mining operations

The evidence before the Commission shows that the proposed mining procedures conform in general with standard practice for open cut mines. As in other uranium mining operations, special precautions against radiation hazards will be needed if mining goes ahead; the precautions proposed for the Ranger mine are discussed in this chapter under the heading **Radiation**. According to the company's plans, ore and waste rock would be broken out by blasting and loaded into haul-trucks using diesel-driven, rubber-tyred loaders or, possibly, electric or diesel-powered face shovels.

Most of the uranium ore in the No. 1 ore body consists of relatively simple uranium oxide minerals, dispersed in rock. However, the uppermost weathered layer contains about 900 000 tonnes of lateritic ore, which has somewhat different leaching and settling characteristics from the bulk of the ore (described as the primary ore). Ranger's plan is to stockpile the lateritic ore and feed it to the treatment plant mixed in controlled proportions with primary ore. Three smaller stockpiles of high, medium and low grade ore would also be established, to enable a blend of constant grade to be fed to the treatment plant. These are referred to as the surge or buffer ore stockpiles.

The waste rock would be placed on a dump which, on completion of mining Nos 1 and 3 ore bodies, would cover an area of about 100 hectares and rise to a height of 100 metres above the surrounding country.

Mill operations

Milling converts uranium ore to yellowcake, which is more than 90 per cent U_3O_8. Briefly, the process involves crushing and grinding the ore, dissolving out the uranium by leaching, extracting the uranium from the leach solution, and precipitating, separating, drying and calcining it to yield the commercial product, yellowcake.

Incoming ore would pass through three crusher stages, reducing it from a maximum size of 1.5 metres across as delivered from the mine or stockpile to particles less than 20 millimetres. It would then be mixed with water and fed continuously to a series of rod and ball mills. The finer material from the grinding mills would be separated from the coarser in 'cyclones'. The coarser material would be returned to the mills for further grinding, while the suspension of finely ground ore would be thickened to a slurry, ready for leaching, consisting of 60 per cent solids and 40 per cent water.

The Commission was told that two methods of leaching had been considered, one using sulphuric acid and pyrolusite (mineral manganese dioxide) and the other using alkaline carbonate. The sulphuric acid process had been chosen because the nature of the rock containing the ore made it less expensive than the alternative at Ranger. An advantage claimed for the acid process is that less of the radium in neutralised tailings from the mill would be in a soluble form, able to enter the environment in seepage from the tailings dam. A disadvantage is the emission of sulphur dioxide from the plant making the sulphuric acid. That problem is discussed in this chapter under the heading **Air pollution**.

It is proposed that the leaching be carried out in a series of vessels, called pachuca tanks, in which the mixed ore slurry and leaching liquid would be continuously agitated by air. Ore would be held in the leaching pachucas for more than twenty hours, and it is expected that 90 per cent or more of the uranium in the primary ore and rather less (80 to 85 per cent) in the lateritic ore would be dissolved.

The next treatment stage would be to separate the uranium solution from the slurry. A series of five settling tanks, called thickeners, is planned for this operation. In such thickeners, acid liquors, initially free of uranium, flow above and in the opposite direction (counter-current) to the slurry. The acid liquors wash the dissolved uranium and some other metals from the slurry, and slowly revolving rakes move the settled solids to the centre of the base of the tank. The acid solution containing the uranium flows from the rim. It is anticipated that only 1 per cent of the dissolved uranium would remain mixed with the slurry as it left the fifth thickener tank.

The slurry of residual solids from the thickeners would constitute the tailings. Initially these would be acidic, but the company's proposal is to neutralise them by adding lime, making them slightly alkaline (pH8), before discharging them by pipeline to the tailings dam.

The acid solution recovered from the thickeners would contain other metals as well as uranium. The next stage in the proposed treatment is extraction of the uranium from this solution. Practically all remaining solids would first be removed by settling and filtration. Then the liquid would be mixed with an organic chemical (a tertiary amine) dissolved in kerosene. The uranium would transfer to the organic solution, leaving the other metals in the acid solution. It is proposed that this process be carried out in a series of four 'mixer-settlers', each consisting of a mechanically agitated tank, in which the organic solvent and the metal-bearing solution would be mixed, and a large shallow settling tank where they would be separated by gravity after the uranium had transferred to the organic solution. Next the organic solution would be passed to a second series of four smaller mixer-settlers where it would be mixed with a solution of ammonium sulphate. The uranium would transfer to this final solution, where it would be about thirty times more concentrated and of a much higher purity than it was in the initial acid solution.

It is intended that, at each stage of extraction, solvent from which uranium had been removed would be recycled back to the previous stage. Complete recycling is planned for the organic solvent. The proposal provides for 10 per cent of the acid solution from the extraction stage to be replaced by fresh solution after each use, to prevent too great a build-up of dissolved metals. The discarded solution, with its load of dissolved metals, would be neutralised and discharged with the tailings.

The next stage in the production of yellowcake would involve introducing ammonia gas into the ammonium sulphate solution now containing the uranium. The uranium would be precipitated as a yellow solid, ammonium diuranate. The solid would be separated and washed in a settling tank and then filtered and washed in a centrifuge. Then it would be pumped to a furnace where it would be converted to a mixture of uranium oxides (calcined) by heating in air to a temperature of 650° to 800°C. Ranger expects that the final dried solid, known as yellowcake, would contain up to 92 per cent U_3O_8. The yellowcake would be crushed in a small hammer mill, turning it into a coarse powder. It would be moved to a storage bin, and then to a packing bay where it would be packed in 200 litre steel drums, each holding 450 kilograms of yellowcake.

Gases driven off in the furnace would include steam, ammonia and some sulphur oxides. Yellowcake dust would be produced during crushing. The company proposes to install a wet scrubber system which would remove most of the yellowcake, ammonia decomposition products and sulphur oxides before the exhaust gases were discharged to the environment.

Plans for transporting the yellowcake product are not yet finalised. However, the drums would probably be containerised and sent by road to ports in eastern Australia.

Tailings dam and other structures

The proposed layout of the S.M.L. area is shown on Map 12. The most important construction work, apart from the mine pits and the mill, would be the tailings dam. This would be located on the upper part of Coonjimba Creek and would cover an area of about 125 hectares. The dam embankment would go right round the perimeter of the tailings storage area, with a total length of about 4 kilometres and a height above ground level when completed ranging between 16 metres and 30 metres. The storage area would be about 100 hectares.

Ranger proposes that the embankment be of earth and rock fill construction, built in a number of zones. On the face nearest the tailings there would be an earthfill zone of relatively impervious clayey material, termed the impervious core. The other zones, which would be much thicker, would consist of more pervious earthfill and rock. Materials for all the zones would be obtained in the course of opening up No. 1 and No. 3 ore bodies. Before construction started, all soil would be excavated along the embankment alignment down to a low permeability layer in weathered rock. The resulting trench, called a cut-off trench, would be filled with the material used for the impervious zone of the embankment. Where the trench crossed more permeable and fractured areas, cement would be injected under pressure into the rock, a process known as grouting, to a depth of 40 metres. This should reduce seepage from the tailings dam.

Under Ranger's proposal, the height of the dam embankment would be progressively raised in six stages over a period of twenty years from the start of construction on the site. The aim of the staged construction would be to ensure that there was always an adequate height of embankment above the water surface in the dam. When the dam was completed, it would be able to hold 27 million cubic metres of settled tailings. This would be sufficient to accommodate all the tailings from No. 1 ore body, but if No. 3 ore body were mined, a total tailings storage capacity of about 45 million cubic metres would be required. Ranger stated that the necessary additional capacity would be obtained by raising the height of the tailings dam a further 10 metres, by building a second tailings dam on an area immediately south of the first dam, or by discharging tailings into the No. 1 pit. The company said that its choice between these three alternatives would depend mainly on economic considerations.

Tailings would be pumped from the mill to the dam through a heavy duty polythene pipeline about 2.6 kilometres long. The route would run around the southern rim of the No. 1 pit. The area through which the pipeline would run drains towards Georgetown Creek (see Figure 4). An embankment with a sluice would be built alongside the pipe, on the Georgetown Creek side, and the sluice could be closed if any leakage from the pipeline occurred. Tailings would be discharged into the dam from a floating pipeline attached to a moveable pontoon, so that a build-up of solid tailings material in any part of the dam could be avoided.

The other major structures on the site, apart from the rock dumps which we have discussed, would be three small compacted earth dams forming retention ponds. These would collect contaminated water draining from various parts of the mine and mill area. Retention pond No. 1 would be built across Coonjimba Creek and retention ponds Nos 2 and 3 across Djalkmara Creek (see Map 12). The proposed operation of the tailings dam and retention ponds is described below under the heading **Proposed water management program**.

Sulphuric acid and other supplies

The acid leaching of uranium ore requires large quantities of sulphuric acid. It is proposed that this acid be made from sulphur in a sulphuric acid plant on the site, with a capacity to produce up to 165 tonnes a day of 98 per cent strength sulphuric acid. The proposed process converts sulphur to sulphur dioxide and then sulphur dioxide to sulphuric acid. The method of conversion to sulphuric acid is about 98 per cent efficient, and it is intended that the unconverted sulphur dioxide be released to the atmosphere. This would result in the release of about 2 tonnes of sulphur dioxide (containing 1 tonne of sulphur) per day. The company intends to import sulphur as bulk cargo, probably from North America, through the port of Darwin, and transport it by road to Jabiru. The operation of the treatment plant at a production rate of 3000 tonnes of U_3O_8 a year would require about 38 tonnes of sulphur each day as sulphuric acid. It is proposed that the sulphur, probably in a pelletised form to reduce dispersion of sulphur dust, be stockpiled in the open at both Darwin and Jabiru. The stockpile at the treatment plant would hold some 2000–5000 tonnes of sulphur.

Consideration was given to the option of importing sulphuric acid to the treatment plant; this would eliminate release of sulphur dioxide to the atmosphere. The Commission was told that this idea had been rejected mainly because of transport costs. The acid weighs three times as much as the sulphur from which it is produced. Also it presents hazards and difficulties in storage and handling.

About 85 tonnes of lime per day would be required for the neutralisation of tailings. The company hopes that, if the mine goes ahead, a limestone quarry will be established somewhere in the Darwin region which would supply the lime under contract. The alternative proposed is to import the lime in bulk through the port of Darwin. The lime would be transported to the treatment plant by road and transferred to a storage bin.

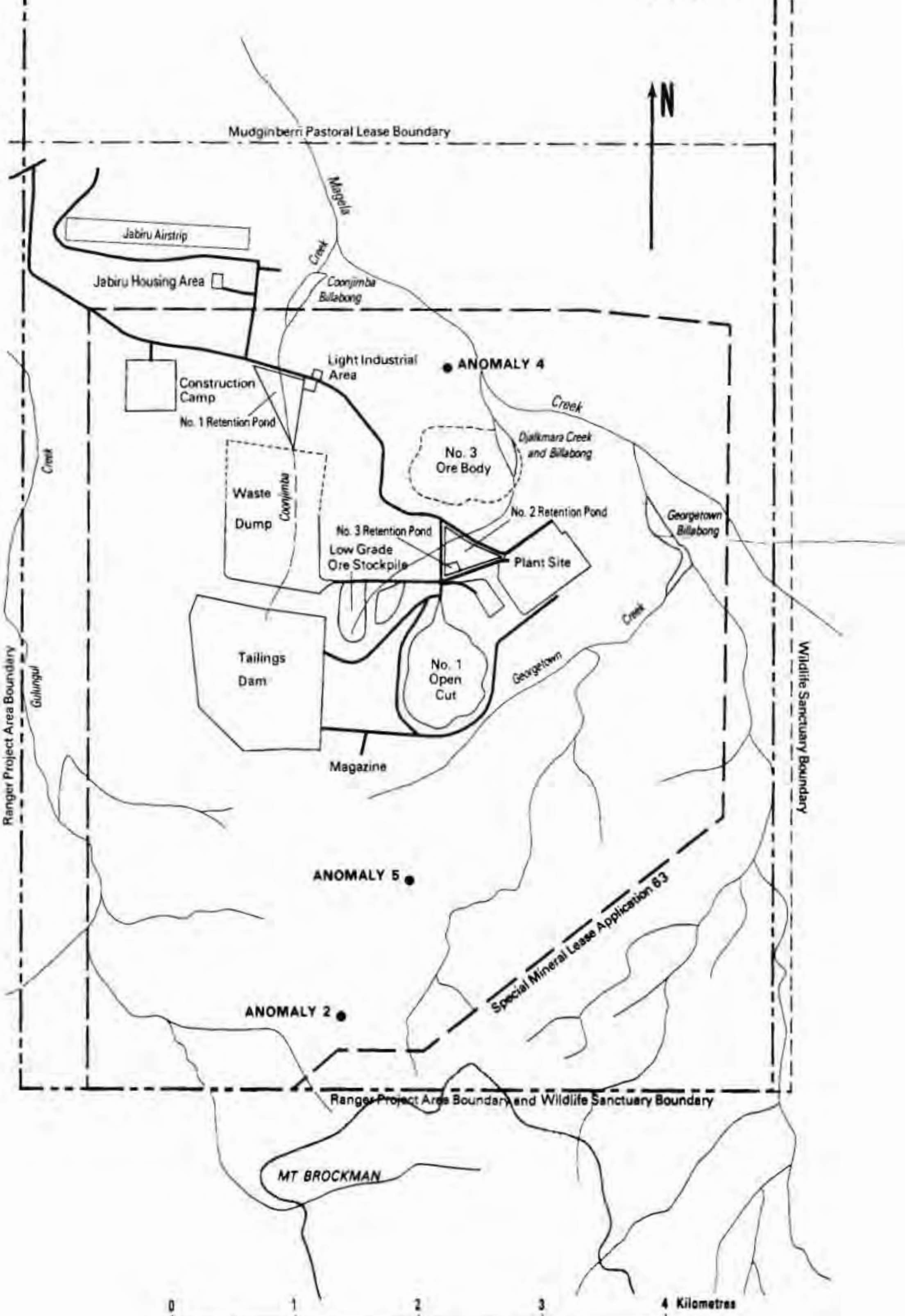
The pyrolusite needed for yellowcake production would be expected to come from the manganese mine on Groote Eylandt, in the Gulf of Carpentaria. It would probably be shipped from there by barge to Darwin and taken by road from Darwin to Jabiru. About 19 tonnes per day would be required.

About 2½ tonnes per day of ammonia would be needed in the mill. It is proposed that liquid ammonia be transported by road tanker to Jabiru and stored under pressure in small tanks isolated from the treatment plant.

Other materials would be used in quantities totalling a few tonnes per day. These materials would include steel balls and rods for the grinding process, kerosene and amine for the organic solvent, and flocculents for use in the thickeners, all of which would be brought to the site by road.

Explosives for blasting in the pit would also be brought in by road. It is expected that the main explosive used would be a mixture of ammonium nitrate and fuel oil, but several other types might also be used in special circumstances. It is proposed that the explosives be stored in a magazine located about 600 metres from the No. 1 pit, and somewhat closer to the wall of the tailings dam.

MAP 12



Map of Ranger Site

NMP 76/221.10

Compiled from Map 3.6.1, 3.8.1 and 4.7.1 of the Ranger Uranium Mines Pty Ltd Environmental Impact Statement

Diesel fuel, fuel oil and petrol would also be brought in by road from Darwin.

Operation of the mine and mill would require a maximum electricity supply capacity of 7.4 megawatts. It has not yet been decided whether the power would be generated at the site or drawn from the Darwin supply, which would require the construction of a transmission line. The Commission was told that the combined demand for electric power from the Ranger project and accommodation for the Ranger and associated workforce would equal about one-fifth of the present output of Darwin power station. We were told that plans are now being prepared for the construction of a second power station in Darwin, and that when the new station starts operating early in the 1980s there will be no difficulty in meeting the anticipated demand from Ranger. It is expected that the cost of the new station will be covered by charges to consumers, including Ranger if it draws on the station's output, in the normal way.

The Northern Territory Port Authority gave evidence that, because of the growth in cargo, a new general cargo wharf costing about $8 million would soon be required in Darwin if expensive delays in the handling of cargo were to be avoided. The development of Ranger would contribute to the growth in cargo, but the Authority's evidence indicated that the new wharf will be required even if uranium mining does not proceed. It is proposed that dry bulk cargoes, such as lime, be handled by the bulk unloading facility to be built in conjunction with the new Darwin power station.

Effects of doubling production capacity

The mining and milling operations as described would be capable of producing 3000 tonnes of U_3O_8 (equivalent to 2540 tonnes of uranium) in yellowcake per year. The company has stated that it would increase the production rate to 6000 tonnes of U_3O_8 (5100 tonnes of uranium) per year if and when market conditions allowed, and is retaining the option of building the mill to operate at a capacity of 6000 tonnes per year from the outset.

At a production rate of 6000 tonnes per year the main difference, so far as mining is concerned, would be that ore and waste would be extracted twice as fast. The numbers of drills, front end loaders and trucks would be increased. However, there would be no change in the final size of the pits or the waste rock dump.

At the treatment plant no change would be made in the design of the crushers, but they would operate for an increased period each week. The number of rod mills and ball mills would be doubled, as would the number of leaching pachucas. The number of thickeners would be doubled if the mill's capacity was increased to 6000 tonnes per year, but if it was built initially for the higher capacity larger thickeners would be installed and the number would only increase by one. The solvent extraction circuit would be duplicated regardless of when the higher capacity was installed. The rest of the processing sequence, consisting of stripping, precipitating, centrifuging and calcining, and the sulphuric acid plant, would be duplicated if production were initially 3000 tonnes a year, but scaled up if initial production were 6000 tonnes a year. The company's proposals for acid production sufficient for the higher production rate include steps to reduce sulphur dioxide output from the amount that would result if the smaller acid plant were simply duplicated. The demand for electric power would be approximately doubled. Since tailings would be produced at twice the rate, the rate of construction of the tailings dam would also have to be doubled.

Non-radiological hazards to workers

The operation of the proposed Ranger mine would involve the types of industrial health problem, largely deriving from various kinds of accidental injury, associated with any large open cut mine. Among the most important of these are accidents involving motor vehicles and mobile equipment, accidents with blasting explosives and rockfalls in the pit. Noise would be a health hazard to operators of drills and other equipment. Radiological hazards peculiar to uranium mining would also be present. These are discussed later in this chapter under the heading **Radiation**.

Most of the health hazards arising within the ore treatment plant would be similar to those which arise in many types of mining and processing operations not concerned with radioactive materials. These include noise, and accidents involving conveyors, drive belts and moving machinery, fuel fires and electrical accidents. Certain non-radiological hazards to workers call for special comment. These are hazards arising from ore dust produced during crushing, from yellowcake dust in the calcining and packaging operations, and from fire and explosions at various points. As in mining, there would also be radiological hazards.

Risks to workers could arise from the escape of liquid materials at various stages as a result of pipework failures, overtopping of tanks or other causes. The materials being used and processed would not, for the most part, be highly toxic, so leaks or spillages would generally not be a serious hazard to workers. However, accidents during the transport, handling and storage of some of the materials used in the mill, such as concentrated sulphuric acid and ammonia, might be a greater hazard.

Liquids spilt in the mill could cause serious water pollution problems. For this reason, Ranger proposes to surround those parts of the plant where leaks and spillages might occur, such as the acid leaching and solvent extraction stages, with systems of embankments and sumps to prevent the liquid spreading.

Material emitted to the atmosphere would include acid mist from the leaching pachucas, lime dust, sulphur dust and pyrolusite dust. Leakages of ammonia also could occur. The evidence indicates that the effects of these would be small and almost entirely localised within the area of the plant. The more important emissions would be sulphur dioxide and radon, both of which could have an impact beyond the plant boundaries as well as within them. They are discussed in this chapter under the headings **Air pollution** and **Radiation**.

Fire and explosion hazards

Since the solvent extraction stage of processing would involve the handling of kerosene and other inflammable chemicals in relatively large amounts, there is an obvious risk of fire. A proportion of the organic solvent in the plant would contain dissolved uranium, and a fire could disperse uranium compounds in smoke over the mine area and beyond. This could cause serious lung damage. Such a fire would also damage the plant. To reduce the extent of damage should a fire occur, and to reduce the risk of fire starting, the company proposes to separate the solvent extraction stage from the rest of the plant as a restricted area and to equip it with fire-fighting equipment and protection from lightning.

There appears to be a small possibility of an explosion in the calciner, resulting from a fault in a burner producing an explosive mixture of oil vapour and air. This could occur even if the correct start-up and operation procedures were followed. Such an explosion could cause loss of life, and disperse up to 4 tonnes of yellowcake over an area of several hectares. The Commission recommends that a test procedure be developed for use during start-up, and after any interruption to operation of the calciner, however short, in order to ensure that the burners are operating properly before ignition.

The sulphur stockpile is another area of the plant where fire could occur. A sulphur fire can be started by sparks or a lighted cigarette butt. The company proposes to install fire hydrants around the heap of sulphur and prohibit smoking in the area. The Commission agrees with these proposals and recommends in addition that the sulphur heap be surrounded by an embankment. It is proposed to handle the sulphur in a pelletised form which, coupled with open air storage, should effectively eliminate the risk of sulphur dust explosions. It should also eliminate air, soil and water pollution from wind-blown sulphur.

Ore dust Particles of ore dust small enough to be taken into the lungs are a health hazard for two reasons. First, because many of the minerals in the ore contain silica, the dust is capable of causing the serious lung disease, silicosis. Secondly, the hazard is aggravated by the radioactive content of the ore and, in particular, the presence of alpha-emitting radionuclides, which appreciably increase the risk of lung cancer. The hazard would be greatest for workers in the mine and the treatment plant, but there would also be a lesser hazard to the local population in the vicinity of the mine, who may be exposed to wind-blown dust. The radiation risk is discussed in the **Radiation** section of this chapter.

The main sources of ore dust would be drilling, blasting and loading in the open cuts, ore haulage to the treatment plant, and tipping, crushing, conveying and storage of ore at the treatment plant. The Commission was told that there would be no workers in the pit when blasting took place. The explosions would be carried out by remote control at regular times daily—probably lunch-time, mid-afternoon or end of day when night-time temperature inversions had cleared and atmospheric conditions favoured rapid dispersion of the dust.

Operators of loaders, large drills and haul-trucks would be in enclosed cabs, so they should not be exposed to large amounts of dust. During blasting, which generates a particularly large volume of dust, workers should be remote from the area. The workers most exposed to a dust hazard seem likely to be secondary drillers, working in the open to break up large pieces of broken rock. It is proposed to control the dust hazard to this group by the use of wet drilling, possibly aided by a wetting agent.

In the treatment plant it is proposed to use a fan ventilation system to prevent the build-up of hazardous ore dust or radon concentrations. The extracted air would be passed through a water scrubber, designed to remove most of the dust, before being discharged to the atmosphere. The collected dust would be put into the leaching pachucas. The plant has been designed so that failure of the scrubber would cause the conveyor system to shut down automatically. Also, a closed circuit TV surveillance system would be installed, covering the conveyor system, with the aim of forestalling excessive exposure of workers to dust. In open areas water sprays carrying a wetting agent would be used to suppress dust.

Doubling the rate of production of yellowcake from 3000 to 6000 tonnes of U_3O_8 per year could be expected to roughly double the quantity of dust produced. However, for some operations including crushing and ore transfer, the increase in dust production would probably be rather less.

Dust would also be raised by traffic on unsealed roads in the mine and treatment plant area. Although this dust would not be as hazardous to health as ore dust, it would constitute a nuisance and should be minimised. The company proposes to suppress this dust using fixed sprays in the treatment plant area and by watering other roads from a tanker several times a day.

The various methods proposed for the control of ore dust should ensure that working conditions in the pit and in the vicinity of the crushing plant were safe in the light of present knowledge, provided that the measures were rigorously applied. However, the Commission wishes to stress that all aspects of dust control must be kept under constant review. If experience, either in Australia or abroad, indicates that modifications to plant or operating practice would be desirable for the protection of health, then such modifications should be implemented promptly. Ranger has stated that the climate of the Region is such as to make it desirable for enclosed cabs on mobile machinery to be air conditioned for part of the year, but it has yet to make a decision on whether to install air conditioning. Having regard both to the desirability of reducing the dust hazard and to the general advantages of increased operator comfort and health, the Commission recommends that all large mobile plant be equipped with air-conditioned cabs.

Yellowcake dust

The handling, crushing and packaging of calcined yellowcake give rise to yellowcake dust, which is mildly radioactive. Yellowcake is also chemically toxic if ingested. Ranger plans to use a ventilation system to keep concentrations of the dust below hazardous levels in areas where yellowcake is handled. The exhaust gases would pass through a wet scrubber before being released to the atmosphere. This should trap most of the yellowcake dust, but it was stated that up to 2.2 kilograms per day would not be trapped and would be vented to the atmosphere and lost. Given the value of yellowcake, this is a surprisingly large loss and it may well be that a more efficient dust collector could be justified on economic grounds. This matter is discussed further in Chapter 7.

The company anticipates that the efficiency of the ventilation system in normal operation would be such that workers would not need to wear protective clothing. However, more stringent precautions would be necessary when equipment was being cleaned before being repaired.

Possible hazards from blasting

Concern was expressed during the Inquiry that blasting operations in the mine pits might damage the sandstone cliff face of Mt Brockman. No. 1 ore body is about 3 kilometres from the cliff and No. 3 ore body about 4.5 kilometres. Damage could be caused by either ground vibration or air blast.

It is anticipated that the heaviest charge set off in mining No. 1 ore body would be 5 tonnes of explosives and that it would break up about 20 000 tonnes of rock. In normal operations such a total charge would be fired as a sequence of four or five charges, timed to detonate at intervals of 23 to 33 thousandths of a second. This technique reduces ground and air vibrations, as well as improving rock fragmentation. It is possible, but improbable, that simultaneous detonation of the whole charge could occur accidentally.

The evidence is to the effect that ground vibration from blasting in the proposed No. 1 and No. 3 pits poses no threat to Mt Brockman. If the maximum charge were exploded in stages as planned, the formula specified by the Standards Association of Australia Safety Code gives the farthest distance at which a disturbing ground vibration could occur as less than 600 metres. This is assuming the worst possible ground conditions. In the event of simultaneous detonation, disturbing ground vibration could occur at up to 1.2 kilometres. A disturbing vibration, as defined in the code, is considerably less than the level of vibration expected to cause structural damage in a building. Blast strengths might have to be reduced if the No. 2 anomaly were mined, because it is less than 1 kilometre from Mt Brockman. The Commission was told that accurate ways of predicting ground vibration due to blasting in an area, based on measurements of the vibration produced by small test blasts, had been devised. Tests of this type should be carried out on site before any mining begins.

The air blasts produced by detonations, measured as noise, appear to pose greater risks than ground vibration. According to calculations presented to the Commission, the air blast effect at the Mt Brockman cliff face produced by 5 tonnes of explosive with controlled delay sequence timing would be more than half that of a direct lightning strike (something to which the cliff is often exposed, though only a part of the cliff face is affected to the maximum extent by any particular strike). Using another comparison, it would be sufficient to produce cracks in the masonry building structures of basic design used in setting standards for vibration tolerance. The Commission notes with concern that, for the unlikely event of simultaneous detonation of the whole charge, the calculated air blast effect at the Mt Brockman escarpment is two or three times that capable of producing cracks in buildings of basic structure and is comparable with that resulting from a direct lightning strike. Some recommendations intended to reduce the risk of damage from air blast vibrations are made in Chapter 7.

The possibility that the explosive stored in the magazine might be accidentally detonated was raised in evidence. The Ranger plan envisages that the magazine would be located between the No. 1 pit and the tailings dam, about 400 metres from the wall of the dam and 2500 metres from Mt Brockman. If 25 tonnes of quarry gel were stored in the magazine and detonated, either accidentally or deliberately, some damage might be caused to the cliff face. Damage to the tailings dam might be considerable. The possibility, remote though it is, that the magazine might explode and cause such damage is a matter of concern to the Commission. We consider this matter further in Chapter 7.

Erosion and other effects on the mine development site

Removal of vegetation, disturbance of soil and destruction of wildlife habitats over about 500 hectares, with some indirect disturbances to the remaining 400 hectares of the mine site, are inevitable if mining and milling proceed. The site is not distinctive; its open forest and woodland vegetation, and the associated wildlife, are typical of large expanses of lowland country near the escarpment. However, some rare birds of the escarpment forage on nearby lowland areas and probably on this site.

The low gradients and natural protective covers of vegetation, gravel or rock in lowland areas like the mine site normally keep erosion rates low. However, disturbance of areas for construction purposes could initiate rapid soil erosion. Even undisturbed soil in the area is sensitive to erosion at the beginning of the wet season if the vegetation cover has been reduced during the dry season by grass fires or heavy grazing.

The possibility that aquatic ecosystems might be damaged by eroded material washed into them was referred to in evidence. It was suggested that damage might be done to stream bed habitats and to fishes and invertebrates, and that photosynthesis by aquatic plants might be reduced. The normal sediment load in the Magela system is low during the period of flow. Increases in suspended material occur in billabongs in the dry season, but these are due more to disturbance of the static water bodies than to the addition of material.

The evidence indicates that, if the Ranger development proceeds, soil erosion could result in substantial quantities of sediments entering the drainages and billabongs on the site and eventually Magela Creek unless special care is taken. Ranger proposes to limit erosion by restricting most construction work to the dry season. It plans to build the retaining embankments for retention ponds Nos 1 and 2, across Coonjimba and Djalkmara Creeks respectively, at the start of construction operations; these are intended to act as traps for material eroded from earthworks. The company stated that, to minimise erosion, it would keep clearing of vegetation to a minimum and restrict traffic to recognised roadways. Revegetation of the waste dump would commence as soon as possible, and slopes which could not be revegetated would be protected from erosion by rock.

The initial construction phase would probably span at least two wet seasons and, for periods in each, bare ground and steep embankments could be exposed. Furthermore, the embankments of the tailings dam would be raised in stages during the life of the mine, creating new occasion for erosion.

In view of the rapidity with which early wet season rains can initiate soil erosion, especially on slopes of about 10 degrees or more, the Commission believes that strict control procedures will be essential if the development proceeds and that appropriate provisions should be explicitly included in any mining lease. Since one of the functions of the retention ponds would be to act as traps for eroded sediments, they would gradually silt up and it might be necessary to dredge them out from time to time. We recommend that all solid materials removed from the retention ponds be placed in the tailings dam.

Disturbance of land surfaces can have two harmful effects in addition to encouraging erosion. The first and more important is the establishment of breeding habitats for species of mosquitoes capable of transmitting human diseases, particularly malaria. These can form in wheel tracks as well as in and around construction areas. The second is the opportunity provided by bare ground for invasion by weed species. Appropriate control measures will be necessary if mining proceeds. All bare areas should be revegetated quickly.

WATER POLLUTION

The possibility that contaminated water from the mine site might cause environmental damage downstream was one of the main arguments advanced against the proposal during the Inquiry. The Commission received much evidence on these risks, most of it pointing to the conclusion that insufficient information exists to enable the possible impact of the proposal on the Magela drainage system to be predicted accurately.

In dealing with the question of water pollution, and also with matters considered later in this chapter under the headings **Radiation** and **The situation after mining**, the Commission encountered a general problem of inaccuracies and inconsistencies in the data which were presented, and lack of data on some important questions. This is in no way a reflection on the scientific competence or diligence of the witnesses giving the evidence, but simply a reflection of the relatively small scientific effort that has so far been applied to studies of the very complex environment in the Region. Data contained in most of the Tables have been taken without alteration from what the Commission considered to be the most suitable evidence presented to it. While the data have been selected carefully, the Commission did not think it desirable to modify them, although in a few cases, which we mention, the data were expanded or augmented by the Commission's own calculations. At the foot of the Tables we mention the witnesses on whose evidence we drew in compiling them. At some places in the text where numerical information is quoted and it appears necessary to state the source, we do so, but at other places we do not.

Uncertainties include:

- the types of contaminants and the amounts and chemical forms of those that will be released if mining goes ahead;
- changes in the toxicity of contaminants with time and as they move to different parts of the Magela system, and their eventual destinations;
- the sensitivity of different organisms to toxic substances and the influence of factors such as temperature changes on this sensitivity;
- the consequences to the whole Magela ecosystem, in contrast to individual organisms, of added contaminants; and
- the extent of non-toxic effects such as eutrophication.

However, a broad assessment of the environmental risks can be made and controls proposed which should keep the risks to a minimum. In making this assessment, the Commission has sought to identify all possible risks. It has adopted a conservative approach in the belief that, where uncertainties exist, caution is essential.

Proposed water management program

If mining and milling proceed in the manner proposed by Ranger large amounts of contaminated water will leave the mine site. This water would be runoff and seepage from the ore stockpiles and waste rock dump, water pumped from the mine pits, seepage and runoff from the tailings dam, and runoff from other parts of the site.

The company has proposed a water management program, which it says has three basic aims:

- to control runoff and seepage from the mine, mill, waste dump and ore stockpiles in a manner largely preventing release of contaminated water except at times when it would be unlikely to cause deleterious environmental effects;
- to prevent siltation of the creek systems by retaining material eroded from the dump and stockpiles behind earthfilled dams; and
- to make water available for ore processing and covering the tailings as it is required. Water collected in the wet season would be stored for use during the dry season, and it is intended to maintain a minimum depth of 2 metres of liquid over the solid tailings in the tailings dam throughout the year to minimise radon and dust emissions.

The essential features of the proposed water management scheme are three retention ponds, from which some releases to the environment are planned, and a closed circuit carrying water between the tailings dam and mill. No water would be released intentionally from this circuit, but some seepage from the tailings dam would be inevitable.

The detailed operation of the water management scheme would vary from year to year with variations in climatic conditions. It is, however, possible to give a broad description of the scheme and to highlight management options.

Runoff and seepage from the waste rock dump area and the northern part of the tailings dam would be collected by retention pond No. 1. Retention pond No. 2 would collect runoff and seepage from the mill area, the low grade and lateritic ore stockpiles, and the eastern part of the tailings dam. Retention pond No. 3, adjacent to retention pond No. 2, would receive water pumped from the mine pits, runoff from the stockpiles of ore ready for the mill, and any other highly contaminated water.

Water from retention pond No. 1 would normally be released directly to

Coonjimba Creek, but it could be transferred to retention pond No. 2 or directly to the mill circuit if high contaminant concentrations made this desirable at any time. The water collected in retention pond No. 2 is expected to be of considerably poorer quality than that in retention pond No. 1. The scheme provides for it to be used in the mill, and for any excess to be released to the environment during restricted periods of high creek flow when conditions are favourable for adequate dilution. Release would be by pumping through a pipeline to two outlet structures placed in Magela Creek.

All the water collected in retention pond No. 3, expected to be of still poorer quality, would be used in the mill circuit in the early years of mining. The Ranger company expects that, after about two-thirds of the No. 1 ore body has been mined–probably about eight years after mining begins–it might be necessary to discharge some to Magela Creek via retention pond No. 2, because of increases in the volume of water collecting in the pit.

Runoff and seepage from other sections of the S.M.L. area, mainly to the south and west, and including the south and west sides of the tailings dam, would normally be uncontrolled, although some control could be exercised if needed over runoff from the tailings pipeline area.

The process water circulating between the mill and tailings dam would have high contaminant concentrations. None would be intentionally released, but replenishment would be necessary because of evaporation and seepage from the tailings dam. In the Region annual evaporation is probably always greater than annual rainfall. At times when the supply from retention ponds No. 3 and No. 2 was insufficient, bore water would be added to the circuit.

After the mine had been operating for five to eight years, the operation of the retention ponds would be broadly as follows in years of average rainfall:

- All runoff during the first weeks of the wet season (November to December) would be retained, some of it going to make up stocks of process water.
- The rest of the collected water, together with all further runoff occurring during the wetter months (January to mid March), would be released subject to the various release controls.
- End-of-wet-season rainfall (mid March onwards) would be retained to ensure the supply of water for the mill–tailings dam circuit in the following dry season.

Operations during the wet season would need to balance the conflicting requirements to release sufficient water from retention ponds No. 1 and No. 2 so that these ponds could contain heavy runoff which might occur in the late stages of the wet season, and at the same time to retain enough water at the end of the wet season to supply the mill circuit during the subsequent dry season. Releases would not be made at the end of the wet season, because of the greater risk then that contaminants would be retained in the Magela system through the following dry season. We recommend that a computer program incorporating, among other things, long-term climatic records be used as a tool to assist in deciding when releases may be made.

Estimates of contaminated water releases during mining

The Ranger company provided estimates to the Commission of the volumes of water involved and their contaminant concentrations. Aided by a submission reviewing the accuracy of the predicted contaminant levels and by several submissions dealing with tailings dam seepage volumes, the Commission has reviewed all the data and selected those it regards as the best available.

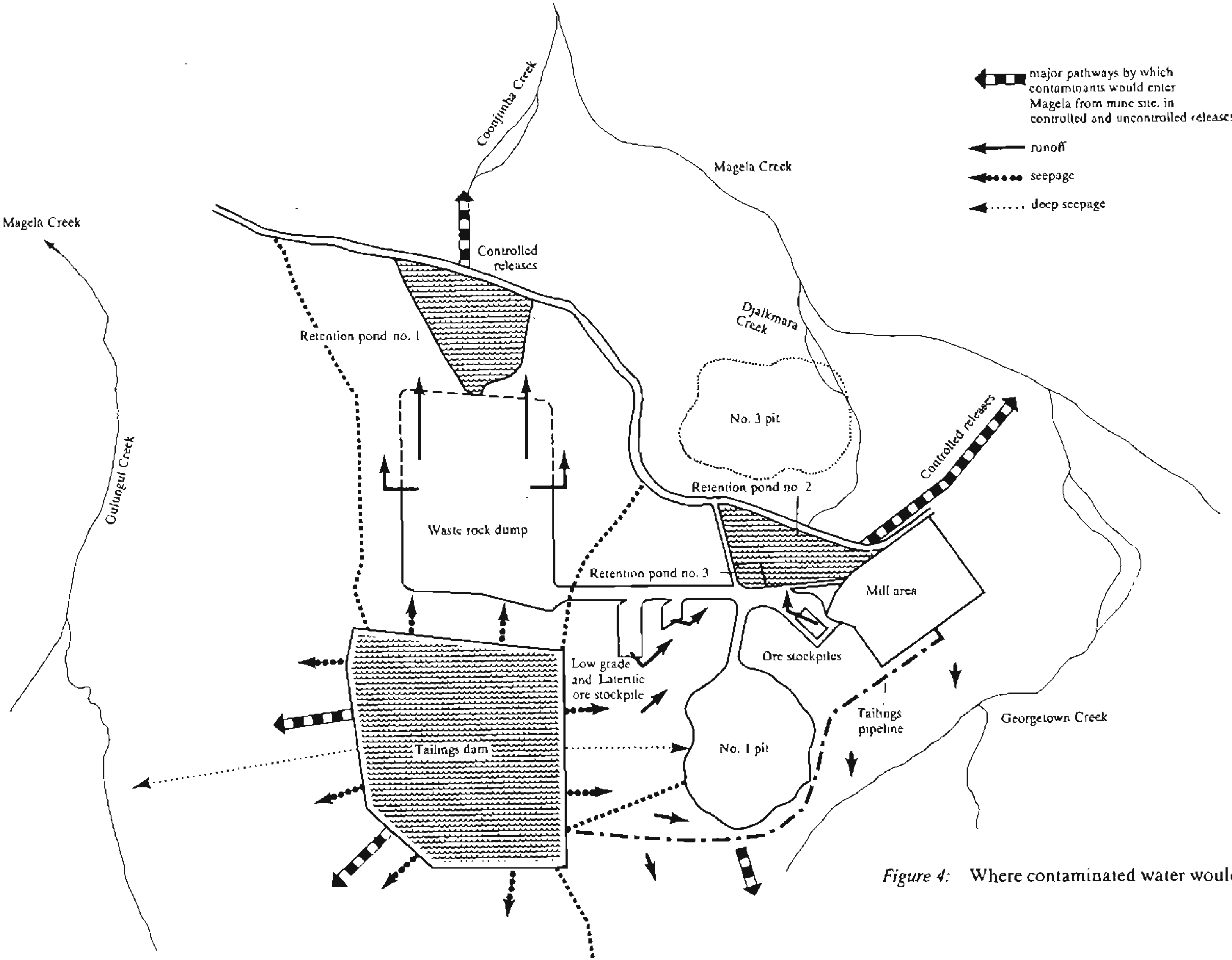


Figure 4: Where contaminated water would go.

It must be stressed, however, that the real situation will become apparent only when mining commences, if it does so. The available data are only estimates subject to considerable uncertainty. The Commission has sought to identify, and where possible quantify, the major areas of uncertainty.

The company used a hydrological model of the developed mine site to calculate quantities of runoff and seepage water leaving by four routes:

- as intentional discharges from retention pond No. 1 to Coonjimba Creek;
- as intentional discharges from retention pond No. 2 directly into Magela Creek;
- as seepage from the tailings dam towards Gulungul Creek; and
- as runoff from the tailings pipeline area into Georgetown Creek.

Coonjimba, Gulungul and Georgetown Creeks all flow into Magela Creek. The estimates, shown in Table 7, indicate that controlled discharges should greatly exceed uncontrolled releases.

Although the Commission received no evidence to suggest that the calculated quantities are seriously in error, the model is largely untested, and the figures produced by it must be regarded as uncertain.

Probably the greatest uncertainty about quantities relates to seepage into the mine pits, which would occur at increasing rates as the pits were deepened. The consequences for the water management scheme would be important if the rate of seepage or the concentration of contaminants in seepage water was greater than estimated. Seepage volumes would depend on the extent and permeability of the fault zones in the pit areas, and these are largely unknown.

The estimates of contaminant concentrations seem, in general, to involve a considerably greater degree of uncertainty than those of water volumes. Part of the reason is the difficulty of predicting the end result of the complex and poorly understood physico-chemical processes involved, such as leaching and adsorption, in the field situation.

Contaminant levels were estimated using the same hydrological model, together with estimates of the quantities of contaminants generated in various situations. The latter, derived from a small number of field and laboratory

Table 7

Proposed and estimated annual volumes of water (m^3) leaving the Ranger site in a year of average rainfall

	Year 2	*Year 10*
Releases from retention pond No. 1	940 000[1]	1 230 000[1]
Releases from retention pond No. 2	370 000[1]	880 000[1,a]
Runoff and seepage in Gulungul buffer zone	220 000[3]	230 000[3]
Runoff and seepage in tailings pipeline corridor	160 000[3]	160 000[3]
Total	1 690 000[b]	2 500 000[b]

Sources: (1) Evidence of J. A. Yeates
(2) Evidence of D. R. Davy
(3) Exhibit 208

Notes: (a) Between 100 000 m^3 and 230 000 m^3 of this would be mine pit water (evidence of J. A. Yeates and Exhibit 208).
(b) This total excludes an estimated 25 000 m^3 entering the lower part of Djalkmara Creek which does not pass through retention pond No. 2.

experiments, were updated by the company during the Inquiry in the light of an additional three years' data. However, the company acknowledged that both the original and modified estimates gave, at best, only a general indication of the contaminant concentrations to be expected.

These data suggest that pit water would have the highest contaminant concentrations, followed by seepage from the tailings dam, runoff and seepage from ore stockpiles, runoff and seepage from the waste rock dump, and runoff from undeveloped areas in that order. This indicates that, of the water leaving the mine area, releases from retention pond No. 2 would be most contaminated, followed by releases from retention pond No. 1, seepage losses to Gulungul Creek, and runoff into Georgetown Creek. Estimates of contaminant concentrations are given in Tables 8 and 9.

A major deficiency in the data on contaminant concentrations in the released water is that almost nothing is known about the chemical forms in which the contaminants exist. These can have a big influence on the toxicity and mobility of contaminants (see *The fate of natural contaminants*, Chapter 5). All assessments of impact assume that the total amount of contaminant is in the most toxic chemical form, and possible effects may therefore be overestimated. On the other hand, estimates of the amounts likely to be present could contain large errors.

The likely output of waterborne contaminants via the four routes listed above is considered in more detail below.

Retention pond No. 1

Ranger anticipates that, in an average climatic year, about 1 million cubic metres of water would be released to Coonjimba Creek from retention pond No. 1 in the early years of operation of the mine, rising to about 2 million cubic metres by the fifteenth year of operations. These amounts are about half the total volume of runoff and seepage expected to be released from the site (see Table 7). In wet years, these volumes would more than double. The total flow in Magela Creek past Jabiru is estimated to be about 250 million cubic metres in an average year.

The highest contaminant levels in water entering retention pond No. 1 are expected in runoff early in the wet season and in seepage during the early part of the dry season. This water would probably be transferred to retention pond No. 2 for use in the mill or release into Magela Creek.

Table 8

Estimated contaminant concentrations in tailings dam seepage water

Contaminant	*Concentration*	*Contaminant*	*Concentration*
Arsenic (μg/l)	3 300 (a)	Molybdenum (μg/l)	52 (a)
Cadmium (μg/l)	0.7 (a)	Uranium (μg/l)	20 (b)
Copper (μg/l)	50 (b)	Radium (pCi/l)	40 (a)
Lead (μg/l)	300 (a)	Calcium (mg/l)	510 (c)
Zinc (μg/l)	80 (b)	Magnesium (mg/l)	2 270 (c)
Mercury (μg/l)	12 (a)	Sulphate (mg/l)	9 300 (a)
Manganese (μg/l)	120 000 (c)	Phosphate (mg/l)	9 (a)

Sources: (a) Exhibit 3
(b) Exhibit 90
(c) Alfredson and Ryan (1975). *Proceedings of the Australian Institute of Mining and Metallurgy* 253, 25–35

The estimates of general contaminant levels in retention pond No. 1 (see Table 9) indicate that heavy metal concentrations would be less than half those in retention pond No. 2 and that uranium and radium levels would be only 10–20 per cent of those in retention pond No. 2. The Commission received limited information on the possible concentrations of other contaminants, such as sulphate, manganese, arsenic, magnesium and molybdenum, which would enter retention pond No. 1 in seepage from the tailings dam.

Ranger estimates that about half the annual seepage into this pond from the tailings dam would be transferred to retention pond No. 2 with the early wet season runoff. It would appear to be relatively simple to collect near its source nearly all the seepage which would otherwise flow into retention pond No. 1 and then pump it back to the tailings dam. This is considered further in Chapter 7.

The planned release controls are not as strict as those intended for retention pond No. 2, but they restrict the times of year when releases could be made via the pond's sluice gate system and the maximum concentrations of contaminants allowed in the water released. Releases would not be made in the early stages of the wet season as runoff would be expected to be most contaminated then, or late in the wet season as the contaminated water might be retained in Coonjimba billabong, between the pond and Magela Creek, and have harmful effects there during the following dry season. The aim should be to ensure that released water would be 'flushed out' of Coonjimba billabong into Magela Creek. The distance between the pond and Magela Creek is about 1.5 kilometres.

Considerable doubt exists about the flow characteristics in Coonjimba Creek at the times when releases might be made. As a result, there is uncertainty about the dilution likely to be achieved initially in Coonjimba Creek and then in Magela Creek, and about the time the contaminants would spend in Coonjimba Creek.

The company's calculations indicate that, in an average year such as 1972–73, there would be two releases from retention pond No. 1 and in each case the released water would remain in the lower part of Coonjimba Creek for five to ten days, during which time it would be diluted some two to three times. These calculations indicate that the diluted water would then be flushed into Magela Creek, where further dilution would occur.

These calculations of the dilution pattern for releases into Coonjimba Creek were based on little, if any, field data relating to actual flow patterns in the creek. The time taken to 'flush out' the contaminants could be significantly increased if backflow conditions existed in the creek either at the time of release or soon after, and it seems quite feasible that such conditions could occur since the proposal is that releases take place during periods of flood flow. In the absence of field data relating to flow characteristics in Coonjimba Creek, the Commission must treat with some reservations the claim that adequate dilution and dispersion of water released from retention pond No. 1 would be achieved at all times.

The company proposes that the last release before the start of the dry season always be made long enough before the end of the wet season to ensure that the effluent would be flushed from Coonjimba billabong into Magela Creek. At present, however, we have no knowledge of the flow conditions necessary to achieve this flushing. In addition, there are obviously difficulties in trying to predict when any wet season will end.

Table 9

Estimated contaminant concentations during mining

	Tailings dam seepage						
Contaminant	(1) *leaving tailings dam*	(2) *entering Gulungul Creek*	(3) *Retention pond No. 1 year 10*	(4) *Retention pond No. 2 year 10*	(5) *Tailings pipeline corridor*	(6) *Runoff from uncontaminated catchment*	(7)(a) *Magela Creek*
Copper (μg/l)	50	10	22 (12)	100 (52)	67	15	0.5 – 5 (2)
Lead (μg/l)	300	60	18 (17)	38 (27)	42	7	0.5 – 3 (1.6)
Zinc (μg/l)	80	16	20 (16)	44 (26)	50	10	1 – 15 (5)
Uranium (μg/l) ..	20	4	30 (26)	170 (180)	8.5	2	<0.1 – 5 (0.2)
Radium (pCi/l) ..	40	8	4.5 (7.5)	50 (37)	8	1	<0.1 – 0.5 (0.2)
Manganese (mg/l)	120	24					< 0.1
Sulphate (mg/l)	9 300	1 860					<2 – 7 (2)
Arsenic (μg/l) ..	3 300	660					
Mercury (μg/l) ...	12	2					
Cadmium (μg/l) .	0 7	0.1					0.05 – 0.5 (0.1)

Sources: Column (1) Table 8
(2) from Column (1), assuming 5:1 dilution
(3), (4) original figures Exhibit 208; (revised figures), evidence of J. A. Yeates
(5) Exhibit 208
(6) Exhibit 3
(7) Evidence of D. R. Davy and R. K. Carruthers

Note: (a) Averages in brackets.

Retention pond No. 2 Ranger estimates that the volume of contaminated water released from retention pond No. 2 in an average year would rise from just under half a million cubic metres at the start of mining to almost 1 million cubic metres by the tenth year of operations. These volumes, like releases from retention pond No. 1, would more than double in years of very high rainfall. In years when rainfall was low it is likely that no water would be released; it would be retained for processing. Releases are planned to occur only at times of high flow in Magela Creek and under strict quality controls.

Ranger's calculations indicate that these releases would account for 40–70 per cent of the heavy metals and more than 80 per cent of the radioactive contaminants entering the environment in waste water from the mine site (see Table 11). However, there is uncertainty about how much seepage into the mine pits would be transferred from retention pond No. 3 to retention pond No. 2, and about the amount of seepage from the tailings dam reaching retention pond No. 2. These uncertainties increase the difficulty of accurately estimating contaminant levels in releases from this pond.

The company estimates that seepage into the mine pits could range from 100 to 1500 cubic metres per day and average 800 cubic metres per day in the second year of mining operations, and rise to a range of 300–3500 cubic metres per day and an average of 1800 cubic metres per day in the tenth year. Its water management scheme provides that, when seepage into the pits approached 1650 cubic metres per day, probably six to eight years after the start of operations, some of this water would have to be released to Magela Creek via retention pond No. 2 if the mill was operating at a production rate of 3000 tonnes of U_3O_8 per year. If the production rate were doubled to 6000 tonnes of U_3O_8 per year, more water would be needed in the mill and less would be released.

Working from its estimates of contaminant concentrations, the company calculates that it could release up to 630 cubic metres of the water to retention pond No. 2 per day and keep releases to Magela Creek within the standards it proposes. However, this is clearly an area of considerable uncertainty in the water management scheme, and it seems unlikely that the uncertainties could be significantly reduced until mining had proceeded for some time. About 5 per cent of the total inflow into the pits is expected to be seepage from the tailings dam via faults.

Seepage through and under the eastern embankment of the tailings dam would find its way to retention pond No. 2. The company estimates that about half of this would be used in the mill circuit and that the rest would form a relatively minor component of total releases from retention pond No. 2. However, the evidence suggests that quantities of sulphate and manganese added to the releases from this source might be quite large, because both those contaminants are expected to be present in high concentrations in the seepage water.

Again quantities could only be determined after mining began, and extensive monitoring would be essential. As for retention pond No. 1, the Commission believes that it would be relatively simple to collect this seepage closer to its source and return it to the tailings dam.

In view of the high contaminant concentrations expected in retention pond No. 2, Ranger has proposed quite detailed release conditions aimed at minimising environmental effects (discussed later in this chapter under the heading **Water release controls and standards**). The philosophy adopted appears to be that adverse environmental effects would be averted if the contaminants were sufficiently diluted and dispersed. The Commission would prefer a policy of containment of these contaminants as far as possible within the mine site, provided this was in a manner which limited the likelihood of their being released to the environment in an uncontrolled manner at some later time. This is discussed further in Chapter 7.

Tailings pipeline area

Ranger plans to build an embankment, carrying an access roadway, to isolate the tailings pipeline area from the off-site environment. All rainfall runoff from the pipeline side of the embankment would be channelled through one culvert. It is planned that, in the event of a pipeline breakage, the culvert would be closed by a gate or sluice preventing release of the tailings material.

Contaminants in this area would probably be largely limited to dust and residue from any tailings pipeline spillages. Some contamination of Georgetown billabong by seepage from a small section of the southern bank of the tailings dam could also be expected. The company's estimates (see Table 9) of the contaminant concentrations in runoff from the area are of the same order as those expected in retention pond No. 1. The company estimates that, ten years after the start of mining, runoff from this area would account for some 10 per cent of the total releases of heavy metals and a somewhat lower percentage of total waterborne releases of radioactive materials from the mine site. These losses would produce, according to estimates before the Commission, a three- to sixfold increase in the annual contaminant loads entering Georgetown Creek via the tailings pipeline area, compared with the natural situation. However, the area is only a small proportion of the total catchment of Georgetown Creek.

Runoff from this catchment area would only occur after heavy rains, and should coincide with significant flows in Georgetown Creek. The company argues that, as a result, sufficient dilution would occur to prevent contaminated runoff from causing adverse environmental effects in Georgetown billabong.

The Commission finds it disturbing that perhaps 10 per cent of the total heavy metal releases from the site would occur in such a direct and uncontrolled manner. If there were occasions when the flow in Georgetown Creek was not sufficient to adequately dilute and disperse the contaminated runoff, contaminants could be deposited in Georgetown billabong. Dust and silt washed from the catchment and deposited in Georgetown billabong could create further problems, as could erosion of the tailings pipeline embankment in earlier years of mining before soil binding vegetation was established. The durability against fire or rupture of the pipeline material is another matter which should be carefully considered.

Seepage losses to Gulungul Creek

Seepage losses from the tailings dam would occur through the embankment, under the embankment foundation and through the dam floor, particularly into permeable zones in the underlying rock. Estimates made by the Ranger company of seepage via each route are shown in Table 10.

The seepage rate would be practically constant, not varying greatly with the season in a given year. However, the eventual fate of the bulk of the contaminants contained in this water would be very much influenced by the season.

During the life of the mine, the seepage losses would progressively increase as the height of the tailings dam was increased. Most of the seepage through the dam floor would go to deep aquifers. All that through the embankment and most under it would emerge at the soil surface downslope of the dam. In the dry season it would evaporate, depositing its contaminant load in the soil. During

Table 10
Estimated volumes of seepage losses from tailings dam

	Year 2		*Year 10*		*Year 20*		*After mining*	
Pathway	*m^3/day*	*Percentage of total*	*m^3/day*	*Percentage of total*	*m^3/day*	*Percentage of total*	*m^3/day*	*Percentage of total*
Through the embankment	33	26	230	48	470	53	150	48
Under the embankment and through the dam floor emerging in the buffer zone	26	20	120	26	240	27	120	38
Into deep aquifers	70	54	120	26	180	20	44	14
Total (m^3/day)	130		470		890		310	
(m^3/year)	47 000		171 000		325 000		115 000	

Source: Evidence of J. A. Yeates.

the subsequent wet season, most of these contaminants would be flushed out by runoff water. Runoff towards the north and east would go to retention ponds No. 1 and No. 2 respectively, but that towards the west and south would run directly into Gulungul Creek. This uncontrolled runoff would, in the Commission's view, represent the greatest potential environmental threat from tailings dam seepage losses during mining operations.

In estimating contaminant concentrations in the tailings dam seepage, Ranger assumed that these would be identical with those in the water discharged to the tailings dam from the mill. This assumption may be conservative, since contaminant levels in the seepage might fall as a result of adsorption onto soil particles as the liquid percolated through the solid tailings and then through rock and soil. However, the actual situation will only become apparent if mining commences.

The tailings dam seepage would almost certainly contain high levels of magnesium, calcium, manganese, arsenic, mercury, lead and sulphate. Some contaminants, including sulphate, magnesium and calcium, could be expected to build up to perhaps double their initial discharge concentrations as a result of cycling between the tailings dam and mill. Estimated levels of copper, zinc, uranium and radium in the tailings dam seepage and in the runoff from the ore stockpiles are of the same order of magnitude.

The company has estimated that, ten years after the start of mining, 155 cubic metres per day of tailings dam seepage through and under the embankments would head towards Gulungul Creek, representing some 44 per cent of this seepage. Most of the remainder would go to retention ponds No. 1 and No. 2. By the twentieth year of operations, estimated seepage towards Gulungul Creek rises to 290 cubic metres per day. A small proportion of the seepage lost through the dam floor would also emerge in Gulungul Creek.

The evidence before the Commission suggests that the company's estimates of seepage losses through and under the embankment are likely to be fairly reliable. The estimates of seepage through the dam floor are much less certain, because of inadequate knowledge of the extent and permeability of the fault zones beneath the dam and of the reliability of the material with which it is planned to seal them. The Snowy Mountains Engineering Corporation has recommended studies which should increase knowledge of likely seepage to aquifers. Because of the importance of the Magela system, the Commission believes that these recommendations should be adopted if the project is to proceed and that the use of an impervious butyl rubber membrane to virtually eliminate seepage should be considered by the supervising authority before construction begins. This matter is discussed in Chapter 7.

Ranger has estimated that runoff towards Gulungul Creek from the tailings dam area would range from 440 000 to 640 000 cubic metres per year by the twentieth year of operations, with almost all occurring during February and March. This would be diluted an estimated two to four times before it entered Gulungul Creek, where further dilution estimated to be between 2:1 and 50:1, would occur.

These runoff estimates could prove to be low if vegetation growing between the dam and Gulungul Creek was destroyed partially or wholly by the high levels of contaminants in the seepage water.

The company's estimates of contaminant concentrations in the seepage water and the water entering Gulungul Creek are shown in Table 9. The uncertainties, referred to earlier, in the seepage water contaminant levels are compounded in the estimated levels for the water entering the creek by lack of knowledge of the processes of adsorption and remobilisation that may occur in the embankment wall and in soil between the dam and creek, and by a lack of data relating to possibly critical runoff periods such as the early and late wet season.

Estimates of the total loads of various contaminants entering Gulungul Creek are shown in Table 11. It can be seen that for copper, zinc, uranium and radium these are only a small fraction of the totals expected to be discharged from the two retention ponds, but this may not be the case for lead.

Contamination of Gulungul Creek would be greatly reduced if the seepage was collected and returned to the tailings dam. Collection of this seepage, as well as that towards retention ponds No. 1 and No. 2, is discussed in Chapter 7.

Seepage losses to deep aquifers

Ranger's calculations indicate that some 20 to 25 per cent of the total seepage losses from the tailings dam would enter deep aquifers. Some would stay in the groundwater under the dam, but most would flow into fault zones and move away from the dam.

The limited information on faults in the dam area suggests that most of this seepage would flow in three directions—westwards towards Gulungul Creek, northwards towards Coonjimba Creek and eastwards towards the No. 1 and No. 3 mine pits. Flow along faults leading to Magela Creek would probably be largely intercepted, at least during the lifetime of the mine, by the mine pits.

The company's estimates of the amounts of this seepage likely to reach No. 1 pit, Gulungul Creek and Coonjimba Creek are shown in Table 12. The bulk of this water is expected to be collected by the mine pit. Seepage reaching the creeks would discharge into them, flow into shallow aquifers under the creek beds, or continue its movement in the regional groundwater. Not enough information is available to estimate the proportion which would join the creek flow.

The company assumed, in making its calculations, that the faults between the tailings dam area and No. 1 and No. 3 mine pits are interconnected. If this did not prove to be the case, or if the fault zone proved to be significantly less permeable than expected, seepage losses to deep aquifers would be less, possibly remaining below 50 cubic metres per day compared with the estimated volume of 70 cubic metres in year two and 180 cubic metres in year 20.

Table 11

Estimated total annual waterborne releases of contaminants from mine site at tenth year of operation in a year of average rainfall

	Source				(5)	(6)	(7)	(8)	(9)	(10)	(11)
Contaminant	(1) *Retention pond No. 1*	(2) *Retention pond No. 2*	(3) *Seepage to Gulungul Creek*	(4) *Tailings Pipeline Corridor*	*Total released from mine site*	*Natural load in Magela Creek past Jabiru*	*Percentage increase on natural load of material contributed by mine*	*Estimated natural load carried by whole Magela system*	*Estimated natural load carried by total East Alligator system*	*Water from mine site in natural condition*	*Increase in contaminant load from mine site due to mining*
Copper (kg)	27	88	3	11	130	500	26%	1000	10 000	45	×3
Lead (kg)	22	33	17	7	80	400	20%	800	8 000	21	×4
Zinc (kg)	25	39	5	8	80	1250	6%	2500	26 000	30	×3
Uranium (kg)	28	152	1	1	180	50	360%	100	1 000	6	×30
Radium (Ci)	0.006	0.044	0.002	0.001	0.05	0.05	100%	0.10	1	0.003	×20
Manganese (t)			7		16[(a)]	<25	>60%	<50		<0.3[(b)]	×50
Sulphate (t)			530		1210[(a)]	500	240%	1000		6[(b)]	×200
Suspended solids (t)						4500		9000			

Notes: Column (1), (2) Calculated using concentrations in Table 9, volumes in Table 7.
(3) Calculated using concentrations in Table 8, volume 57 000 m^3/year.
(4) Calculated using concentrations in Table 9, volume in Table 7.
(5) = (1) + (2) + (3) + (4)
(6) Calculated using concentrations in Table 9, Column (7), volume 250 million m^3/year.
(7) = (5) ÷ (6) × 100.
(8) Calculated using concentrations in Table 9, Column (7), volume 500 million m^3/year
(9) Calculated using concentrations in Table 9, Column (7), volume 5100 million m^3/year.
(10) Calculated using concentrations in Table 9, Column (6), runoff volume 3 million m^3/year in a year of average rainfall.
(11) = (5) ÷ (10).

(a) Calculated using concentrations in Table 8, and assuming total losses of 130 000 m^3/ year through and under the tailings dam embankment enter the environment.
(b) Sulphate concentration 2 mg/l, manganese concentration 100 μg/l.

Table 12
Estimated volumes of seepage (m^3/ day) lost to deep aquifers emerging at different places

Area of emergence	*Year 5*	*Year 10*	*Year 20*	*After mining*
Mine pit No. 1	53	74	125	21
Gulungul Creek	6	6	8	11
Coonjimba Creek	2	0	0	3
Magela Creek	0	0	0	8

Source: Evidence of J. A. Yeates.

If, on the other hand, the fault zone proved to be ten times more permeable than expected, the company has calculated that the amounts reaching Coonjimba and Gulungul Creeks would increase by perhaps 5 cubic metres per day, that is nearly double, and the flow to No. 1 pit by about 30 per cent.

Seepage from the tailings dam would move slowly in the faults; the company's calculations indicate that it would take five to ten years to reach Coonjimba and Magela Creeks, six to eight years to reach Gulungul Creek, and about one year to reach mine pit No. 1. A number of observation bores are planned for monitoring of flow in the seepage pathways.

If seepage flows proved to be excessive, the only practicable way to reduce them would be to intercept the main fault zones with deep bores, pump the groundwater out and dispose of it in the tailings dam. This would probably be an effective remedial measure only during mining operations, since constant maintenance of the bores and pumps would be necessary.

Seepage from the tailings dam would probably not increase the concentrations of copper, lead, zinc, uranium and radium in the pit water, but would certainly increase magnesium, manganese, calcium and sulphate concentrations. It seems quite likely that levels of other contaminants, such as molybdenum, arsenic and mercury, would also be increased. As some pit water is expected to be released to the environment after the first years of mining operations, the possibility of harmful effects arising from these increases needs to be noted.

Deep aquifer seepage could also cause other environmental problems. Contaminants in water which seeped into the alluvial bed of Gulungul Creek adjacent to the tailings dam could be concentrated in the groundwater during the dry season and then flushed into the creek in the wet season. On an annual basis, it is unlikely that this seepage water would result in any significant change in natural contaminant levels because of massive dilution; flow into the creek from these beds in an average year has been estimated at 5000 cubic metres, which compares with an average annual flow in the creek of about 19 million cubic metres. However, local effects could occur, including the formation of pools of contaminated water in the creek during at least part of the dry season, and runoff into Gulungul billabong of small quantities of contaminated water at critical times such as the beginning or end of the wet season. We are unable to assess the probability of such events occurring or of the likely environmental ramifications if they did occur.

Another possibility raised in evidence is that contaminated groundwater could move along the fault zone believed to be associated with Gulungul Creek and reappear in Corndorl billabong or the aquifer used to supply water to Mudginberri homestead. Ranger has argued that this would not be a problem because the hydraulic gradients causing groundwater movement in the area are so low that water would take 130–150 years to travel the 7 kilometres to Corndorl billabong and about 200 years to travel the 10 kilometres to Mudginberri homestead. In addition, the company argues, there would be extensive dilution of the contaminants en route. Again it is impossible to quantify this seepage effect. However, the risk of any problems arising appears small.

The likelihood and consequences of seepages of contaminated water occurring to deep aquifers after the completion of mining are discussed in this chapter under the heading **The situation after mining**.

Possible effects of contaminated water discharges

Estimates for a number of contaminants of what are referred to as 'safe levels', i.e. concentrations that are expected not to have any significant effect on fish or other aquatic species, were presented to the Commission (see Table 13). Safe levels are derived by first finding in laboratory tests the concentration that kills 50 per cent of a selected test species in a given period of time (the TLm concentration, or median tolerance limits). This figure is then reduced by a safety (or application) factor to estimate the 'safe level'. The selected species was the local hardyhead fish (*Craterocephalus marjoriae*) a common food source for larger species, and the time period chosen was four days. The contaminants were added to water taken from the Magela Creek. The application factors used were different for the various contaminants; for the main heavy metals, all were between 0.05 and 0.005. This 'acute bioassay test' for assessing toxicity has some degree of credibility from experience elsewhere. However, as the TLm values are very uncertain and as the validity in the Region of the application factors used is not known, it clearly provides nothing more than a starting point for impact assessment. A general discussion of the difficulties involved in carrying out toxicity studies is in Appendix IV.

The concept of 'fish avoidance levels' was also used in some submissions. This is based on the observation that fish may, where they can, avoid water with contaminant concentrations above certain levels. There is no guarantee that avoidance eliminates sublethal effects. The 'fish avoidance levels' are higher than the 'safe levels'; experience indicates that they are generally about one-third of the TLm levels, and they were derived in evidence by multiplying the TLms by 0.3.

The derived 'safe levels' for copper, lead and zinc are within the range of natural concentrations reported for Magela Creek. The figure for zinc is at the

Table 13

Bioassay data for waterborne contaminants

Contaminant	(1) TL_m	(2) *Avoidance level* $(= 0.3 \times TL_m)$	(3) *Application factor*	(4) *'Safe level'* $(=$ *application factor* $\times TL_m)$
Copper	40 µg/l	12 µg/l	0.05	2 µg/l
Lead	180 µg/l	54 µg/l	0.01	2 µg/l
Zinc	140 µg/l	42 µg/l	0.005	1 µg/l
Uranium	2500 µg/l(a)	750 µg/l	0.05	130 µg/l

Sources: Columns (1) and (3) evidence of D. R. Davy.

Note: (a) Values for copper, lead and zinc were obtained using hardyhead fish. The uranium figure is for the striped grunter and is lower than that for the hardyhead (4000–4500 µg/l).

lower end of that range, and the data indicate that the zinc concentration in Magela Creek can sometimes be fifteen times higher than the 'safe level'. Some witnesses suggested that this might indicate that the system is at its threshold with regard to zinc and that no additional inputs of the metal should be allowed. Others suggested that it might indicate that the system has adapted to high zinc levels. A third possibility is that the application factor used is not appropriate to these conditions. The extent, if any, to which the zinc affects aquatic organisms will depend on the proportion of zinc in a toxic form, which is not known, as well as on the accuracy of the 'safe level' figures. The same would apply for any additional zinc entering the system. Whether copper or lead added to the system would have adverse affects would depend on the same factors, and is equally uncertain.

If the company's proposed water management scheme is adopted, virtually all the radioactive materials, radium and uranium, and an estimated 70–90 per cent of the copper, lead and zinc should leave the mine site in a reasonably controlled manner, via the retention ponds, at times when there would be a high probability that they would be rapidly flushed through the system. Possibly half of the other contaminants, such as sulphate, manganese, magnesium, mercury and molybdenum, would also be discharged under control. Contaminants entering the environment in an uncontrolled manner would be more likely to be retained in the system for long enough to cause adverse changes.

The Commission received no estimates of the amounts of suspended material, particularly clay, likely to enter Magela Creek from the mine area as a result of erosion. An important function of the retention ponds would be to trap sediments, especially the larger silt-sized particles. However the calcium and magnesium sulphate concentrations in the water could cause some of the clay also to settle. Suspended clay could transport contaminants downstream, but the data are not available to estimate amounts or distance.

Consideration of possible effects of contaminants in different parts of the Magela system follows. Assessments have been based on the assumption that the estimated total amounts of contaminants are in toxic forms, and therefore may overstate the risk.

Drainages on the site

Djalkmara, Coonjimba and Georgetown Creeks and billabongs will all be subject to some degree of chemical and sediment pollution if mining goes ahead. Because the flow pattern in Djalkmara and Coonjimba Creeks would be greatly altered, Djalkmara billabong would almost certainly be destroyed, and Coonjimba billabong might be seriously affected.

Ranger submitted that the planned controls on releases from retention pond No. 1 should ensure adequate environmental protection because contaminant concentrations in Coonjimba Creek would remain below 'fish avoidance levels'. On the basis of the company's figures, a fourfold dilution of release water would be needed to reduce the concentration of perhaps the most critical contaminant, copper, to the avoidance level. However, the company expects only two- to threefold dilution to occur in Coonjimba Creek.

The limited information on flow in Coonjimba Creek and the limited precision of the avoidance level figures presented to the Commission make it uncertain that levels of contaminants that fish would actually avoid would not be exceeded. Even if they were not, the Commission has serious doubts about whether adequate environmental protection would consequently be achieved. The evidence suggests that, during release periods, the concentrations of some metal contaminants in the creek would rise to levels some five to ten times above calculated 'safe levels'.

The evidence points clearly to the conclusion that fish and other organisms in Coonjimba Creek may be adversely affected by releases from retention pond No. 1 if the heavy metal contaminants are mainly in a toxic form. The organisms which live and feed on the bottom of Coonjimba billabong would probably be most affected, being unable to move away from contaminated areas. If accidental releases of water occurred from this pond at periods of below-peak flow, fish could be killed in Coonjimba Creek and billabong.

Flow through Georgetown billabong should not be greatly altered by the mine and mill, and the billabong should persist. Water quality in the billabong deteriorates significantly by the end of the dry season now. As it appears likely that the mining operation would increase the quantities of contaminants entering the billabong, dry season water quality would be likely to undergo further deterioration.

Ranger expects that contaminated runoff would enter Georgetown Creek at times of strong flow in the creek, and it estimates that this should ensure at least a fiftyfold dilution of the runoff before it reached Georgetown billabong. However, even with this dilution, zinc and copper concentrations might reach levels close to the 'safe levels'. Also evidence suggests that there could be times when runoff into the creek would not coincide with large flows, and minimal dilution, perhaps as little as 3:1, would result. Under such circumstances, contaminant concentrations could rise to some ten to twenty times the 'safe levels'. Although the probability of this is low, it would be prudent for the quality and quantity of runoff water from this area and the quality of water in Georgetown billabong to be monitored regularly if mining proceeds, and we recommend that the company be required to do this (see Chapter 17). If contaminant levels were found to be excessive, or if deterioration in water quality in the billabong was detected, the supervising authority should take steps to have the most contaminated portion of this runoff intercepted before it reached Georgetown Creek. It could then be released during periods of high flow.

Seepage from the tailings dam, and possibly from the retention ponds, which reappeared at the soil surface could harm vegetation. If it limited plant growth, soil erosion could result. The data needed to assess this possibility do not exist.

Gulungul Creek

Gulungul Creek has two branches. The main one flows past the mine site on the west and joins Magela Creek about 6 kilometres downstream. The other drains from the area of the proposed regional centre. Gulungul billabong is in the main branch, near its junction with Magela Creek. The other branch includes an unnamed billabong and numerous waterholes. Both billabongs probably receive backflow from Magela Creek. The main branch is the one that would receive runoff and seepage from the tailings dam.

The data in Tables 9 and 13 suggest that lead is the toxic contaminant most likely to be in excess of derived 'safe levels'. The figures indicate that, if only a fourfold dilution of the runoff, the estimated minimum, occurred in Gulungul Creek, the lead concentration in the creek would rise to some seven times the 'safe level'. Copper and zinc would also be present at concentrations above their 'safe levels'. Excessive levels of mercury, arsenic, cadmium and molybdenum could also occur, but the Commission has little information about these. However, as any problems arising from seepage into the creek would take a few years to become significant, there would be time to monitor concentrations and rates of movement of seepage water. Necessary corrective measures could be based on these data.

The evidence suggests that direct toxic effects of metal contaminants on aquatic fauna and vegetation of Gulungul Creek and billabong should not be important through most of the wet season. However, there is a high probability that unacceptable effects would occur in the billabong late in the dry season and at the start of the wet season.

Contaminants washed into the billabong at the end of the wet season and retained there would aggravate the normal deterioration of water quality towards the end of the dry season. At the start of the wet season, the first flow of runoff would wash into the creek contaminants accumulated in the surface soil from evaporated seepage water during the dry season. At the same time, the first flow in the creek would pick up contaminants concentrated by evaporation in the stream bed. The combined effect would probably be a slug of comparatively highly contaminated water entering Gulungul billabong. It is not possible to estimate the concentrations that might be reached, or the effects.

In addition to the possible effects of toxic contaminants, Gulungul billabong could be adversely affected by nutrients, especially phosphates, entering in seepage water and promoting increased algal growth. However, some of the phosphate in seepage water might become fixed in the soil, thereby reducing the amount entering the creek. Also soil erosion from the tailings dam walls could lead to sedimentation in the creek and billabong and add clay which could act as a trap immobilising metal contaminants, some of which could later become available to organisms.

The amounts of sulphate entering the creek would probably be sufficient to produce white encrustations on the creek banks in the dry season. These probably would not cause much harm to plants or animals, but they would be ugly. The amounts of manganese entering the creek would also be large, and could lead to high concentrations in algae and possibly other organisms. The effects of such a build-up in concentrations are unknown.

Magela Creek —Jabiru to Mudginberri waterhole

If the mining proposal proceeds, this section of Magela Creek will receive contaminated water directly from retention pond No. 2, from retention pond No. 1 via Coonjimba Creek, and from Georgetown and Gulungul Creeks.

The most contaminated input would be from retention pond No. 2. Concentrations of copper in the water released from this pond would probably exceed the TLm (median tolerance limits) for the fish species tested. Concentrations of other contaminants would be below this level, but well above 'safe levels'. However, as releases are planned for times of flood flow, immediate dilution would occur. A five to ten times dilution would reduce concentrations to below the fish avoidance level, and twenty-five to fifty times to below the 'safe level'. None of these estimates takes account of possible synergistic effects of other toxic materials present. These may have the effect of reducing the TLm for an individual contaminant such as copper. That is, in the presence of certain other contaminants, the copper may be more toxic at lower levels than if it were present on its own.

Billabongs in this section of Magela Creek are used for fishing by Aboriginal and European people. It is not possible to reach a conclusion as to whether levels of heavy metals in the flesh of barramundi and other edible fish would rise significantly as a result of contamination from Ranger. It is unlikely that heavy metals in fish would rise to such high concentrations that the fish would become unfit for human consumption; regular monitoring would enable such an event to be detected, should it occur.

Ranger has designed a pump system and outlet structure which it says would allow it to regulate accurately the discharge rate between 0.1 and 2 cubic metres per second, and to achieve dilutions of 15 to 1 in the immediate vicinity of the outlet and 100 to 1 within 1500 metres downstream of the discharge point. However, the Magela Creek dilution factors submitted by the company are largely the result of computer simulations, and adequate field investigations to determine the dilution and dispersion characteristics of Magela Creek in the vicinity of the proposed discharge structures would be essential before release conditions were decided upon.

A high dilution rate should also apply to releases entering Magela Creek from retention pond No. 1, via Coonjimba Creek, because of the intention to restrict releases to periods of flood flows. Water would flow into Magela Creek from Georgetown and Gulungul Creeks during the wet and early dry seasons, and dilution would vary markedly with relative flow rates. Data on annual flow rates suggest that the additional dilution rate of Gulungul Creek water in Magela Creek would be between 10 : 1 and 15 : 1.

It is difficult to identify all effects of releases on this section of Magela Creek. Restriction of controlled discharges to periods of strong flows should result in most of the contaminants in these releases being carried rapidly through the system with further dilution. However, the fact that uncontrolled losses would account for about half the total output of sulphate, manganese, mercury, arsenic and molybdenum is a matter for concern, as some of these releases could enter Magela Creek at times of only moderate to low flow. Encrustations of sulphate on the creek banks and accumulation of manganese in algae, as expected in Gulungul Creek, could result.

As the soils and sediments of the main channels in this section of Magela Creek are mostly sandy, metal contaminants would be unlikely to accumulate in them in potentially harmful quantities. However, if contaminated water flowed from the main channels into back swamps and billabongs, metals could be trapped in their finer textured soils, from which it could later be released back into solution towards the end of the dry season when water conditions favour such remobilisation. Restriction of controlled releases to periods of peak flow should ensure that most contaminants were flushed directly down the main channels between Jabiru and Mudginberri.

Mudginberri corridor

Further dilution would occur in this section of Magela Creek, and direct ecological effects of the contaminants there should be small. The rates of flow at times when controlled releases were made should convey dissolved contaminants and very fine suspended material through the corridor quickly. However, coarse sediments containing contaminants could be deposited. Depressions in the corridor are likely to contain acidic soils and organic matter. Adsorption and chelation on fine organic materials could assist transport of heavy metals during flow conditions. However, when flow ceases, they would remain on the soil where some could be available to organisms.

Existing information is inadequate to assess the consequences of these effects, and information on soils in the southern section of the corridor, at present lacking, should be obtained. The area should also be among the monitored sites if mining proceeds. As it is one of the few parts of the Magela system with dense paperbarks, the suggestion that this species might be a biological indicator of levels of uranium in the soil could be examined there.

Magela flood plains When floodwaters reached the plains, the concentration of contaminants would be reduced to half or less by rainfall and additional runoff from the adjacent lowland areas. Thus the risk of direct ecological effects would be reduced to a low level. However, if the Jabiluka mining project goes ahead, it will discharge additional contaminated water onto the plains.

Releases from the Ranger site would increase the amounts of copper, lead, zinc and uranium in Magela Creek water passing Jabiru by, respectively, an estimated 26, 20, 6 and 360 per cent. The percentage increases in the water on the flood plains attributable to the Ranger output would be half or less of these figures.

If releases of contaminants were restricted to periods of continuous floods, as proposed by this Commission, some of the additional contaminants would be carried across the plains into the river estuary and the sea and some would be left in the water remaining on the plain. Existing information is inadequate to estimate what proportion would remain. It would vary with annual rainfall. Most of the contaminants deposited on the plains when the flood waters receded would probably be immobilised by adsorption onto clay particles or by chemical bonding with organic matter. Immobilisation would be likely to occur near the end of a wet season, or at the beginning of the next wet season. The water remaining in flood plain billabongs at the end of the wet season would contain additional contaminants. However, because of late wet season dilution, these would be at concentrations somewhat, and possibly considerably, below those of the main floodwaters during the periods of discharge.

Nevertheless, the increase in contaminant levels due to the Ranger discharges, whatever its size, would have some influence on the quality of water in the billabongs at the end of the dry season. What that influence would be cannot yet be predicted. The role that increasing concentrations of heavy metals play in the progressive development of stresses on organisms in the billabongs in the dry season is not known. Information is lacking on the chemical forms of contaminants in the billabongs and their toxicity, and on any changes in chemical form caused by turbidity and organic matter in the billabongs late in the dry season. While these uncertainties exist, an ecological management program which includes keeping contaminant increases to a minimum is the only acceptable approach.

If a management program succeeded, after mining began, in preventing environmental stresses in the billabongs exceeding those that occur naturally in years of low rainfall, billabong ecosystems very similar to the present ones should persist. However, changes in the relative abundances of some species could occur, and long-term cumulative changes are possible. These changes could be equivalent to those which would result naturally in periods of several successive dry years or if the proportion of dry years increased, but this comparison should not be drawn too closely. Acclimatisation of organisms to higher contaminant concentrations might contribute to adjustments within the ecosystems.

The paperbark-vegetated depressions at the edge of the flood plains would not be affected in the same way as the billabongs closer to the main flood flow. Being adjacent to the lowlands they receive direct runoff, and this would tend to divert flow from the main stream away from these areas during periods of general flooding. As a result, contaminants in controlled discharges from the mine site at such times would be less likely to reach and accumulate in the depressions in any quantity. More information is needed if the risk of contamination is to be assessed more precisely.

The East Alligator riverine plain As this plain acts as a barrier to the free flow of water from the Magela flood plains to the East Alligator River, its low inland margins could be a site for accumulation of chemical contaminants remaining in floodwaters. The soils of this plain are similar to those of the main Magela flood plains. If heavy metals were adsorbed onto soil particles, a proportion might be scoured into the estuary at the start of the wet season. The plain has relatively few water bodies which survive into the dry season. As a result, the proposed discharges are unlikely to have any marked ecological effects in this area. Except during the main flood period, water is restricted mainly to the channels which allow the Magela water to flow into the river. It is not known whether contaminants accumulate in these channels; their bottom sediments and the organisms inhabiting them should be examined in more detail.

East Alligator River estuary and marine environment Contaminants reaching the estuary would be incorporated into its sediments, accumulated by living organisms, or transported to the sea. Dilution by the river flow, runoff from the river's extensive eastern flood plains, and flow from Cooper Creek would greatly reduce the concentrations of added contaminants, and their direct impact should be small. Mineralisation is well distributed throughout the Region, so natural inputs of contaminants are likely to come from many areas. If these are assumed to be roughly proportional to runoff, it can be calculated that the contribution of a contaminant such as copper from the Ranger project would be only about 1 per cent of the total input of copper to the estuary. The small effects of such an increase are likely to be obscured by seasonal variations, and it is doubtful whether they would be detectable. It is not possible to determine the long-term effects of these increments of heavy metals relative to natural inputs. Contamination from Ranger would be unlikely to affect commercial fishing in the estuary, at least in the short term (Chapter 8).

Comparison with Rum Jungle A number of witnesses suggested that pollution downstream from the proposed Ranger mine might be as severe as that downstream of the now abandoned uranium and copper mines at Rum Jungle, on the Finniss River south of Darwin. The environmental pollution at Rum Jungle has been studied by the AAEC. While lessons can be learned from Rum Jungle, it is not directly comparable with the Ranger situation. One important difference is the fact that the Rum Jungle operation was not controlled by the environmental constraints which will apply at the Ranger mine if the project proceeds. Another is the composition of the ore and waste rock.

Many metal ores are sulphides or have large quantities of minerals containing sulphides associated with them. When exposed to the atmosphere in ore stockpiles, tailings dumps or waste rock piles, the sulphides are oxidised to sulphuric acid by weathering processes, often facilitated by bacterial action. As a result, water permeating through the materials becomes acidic and a high proportion of the heavy metals in the minerals may go into solution and spread through the environment with the water. Areas downstream may experience severe pollution.

This has happened in some parts of the Rum Jungle uranium field. Tests on waste rock dumps at Rum Jungle have revealed sulphur contents ranging up to more than 3 per cent; these areas are associated with severe heavy metal pollution. By contrast, at another of the old mine sites, Rum Jungle Creek South, waste rock contains only about 0.3 per cent sulphur. The acidity of leach water and the heavy metal pollution there are negligible.

The Ranger situation appears to be more comparable with the latter. Separate tests of representative samples of the primary (unoxidised) ore from the Ranger No. 1 ore body have given values of 0.22 per cent and 0.24 per cent for the sulphur content of the ore in the form of sulphides. The oxidised ore in the secondary ore zones contains negligible amounts of sulphide.

The primary ore contains three main sulphide minerals. One of these, pyrite, is confined to a rock type which makes up some 9 per cent of the primary ore and an estimated 10 per cent of the waste rock that will be extracted if the ore is mined. The pyrite is a relatively minor constituent of this rock type, and the sulphide concentration in the rock averages only about 0.5 per cent. However, some of the pyrite is concentrated in pockets (lenses) in the rock; these are small, measuring up to only a few centimetres across. The second important sulphide mineral is galena (lead sulphide) which is found in disseminated form throughout all the rock. Copper sulphides are the third important sulphide mineral in the No. 1 ore body; they are found in small quantities in rock types around the ore. No significant pockets of copper sulphides have been found in No. 1 ore body.

The evidence indicates that no large patches of much higher than average sulphide concentration, in any mineral form, are likely to be found in the ore or the waste rock removed from the No. 1 pit. The Commission was told that, if pockets of material with a sulphide content significantly above average do exist, mixing during disposal would ensure that these were not transferred intact to the tailings dam or waste dump.

The possibility that bacterial action might promote acid leaching from sulphide-bearing ore has been investigated. The types of bacteria most able to promote rapid leaching only thrive in a very acid environment. Such an environment can be produced by the preceding action of other types of bacteria which oxidise sulphide minerals to sulphuric acid more slowly. Laboratory tests indicate that the sulphide content of the Ranger ore is so low and the concentration of minerals capable of neutralising sulphuric acid so high that conditions of extreme acidity could not be achieved in the ore by such a process. It is therefore most unlikely that bacterial action would promote rapid acid leaching of heavy metals from ore piles or waste dumps at Ranger. Serious environmental problems from this source are therefore unlikely.

Another important difference between Rum Jungle and Ranger is the fact that, at Rum Jungle, the unvegetated dumps leach and drain directly into through-flowing streams while at Ranger the dump and tailings dam would occupy the headwater section of a small local catchment. At Rum Jungle uncontrolled leaching and runoff result in slugs of highly polluted water passing down the streams at intervals. Fish kills have been observed in the Finniss River at times when flushes of contaminated water from the East Branch of the Finniss have not coincided with high flows in the main stream. By contrast, during the life of the mine at Ranger streams would not be subjected to slugs of concentrated contaminants, with the possible exception on a minor scale of Gulungul Creek. Water in retention ponds No. 1 and No. 2 and releases from them, even if unintentional, would not be likely to reach levels of pollution approaching those of water leached from the old mines.

About 100 square kilometres of the Finniss flood plain have been affected by contaminants, which are mainly concentrated in the surface layers of the soil.

The highest concentrations occur near river banks, particularly at sites where waterholes discharge onto the plains. Most of the total discharge of manganese and zinc and two-thirds of the copper can be accounted for if the increased concentrations recorded in flood plain surface soil apply to a depth of 10 centimetres. However, only a small amount of the released radium has been retained in the surface soil, and its fate is not known.

In the 10 kilometres of the East Finniss River downstream from the mine, fish and other aquatic fauna have been almost eliminated. In the main Finniss River, the diversity and number of fish during the dry season is lower close to the junction with the East Branch than in unpolluted areas. The effect on fish reduces over the next 15 kilometres downstream, and no effect is noticeable 30 kilometres from the junction. The Commission was told that a large number of professional fishermen still work round the mouth of the Finniss River.

The concentrations of contaminants estimated for retention pond No. 2 at Ranger before discharge are of the same general order as those measured 30 kilometres downstream of the Finniss junction. Dilution after release could be expected to greatly reduce these concentrations while the mine was operating. However, direct comparison of effects is difficult because of differences in the hardness of Magela and Finniss water, an important factor in determining the toxicity of heavy metals. The Finniss water is harder, and heavy metal contaminants are generally less toxic in harder than in softer water.

Pollution from Rum Jungle has killed pandanus palms along the East Branch of the Finniss River. It has also eliminated reeds, water-lilies and other rooted aquatic plants from that waterway. Erosion has occurred along the stream banks. How much of the damage has been caused by the high acidity of effluents and how much by toxic substances is not known.

Some of the contaminants in the Finniss flood plain soil are taken up by pasture plants growing there. A comparison of radium, copper and zinc concentrations in vegetation from polluted sections of the Finniss plain and from the unpolluted Magela flood plain, showing much higher levels for the Finniss vegetation, is given in Table 14.

Table 14
Comparison of Rum Jungle with Ranger

	(1) *Annual waterborne release from Rum Jungle*	(2) *Natural annual content in Magela Creek at Jabiru*	(3) *Annual contribution by Ranger*	(4) (a) *Concentration in 'pasture species' on Magela Plain*	(5) (a) *Concentration in 'sedge grasses' on Finniss Plain*	(6) (a) *Concentration in Para grass on Finniss Plain*
Copper	50 t	0.5 t	0.13 t	0.9–8.7 μg/g	6–150 μg/g	7–57 μg/g
Zinc	20 t	1.3 t	0.08 t	4.2–8.6 μg/g	30–200 μg/g	18–130 μg/g
Manganese	50 t	25 t	16 t	—	—	—
Radium	—	0.05 Ci	0.05 Ci	0.06–0.65 pCi/g	0.1–6.0 pCi/g	0.1–1.5 pCi/g

Sources: Column (1) Exhibit 337
(2) Table 11
(3) Table 11
(4) Exhibit 90
(5) Exhibit 337
(6) Exhibit 337

Note: (a) All concentrations are expressed per gram of dry weight of grass or sedge material.

The evidence indicates that the only possible cause of pollution downstream of Ranger comparable with that in the Finniss River would be a breach in the tailings dam wall. The amounts of radium, manganese and sulphate escaping annually would probably be similar to those at Rum Jungle if this occurred, but copper and zinc output would still be much smaller.

Total losses from Rum Jungle in the twenty years from 1954 have been estimated to be 1300 tonnes of copper, 200 tonnes of zinc and 90 curies of radium. Estimates of waterborne releases from Ranger over a mining life of thirty years are 2.6 tonnes of copper, 1.5 tonnes of zinc and 1.4 curies of radium. Losses would continue after mining ceased, but at a reduced rate (see **The situation after mining**, later in this chapter).

Water release controls and standards

The objective of controls on effluent releases from the mine site should be to ensure that the environment does not undergo significant short- or long-term changes as a result of the project. This assumes, of course, that changes could be measured and related directly to the project. This might prove extremely difficult.

The Commission is of the opinion that the Ranger company, as a general strategy, should introduce all modifications and options available to reduce the amounts of contaminants released from the site. A 'no-release' situation would be the ideal. However, the evidence suggests that releases might have to be made at times, even if all feasible alternatives were implemented. This matter is discussed in Chapter 7.

Standards for releases are generally of two types–controls on the composition of effluents leaving an operation and controls on the changes allowed in the water receiving the effluents. To be effective, standards must be capable of enforcement. Experience in the United States indicates that receiving water standards are impossible to enforce unless there is an associated scheme for licensing all discharges. We recommend that a scheme, based on a set of standards relating to the quality of the effluent, its quantity and the times at which releases can be made, should be adopted.

If effluent standards are to be effective, they must be derived from knowledge of changes that the discharges will produce in the receiving water. Information must be available on the degree of mixing and the chemical and biological changes that will result.

Receiving water standards are formulated on the basis that it is possible to define the water quality necessary to maintain effectively the aquatic environment in a desired state. However, when one is dealing with toxic contaminants that may accumulate, the risk exists that contaminant levels with no immediate adverse effects might prove harmful in the long term if they are remobilised later.

The bioassay method used to derive 'safe levels' for toxic contaminants has been described. Some degree of uncertainty is always involved, and it would be most unwise not to couple use of the method with a monitoring program designed to identify any subtle changes occurring because of the added contaminants.

A number of witnesses questioned the quality of the bioassay results presented in evidence, and by implication also cast doubt on any water quality standards derived from them. They objected to the experimental techniques and the narrow range of test organisms used. The Commission regards the criticisms as valid, and believes it would be unwise to see the data presented as giving anything but a preliminary indication of possible 'safe levels'. It is absolutely essential that this bioassay work be extended before any firm water quality standards for the region are developed.

The complexity of the ecological interrelationships in the Magela system makes it virtually impossible to predict precise effects of changes in any water quality parameter. For this reason we recommend that only minimal changes from natural levels, if any at all, be allowed in concentrations of both toxic contaminants and non-toxic ones such as sulphates, nitrates, phosphates and suspended solids.

Standards proposed by Ranger would allow effluents to raise sulphate concentrations, for example, from a natural level of about 2 milligrams per litre to an arbitrarily selected level (based on drinking water standards) of 250 milligrams per litre. There is no rational basis for permitting such an increase, when the aim is to preserve the natural environment.

Three sets of water quality standards were put forward during the Inquiry. All three may be generally labelled as 'receiving water standards'. Only to a limited extent were they developed with due consideration of the present natural condition of Magela Creek water and the qualities of the Magela system requiring protection.

The Commission finds these standards unacceptable in their present form, and recommends that they be fully revised within the framework of an integrated ecological management strategy for the Region. This should be done in consultation between the various government departments and instrumentalities responsible for monitoring and supervision, and the company (see Chapter 17).

Ranger's proposed controls on releases from retention pond No. 1, as mentioned earlier, restrict the concentrations of contaminants allowed in released water and forbid releases near the beginning and end of the wet season. The company says the controls aim at ensuring that the effluent is flushed through Coonjimba billabong into Magela Creek. The evidence shows, however, that existing information is inadequate to plan release practices to achieve this objective.

The Commission recommends that, before any release conditions are agreed to, Ranger be required to have adequately investigated the flow, mixing and dispersion characteristics that would exist in Coonjimba Creek at the times of the proposed releases. This information should be used to develop release procedures for retention pond No. 1 which ensure that the specified receiving water quality standards would be met.

Ranger has recommended that releases from retention pond No. 2 be permitted only when the following conditions hold:

- The flow rate in Magela Creek at the discharge point exceeds 20 cubic metres per second. In essence, this means that Magela Creek would have to be either in flood or experiencing conditions of high flow.
- The discharge rate is regulated to obtain sufficient dilution to ensure that the contaminant concentrations in the receiving waters are within a set of water quality constraints proposed by Ranger. The maximum allowable concentrations are based on fish toxicity studies and derived 'safe levels' for copper, lead and zinc, and on general water quality standards for the other contaminants.

Witnesses suggested that two additional release conditions be required:

- a requirement that there be a continuous water flow between Jabiru and the northern end of the Magela flood plain at the time of discharge;

- a restriction on the total amount of contaminants discharged from the Ranger operation in addition to the restriction based on maximum concentrations.

The first of these proposed additional release conditions aims at increasing the probability that wastes released at Jabiru would be transported across the flood plains into the East Alligator River and then into Van Diemen Gulf. The Commission endorses this proposal, believing it should be mandatory that, if releases are to be made, they only be permitted when there is continuous flow between Jabiru and gauging station G.S. 821019 at the northern end of the Magela flood plains and a high probability that this will persist long enough for discharges to reach the estuary.

Existing flow data are insufficient to enable this release condition to be stated in terms of flow past Jabiru. If mining is permitted, the supervising authority should obtain the necessary data and establish the release condition. We recommend that a hydrological–meteorological–water quality model be developed for this purpose (this is discussed further in Chapter 17).

It was argued that the second condition would give additional control over the total amount by which the Ranger operation was permitted to affect the Magela system, and that this was necessary because of the remarkable ability of many aquatic plants and animals to concentrate extremely small quantities of toxic materials, including heavy metals.

A third additional condition, that there be a constraint on the length of the period of any continuous discharge, is recommended in Chapter 7.

We also recommend that the company be required to obtain approval from the supervising authority before making any release.

The company has agreed that the total amount of radium released to the Magela system by its operations should not exceed that naturally transported by Magela Creek. We discuss this suggestion later in this chapter under **Radiation**. It has not proposed constraints on the loads of other contaminants released, but has argued that its suggested incremental standards implicitly impose such restrictions.

The Commission believes that the following broad principles must hold in the development of release standards for the Ranger operation, if it is to proceed.

- The total amount of contaminants to be released from the operations should be minimised. This means that all practicable modifications to the water management program which would result in less releases of contaminants, whether by runoff or by deliberate releases, both during and after mining, should be introduced.
- Deliberate releases should only be permitted under conditions of high flow in Magela Creek (flow at Jabiru exceeding 20 cubic metres per second), and then only if there is a continuous flow between Jabiru and the northern end of the Magela plains.
- Deliberate releases should not be permitted late in the wet season since there would be a greater risk then of contaminants being trapped in billabongs and swamps within the Magela system. The precise timing in any year would have to be determined by reference to the proposed hydrological–meteorological–water quality model.
- Release standards for toxic materials should be based on acute bioassay tests and application factors.

- Release standards for other contaminants should be based on achieving the minimum practicable disturbance to the environment.
- Standards for deliberate releases should take account of the total amounts of each contaminant discharged, the concentrations in the retention ponds, the dilution actually achieved in Magela Creek and the length of time of each release. If discharges are to be permitted directly into the flooded creek, a mixing zone, where initial rapid dilution of the effluent would take place, will need to be defined and the required dilution stated. Maximum contaminant levels in this zone should be restricted to below derived 'fish avoidance levels'.

Any attempt to formulate standards will involve uncertainties. A mechanism enabling the standards to be regularly reviewed and necessary changes to be implemented must be established if mining proceeds. To be effective, the review procedure would need to be based on the results of a continuing program of research and monitoring and take note of all relevant information from the scientific literature (see Chapter 17).

AIR POLLUTION

The Ranger mine and mill area, including the tailings dam and waste rock dump, would be a source of air pollution, affecting the surrounding area. Four types of pollutant may be important. These are sulphur dioxide, which would be emitted from the acid plant; radon, which would escape from the pit, ore dumps, tailings dam and mill; radioactive ore dust, which would escape from the pit, ore dumps and the ore-crushing area in the mill; and radioactive yellowcake dust, which would be emitted from the part of the mill where dried yellowcake is handled. Dust would also be raised from bare ground and sulphur dust would come from the sulphur stockpile; neither of these is likely to be an important health or environmental problem. The concentration of a pollutant at any point depends on its rate of emission and the way it is dispersed in the atmosphere. We deal in this section with the meteorological conditions in the Region which would determine the way pollutants were dispersed and with the possible hazards created by the sulphur dioxide emissions. The other air pollutants, which could cause problems because of their radioactivity, are considered in the **Radiation** section.

Dispersion of pollutants

Any pollutant released into the air would be carried along by the wind blowing at the time. In a steady wind, the pollutant would move in a plume downwind from the point of emission and gradually fall out onto the ground under the plume. The rate of fallout would depend on the nature of the pollutant (e.g. dust particles or gas) and on other factors. If the wind was gusty or turbulent—changing quickly in speed and direction—the pollutant would be spread over a much wider area. As it would then be dispersed through a much larger volume of air, the concentration at any point would be very much less than it would be in the plume in less turbulent conditions.

Information about wind conditions at Jabiru has been gathered continuously since 1971. It shows that, during the wet season, winds from the north and north-west predominate. During the dry season, winds from the east and south-east prevail.

Taking the year as a whole, east and south-east are the most common wind directions. This means that the site of the proposed regional centre, a little north of due west of the Ranger site, is directly downwind from the source of air pollution. In other words, so far as air pollution is concerned, the proposed regional centre is in the worst possible position. The significance of this fact depends on the actual concentrations of pollutants that could be expected at the site (see below).

The rate at which a pollutant is dispersed in the atmosphere depends, as mentioned above, on the degree of turbulence in the atmosphere. To enable estimates to be made of the amount of dispersion that will occur at any particular time, meteorologists have classified possible turbulence conditions into a relatively small number of categories, which they call stability categories. For each category they have derived formulae which enable the extent of dispersion to be calculated.

Estimates of air pollution contained in the EIS were made using a set of stability categories called the Pasquill stability classification. There are seven categories in this system; however, in calculating average annual pollutant concentrations, it was assumed that only four of these were needed to represent the average atmospheric dispersion situation at Jabiru. The wind records were used to estimate average wind speeds and wind directions for each of the four stability categories there. Knowing the release rate and height of emission for each of the pollutants, the average annual concentration at any point downwind could be calculated.

A more thorough estimate of dispersion characteristics was made by the AAEC, based on records of hourly average wind speed, wind direction and the way in which wind direction varies during the hour. Atmospheric conditions for each hour throughout a year were assigned to stability categories.

Two methods of classification were used—the Pasquill classification used in the EIS and another termed the 'turbulence' method. The concentration of pollutants at any point downwind could be calculated for each hour. Average conditions for the whole year were worked out by adding all the hourly estimates.

Results given by the two methods are in reasonable agreement, the difference being a factor of about 1.5. The reliability of the procedures has been tested in the U.S.A., where the results of similar calculations have been compared with actual measurements of concentrations of air pollutants. Close agreement has been found between measurement and prediction. An independent assessment by the Bureau of Meteorology confirmed the results obtained by the AAEC and suggested that, for estimates of average annual concentration of the various pollutants, an error factor of four would be realistic, i.e. the actual value might be as low as one-quarter or as high as four times the predicted value. The AAEC, while not willing to estimate the error, did not disagree with the Bureau of Meteorology estimate.

Error arises partly from deficiencies in the wind records. Also the various methods of estimating pollutant concentration assume that the ground below is a level plain, covered with short grass, while at Jabiru it is undulating and covered with trees. This means that turbulence, and hence dispersion, would be greater than assumed in the calculations, so actual pollutant concentrations may be lower than those calculated. Similarly, dispersion would be greater when winds were blowing from the north over the escarpment, again reducing concentrations. On the other hand, hourly average concentration figures could disguise much higher concentrations occurring for short periods.

Sulphur dioxide

The design of the acid plant for the proposed Ranger mill allows for sulphur dioxide emission from the stack at a rate of 25 grams per second and a concentration of 4.6 grams per cubic metre. This is equivalent to about 800 tonnes of sulphur dioxide a year in 330 days of operation. The company stated in evidence that, if the acid plant were designed from the outset to supply a mill producing 6000 rather than 3000 tonnes of U_3O_8 a year, a different process (double instead of single catalysis) would be used, primarily because of the savings in sulphur consumption that could be achieved. This would reduce the concentration of sulphur dioxide in the stack gases to less than half that achieved with single catalysis; as a result the total amount of sulphur dioxide emitted should be less than that from the smaller acid plant. If the acid plant were expanded at a later date by duplication, the exhausts from both plants would be combined and passed through a scrubber which would be expected to reduce the concentration of sulphur dioxide in the stack gases, so that the total emission of sulphur dioxide would be about the same as from the single acid plant.

Sulphur dioxide emitted from the stack would be hotter than the surrounding air, and would therefore tend to rise as it was carried downwind. Methods have been devised for estimating the height to which a plume will rise. These, together with the methods of estimating atmospheric dispersion previously described, were used by the AAEC to calculate the concentration of sulphur dioxide at ground level under various conditions and at various places in the vicinity of the proposed Ranger treatment plant.

The estimated average annual concentration of sulphur dioxide 1 metre above the ground at the southern boundary of the Mudginberri pastoral lease (the closest point of the lease to the Ranger site), at the Mudginberri homestead, at the site of the proposed regional centre and at the southern boundary of the proposed Special Mineral Lease (within 300 metres of Mt Brockman) are shown in Table 15. The table also shows the ambient air quality standard recommended by the U.S. Environmental Protection Agency for maximum average annual sulphur dioxide concentration. The estimated concentrations in the Ranger area are well below this maximum. No ambient air quality standards exist for the Northern Territory.

As previously described, two different methods, which gave different results, were used to calculate air pollutant concentrations. Table 15 shows only the higher of the two estimates of concentration obtained for each location. In making the calculations, possible deposition of sulphur dioxide on the ground was ignored. Since this would tend to reduce the concentration in the air, actual concentrations might be less than those estimated.

Table 15 also shows estimates of maximum short-term sulphur dioxide concentrations, averaged over one hour, three hours and twenty-four hours.

Table 15

Estimated sulphur dioxide concentrations ($\mu g/m^3$) in the vicinity of the Ranger site

	Mudginberri pastoral lease boundary	*Mudginberri homestead*	*Town centre*	*Special Mineral Lease southern boundary*	*U.S. EPA standard*
Annual average	1.28	0.92	0.97	0.05	80
Annual maximum—24 hour	75	40	45	100	365
short term peaks —3 hour	460	210	195	680	1 300
—1 hour	1 340	540	1 590	1 990	—

Source: Evidence of G. H. Clark and J. E. Cook.

These are the concentrations that could be expected in a hypothetical 'worst case' situation in which an atmospheric inversion—a layer of cold air preventing the upward movement of air nearer the ground—was located just at the height to which the plume would rise, some metres above the top of the stack. Beneath the inversion, uniform mixing of sulphur dioxide and air is assumed to occur as a result of turbulence caused by rising air, warmed by contact with the ground heated by the early morning sun. Such a condition is termed 'fumigation'.

The one-hour figures shown in the table are for a one-hour fumigation period. It has been observed at another location in northern Australia, Mt Isa, that during fumigation the inversion does not stay stationary but moves upward as a result of the turbulent influence of the warm air underneath. This suggests that the calculated concentrations for the Ranger area may be unrealistically high. The three-hour and twenty-four hour figures were derived by assuming that fumigation lasts for one hour and is followed by periods of two hours and twenty-three hours respectively during which average conditions prevail; the concentrations given in the table are averages for the whole three-hour and twenty-four hour periods. The U.S. Environmental Protection Agency three-hour and twenty-four-hour standards are also shown in the table. The calculated concentrations are all well within the standards.

Calculated concentrations of sulphur dioxide during fumigation, given the assumptions made about the phenomenon, depend only on the distance from the source. The available meteorological data from Jabiru are insufficient to enable the probability of fumigation conditions occurring with any particular wind direction to be estimated. As a result, the probability of such high sulphur dioxide concentrations occurring at, say, the regional centre is unknown. However, it has been observed that inversions occur more frequently during the dry season, when the prevailing wind is towards the regional centre site, than during the wet season when the prevailing wind blows towards Mt Brockman.

During fumigation, sulphur dioxide concentrations could be expected to reach, for brief periods, values higher than the one-hour figures. For example, the estimated peak three-minute concentration under fumigation conditions at the regional centre site is 1110 micrograms per cubic metre, which is about twice the one-hour figure and just below the threshold for taste and smell. The health effects of such levels are unknown, although sulphur dioxide in non-irritating concentrations has been incriminated as a factor contributing to relatively high frequencies of chronic respiratory disease among people living in industrially polluted atmospheres. For periods of less than a minute, the concentration could reach even higher levels, and people in the regional centre might smell sulphur dioxide.

The Mt Brockman escarpment may be exposed to transient high concentrations of the gas. Because the escarpment is higher than the expected height of the plume, it would be exposed directly to the plume when the wind was blowing from the north. Even under normal conditions, the sulphur dioxide concentration could reach several thousand micrograms per cubic metre. However, the plume would wander over the cliff face as the wind direction fluctuated, and it is unlikely that any one point would be exposed to these concentrations for more than a few minutes. This exposure would be most likely to occur during the wet season because the prevailing winds then are from the north and north-west. However, when rain was actually falling it would wash sulphur dioxide out of the air, causing a significant reduction in concentration. In preliminary tests continuous exposure of Kombolgie sandstone and ochre, the material used for Aboriginal rock paintings, to high concentrations of sulphur dioxide and humidity over a period of some months did not cause visible damage. However, the long-term effects of sulphur dioxide on the paintings at Djidbidjidbi are still uncertain.

It has been estimated that 0.30 grams of sulphur dioxide per square metre would be deposited on the ground annually at the southern boundary of Mudginberri pastoral lease in dry conditions. The corresponding estimate for Mudginberri homestead is 0.15 grams per square metre.

The possibility that sulphur dioxide emitted from the acid plant could cause ecological damage was raised by several witnesses. It was suggested that vegetation could be directly harmed by high concentrations occurring for short periods, excessive average concentrations, the cumulative effects of successive exposures to moderately high concentrations, and rain made acid by sulphur dioxide in the air. In addition, these witnesses argued that sulphur dioxide deposited on the ground could increase sulphur concentrations in soil and soil acidity, and these changes could affect the growth of some plant species, while sulphur finding its way into streams could make the water more acid, and this could harm aquatic fauna and vegetation.

As the maximum three-hour sulphur dioxide concentration estimated for the boundary of the proposed special mineral lease closest to the source of sulphur dioxide, the southern boundary, is about half the U.S. Environmental Protection Agency standard, serious damage outside the mine site from increased concentrations lasting three hours or longer is unlikely. The fact that the estimate is for 'worst case' situations, and is likely to err on the high side as sulphur dioxide deposition and terrain characteristics are ignored, reinforces this conclusion.

The possibility of damage being caused by higher concentrations occurring for shorter periods cannot be excluded. The time of year when high concentrations are most likely to occur briefly is the wet season, when north-westerly winds predominate. This is the period when vegetation grows rapidly and is likely to be most susceptible to damage from sulphur dioxide. Vegetation on Mt Brockman could possibly be affected. For this reason, the Commission believes that the sulphuric acid plant should be designed to keep sulphur dioxide output to the minimum practicable level. This is discussed in Chapter 7.

Plants are normally tolerant of wide ranges of sulphur concentration in the soil, and it seems unlikely that, in the absence of additional amounts of the major nutrients phosphate and nitrogen, the small expected additions to soil sulphur would have a significant effect on vegetation growth. However, the effects of deposited sulphur on the acidity of water in the region and on aquatic fauna are difficult to quantify and could be significant. We recommend, for this reason, that the acidity of billabongs in the dry season be monitored.

Acid production can be expected to cease when mining and milling operations end. Therefore, unlike many of the other contaminants discussed in this chapter, sulphur dioxide should not be a problem after operations end.

RADIATION

One of the consequences of mining and milling uranium is the release to the environment of uranium and its various decay products, all of which, except the final decay product, are radioactive. The basic radioactive properties of uranium and its decay products, the biological effects of radiation, radiation protection standards and recommended protective procedures were discussed in the Commission's First Report (pp. 85–91). A very brief recapitulation is given here, dealing in particular with the most important radioactive contaminants from uranium mining and milling—radium and radon. Both of these are present naturally in the environment at low concentrations—radium in soil and water, and radon in the air.

Radium emits energetic alpha particles. Many of its compounds are soluble in water, but the solubility of radium sulphate is very low. When it is taken into the bodies of human beings or higher animals, for example in drinking water, it tends to become concentrated in bones and to remain there for a long time. Waste water released from the proposed Ranger operations would contain some radium, which would find its way into the waters of Magela Creek. It would also be one of the radioactive components in ore dust which would be blown from the site and subsequently deposited on the surrounding countryside. Amounts of radium are measured in terms of their radioactivity, expressed in curies (Ci), the curie being the unit of radioactivity. Concentrations of radium are commonly quoted in units of picocuries (pCi) per litre (one picocurie is a million millionth (10^{-12}) of a curie). The most abundant isotope of radium is radium-226, which is a decay product of uranium-238. Although uranium itself and thorium, another of its decay products, are also released in wind-blown ore dust and dissolved in water, they are much less radio-toxic than radium and the quantities that might be released generally result in concentrations in the environment much farther below the maxima allowed by ICRP recommendations than is the case with radium. Evidence presented to the Commission examined the dispersion of uranium and radium from the site, but made very few explicit references to thorium.

Radon is a gas produced by the radioactive decay of radium. The most important isotope is radon-222, which decays with a half life of 3.8 days to a series of short-lived alpha-emitting decay products. When air containing radon and its decay products is inhaled, lung tissues are exposed to radiation, increasing the risk of cancer. Radon decay products could be a particular hazard to uranium mine workers. Radon would also be present, at lower concentrations, in air over the surrounding countryside. Quantities of radon released from mine and mill operations are also expressed in terms of curies. Radiation protection standards for mine workers, which must take account of the amounts of the various radon decay products present with the radon, are expressed in terms of Working Level Months (WLM). The definition and use of the WLM unit were explained as follows in the Commission's First Report:

'Precise calculation of the radiation dose received by lung tissues when these decay products are inhaled is difficult. To cope with the problem, radiation protection standards based on the relation between the estimated intake of the decay products and the incidence of lung cancer amongst underground miners have been adopted by some countries, including the U.S.A., but not yet by Australia. These standards are based on the intake during a miner's assumed thirty-year working lifetime, and are expressed in terms of Working Level Months (WLM). One WLM is the dose received from breathing air containing decay products at a concentration of 1 Working Level throughout the working portion of a month (taken as 170 hours). A Working Level (WL) is the quantity of radon decay products which, in 1 litre of air, would deliver a specified total amount of alpha particle energy (equivalent to a ten-thousand millionth of a curie of radon decay products in a situation where radon and the decay products are in equilibrium).

'The Australian *Code of Practice* recommends a maximum radon decay product intake of 4 WLM per year, corresponding to an average concentration of 0.33 WL throughout the year. This standard is as restrictive as that in force anywhere in the world, and corresponds to a cumulative intake of 120 WLM over a thirty-year period.

'In a study of uranium miners in Colorado, the U.S. National Institute for Occupational Safety and Health has attempted to work out the relation between lung cancer incidence and radon exposure. In miners exposed to a total dose of 120 WLM or less, no increase over the normal lung cancer incidence has been detected. Miners exposed to higher doses have shown a higher than normal incidence.'

Mention has been made of the dispersal of radioactive ore dust particles from the mine, which would contain uranium, thorium, radium and other radioactive elements. Another type of radioactive dust would be yellowcake dust from the mill. Since yellowcake is a partially purified uranium compound, uranium would be the only important radioactive component.

The food chain is another route by which radioactive material might enter the human body. Dissolved uranium, thorium and radium could be taken up from soil or water by plants. Thus dust, radon and dissolved uranium, thorium and radium might be taken into plants, animals or human beings where they could be partly concentrated in particular organs such as lung or bone. Evidence was given concerning the concentrations of uranium and radium in water leaving the mine site, but thorium was not dealt with. As mentioned above, it would normally be expected to make a relatively small contribution to the total radioactive dose which might be received by living organisms.

In order to determine the radiological significance of a particular quantity of any radioactive material present in the environment, it is necessary to know the quantity of radioactive elements entering the body and their location within the body. A great deal of information about such factors as life cycle, place of living, diet and metabolism may be required. When the amount and types of radioactive elements in the various body organs are known, the internal radioactive dose equivalent, measured in rems (First Report, p. 15), can be estimated.

In the pages that follow, the various estimates of the amount of radioactivity that might be released from the Ranger operation and the radiological consequences of such releases are considered. Alpha radiation, which has low tissue penetration, is the component of internal radiation of greatest biological significance. This is a consequence of the highly concentrated dose of energy delivered to living tissue cells which are in close contact with the alpha-emitting radioactive particles. A further type of radiation exposure, termed external radiation, is also discussed. Exposure to external radiation, which, as the name suggests, is a radiation dose delivered from outside the body, may occur close to large quantities of ore or drums of yellowcake. The biologically significant components of this external radiation are mainly beta and gamma radiation.

Radiation protection regulations

Before discussing the radiological impact of the Ranger proposal, some discussion of the legislative and regulatory framework covering radiation protection is desirable. The most important document is the *Code of Practice on Radiation Protection in the Mining and Milling of Uranium Ores*, published by the Australian Department of Health in 1975. *The Code of Practice* was prepared by a working panel of experts and takes account of comments received from Commonwealth and State Government departments and authorities, mining companies and trade unions. It takes account of the most recent information and recommendations available from relevant international bodies. The purpose of the Code is to set standards for the protection of both persons engaged in the uranium mining and milling industry and members of the general public whose health may be put at risk by radiation exposure arising directly from the industry's operations.

One of the criteria on which the Code is founded is the principle enunciated by the International Commission on Radiological Protection that radiation exposure be kept to the lowest practicable level. The Code specifies safe practices to be followed both by the operator and his employees. It requires the mine manager to institute a comprehensive health surveillance and monitoring program within the mine and mill area to ensure that the specified standards are not exceeded. It specifies the types of monitoring equipment to be used and states that all results must be recorded and made available to the relevant statutory authority. The Code requires that surveys be conducted by a Radiation Safety Officer in the working environment to determine the concentration of radon decay products and of airborne long-lived alpha-emitting dusts, surface contamination levels and the intensity of external radiation fields. The Code specifies allowable working limits and requires the manager to take protective action when necessary. Over and above this, it requires radiation exposure of employees and of members of the public to be reduced to the lowest practicable level. It also requires that monitoring of specified individuals likely to be exposed to higher radioactivity levels be carried out. The health surveillance of employees includes the requirement that the health records be held in a central registry for fifty years.

The Code requires that dusts and effluents released from the mine and mill, both airborne and liquid, be limited to ensure that doses to members of the public do not exceed specified dose limits, and wherever practicable are kept as far below these limits as is reasonably achievable. These dose limits are those currently recommended by the International Commission on Radiological Protection and their adoption has been recommended by the National Health and Medical Research Council.

The Code does not lay down details of the off-site monitoring program which should be undertaken in order to ensure that these dose limits are met. We recommend that such monitoring be carried out under the supervision of the relevant statutory authority, which should also be empowered to require that any changes be made to mine and mill operating procedures that might be needed to provide proper protection to the public. We discuss this further in Chapter 17.

The Commission concludes that the *Code of Practice* is very comprehensive and consistent with internationally accepted standards and practices. Ranger has stated that it would abide by the requirements of the *Code of Practice*. However, the Code has no legal status at present, in any part of Australia, although it was endorsed by the then Minister for Health in 1975 and its general release was authorised in 1976 by the present Minister. As previously stated (First Report, p. 89), the Commission regards the Code as an authoritative document which should be incorporated in legislation in the Northern Territory at the earliest opportunity. The legislation will have to specify an 'appropriate statutory authority', which is given a most important role by the Code in administration and enforcement. In the event that more than one mine and mill contributed simultaneously to the doses to the general public in an area, as may be the case in the Region, apportionment of emission levels to each individual project and consequent monitoring would have to be administered by the relevant statutory authority. At present there is no radiation protection legislation in the Northern Territory. This matter is dealt with in Chapter 17.

The radiation protection standards for employees of the uranium mining and milling industry and for members of the public laid down by the *Code of Practice* are expressed as maximum permissible radiation doses, called dose limits for members of the public. They are the same as those recommended by the International Commission on Radiological Protection, which were discussed in this Commission's First Report (pp. 86–7). These are shown in Table 16. Radiation protection standards for radon decay products have already been mentioned.

These maximum permissible values provide a measure for assessing the significance of the doses which it is estimated would arise from radon and its decay products, dust and external radiation emitted from the proposed Ranger mine and mill.

The same radiation protection standards apply for dissolved radioactive materials, such as radium, but determination of the dose to which people in the Region might be exposed as a result of the release of radium into Magela Creek waters is a very difficult task. One exposure path would arise if Magela Creek water were used for drinking. However, it is possible that a higher dose might result from eating food, such as mussels, barramundi or buffalo meat, contaminated with radium.

Estimates of maximum dose received are based on what is termed a 'critical group', which is a group of people, hypothetical or actual, who because of diet, habits, place of living or other factors are exposed to the greatest amount of the radioactive material, in this case radium. In evidence presented by the AAEC, an arbitrarily defined critical group was considered, consisting of people, such as local Aboriginals or some mining camp workers, who drink Magela water and eat buffalo, fish, cultivated fruit and vegetables watered with bore water containing radium at several times the concentration of Magela water, plus some wild food such as crocodile, goose, mussels and native fruit. On the basis of measurements of radium levels in these foods, under present (natural) conditions, it was calculated that the hypothetical critical group would receive about 8000 picocuries of radium a year. This estimated level of annual intake is sixteen times higher than that of the average inhabitant of the United Kingdom or Italy where such dietary measurements have been made.

The ICRP recommendations for maximum exposure to radiation are not concerned with the natural (background) exposure, but refer only to the additional exposure caused by human activities (excluding medical exposures). It happens that the recommended maximum permissible annual consumption

Table 16

Annual maximum permissible radiation doses (rem)

Organ or tissue	*For a member of the public (a)*	*For a radiation worker*
Gonads, red bone-marrow, whole body	0.5	5
Skin, bone, thyroid	3(b)	30
Hands and forearms, feet and ankles	7.5	75
Any other single organ	1.5	15

Source: Australian Department of Health. *Code of practice on radiation protection in the mining and milling of radioactive ores*. 1975.

Notes: (a) These are termed 'dose limits'.

(b) 1.5 rem to the thyroid of children up to 16 years of age.

of radium (resulting from human activities) is also 8000 picocuries. In other words, if the additional annual radium consumption by the critical group after mining started were to equal the allowable ICRP maximum, the total annual radium consumption by the group would be about 16 000 picocuries. It should be noted that, as explained in our First Report (page 86), the ICRP recommendations are derived on the basis of cost–benefit analysis and the assumption of a linear relationship between radiation dose and the effects of the dose. This makes it logical to be concerned only with the incremental radiation exposure, but it also means that if the group on which the cost of increased exposure to radiation falls (in this case, most probably local Aboriginals) is not the group which also receives the benefits from the mining, important questions of equity arise.

This uncertainty concerning expected levels of radium is clearly unsatisfactory. The Commission recommends that much more research into the behaviour of radium in the Magela system, along the lines outlined in Chapter 17, be undertaken before mining is allowed to start. If mining takes place, this research should be augmented by investigations into the behaviour of radium and thorium throughout the tailings disposal system.

The mine and mill

All parts of the mine and mill complex will be potential sources, to a greater or lesser extent, of radiation exposure if the Ranger project proceeds. The undisturbed ore contains uranium, together with its decay products thorium, radium, radon and the short-lived radon decay products. Opening up the mine would expose the uranium ore, which would be a source of external radiation. It would also enable radon gas to escape to the atmosphere, and enable seepage water containing dissolved radium to collect in the bottom of the pit. Although some of the uranium decay products would escape to the environment in this way, most would be carried to the mill in the ore. Some would also be contained in the waste rock; radon and dissolved radium would slowly escape from the waste rock pile and also from the ore stockpiles. Blasting, ore handling, crushing and grinding would cause more radon to be released, together with ore dust. The subsequent leaching and solvent extraction stages of the mill would separate uranium from its decay products; most of the latter would be sent to the tailings dam. Neutralisation of the tailings would ensure that most of the radium was precipitated out of solution, thereby greatly reducing the concentration of dissolved radium in tailings dam and retention pond water. A small proportion of the uranium decay products would remain as impurities in the yellowcake. Consequently, the yellowcake, some of which would escape as dust into the atmosphere, would be slightly more radioactive than if it were not contaminated.

The volume of tailings would gradually build up over the life of the mine, and the dam would finally contain about 30 000 curies each of thorium-230 and radium-226 (this estimate is based on the presently known reserves in No. 1 and No. 3 ore bodies). Some radon would escape from the tailings, the amount depending on the depth of covering water and other factors. Radon which did not escape would give rise to radon decay products in the dam. In addition, there would be a quantity of unextracted uranium, amounting to about 13 per cent of that originally present in the ore. It has been estimated that about three-quarters of the radioactivity of uranium mill tailings are contained in the fine fraction of the solid material (referred to as slimes).

External radiation According to estimates by the Australian Atomic Energy Commission, the level of gamma radiation at the mine face is expected to be about 1.6 millirems per hour. If pockets of high grade ore existed, the localised dose rate might be as high as 20 millirems per hour.

Radiation emitted by the ore stockpiles would depend primarily on the grade of ore in each pile. The stockpile of ore ready for crushing and the lateritic ore stockpile would probably have the highest emission rates. No estimates of emission rates from these piles were presented to the Commission. The maximum rates would probably be similar to the maxima in the mine pits.

In the mill radium and its decay products in ore undergoing treatment would be a source of external radiation. Ranger expects that radium would reach its highest concentrations in the mill in the counter-current decantation thickeners. The AAEC expects that the level of gamma radiation near these, or near any other mill equipment, would not normally exceed about 1 millirem per hour, but that higher levels could be anticipated if ore of higher than normal grades were treated. The anticipated maximum beta radiation level in the mill, close to some plant items, would give a dose rate of about 2 millirems per hour.

As mentioned above, the yellowcake product of milling operations is slightly radioactive. The AAEC's estimate of the dose rate at the surface of a stack of drums of yellowcake is about 3 millirems per hour.

The average radium concentration in retention pond No. 2 is estimated by the Commission as being about 40 picocuries per litre, which is about 1 per cent of the highest concentration expected in the mill. The level of radiation emitted by pond water should therefore result in a dose rate well below 1 millirem per hour, the maximum gamma radiation emission rate expected in the mill. Water in the small retention pond No. 3 would have somewhat higher radium concentrations, but in retention pond No. 1 concentrations would be lower.

The AAEC estimates that, if Ranger's proposal for the tailings dam goes ahead, the level of external radiation at the surface of tailings themselves will be equivalent to a dose rate of about 1 millirem per hour. However, if tailings slimes were allowed to accumulate in any part of the dam, the local dose rate would probably be somewhat higher. So long as the layer of water were maintained over the tailings during the life of the mine, as proposed, the radiation level would be considerably reduced, and at about 50 metres from the dam the tailings' contribution above the natural background radiation level should be very small indeed.

The expected external radiation levels to which employees would be exposed are 3 millirems per hour in parts of the mill, 1–2 millirems per hour at the mine face, in the cabins of ore haul-trucks and near the ore stockpiles, and 1 millirem per hour or less at other places. Ranger proposes to limit the time spent by workers in the higher dose rate areas so that no individual received more than the maximum permissible whole body dose of 5 rems per year. Since a ten-hour, six-day working week is proposed, at least for the early years of operation, comprehensive monitoring would be necessary to ensure that no workers would receive more than the maximum permissible dose.

The Commission received evidence that the average whole body dose from external radiation actually received by uranium miners overseas is about 0.5 rems per year, one-tenth of the recommended maximum. We have not been able to estimate what the average whole body dose to workers in the proposed Ranger mine and mill would be. The Commission strongly recommends that exposure be kept to the lowest practicable level, as laid down by the *Code of*

Practice. A management scheme which resulted in the bulk of employees receiving close to the maximum permissible exposure would not be acceptable.

Radon emission

Radon gas is produced wherever the uranium decay product, radium, is found. Thus it is present in uranium ore, and would be released when the ore was exposed to the atmosphere. This might be in the pits, on ore stockpiles or, to an extent depending on the amount of uranium present, on the waste rock pile. It would be released when ore was crushed and leached in the mill. Since most of the radium would remain in the tailings, negligible amounts of radon would be released from later stages of milling, but it would be released from the tailings dam.

In the pit, radon gas would diffuse from the exposed surface of the ore. Drilling and blasting during mining would increase the radon release to the atmosphere because they would enlarge the surface area of the ore. As explained in the First Report (p. 88), mining procedures must be designed so as to restrict radon exposure to levels well below cumulative concentrations that have been observed to increase the risk of lung cancer in uranium miners.

The Commission was presented with a number of estimates of the rate at which radon might be released from the pits. Since the rate of release from the pit walls would depend on both the surface area of the exposed ore and on the grade of ore, the rate would vary somewhat during the life of the mine. The amount of radon released by mining operations is expected to be roughly constant. Some radon would also be emitted from broken rock lying in the pits. Two independent estimates of radon release rates were presented on behalf on Ranger. One was 0.54 curies per day and the other 0.72 curies per day. Both these estimates were described as being 'realistic'. The AAEC presented an estimate of 7.6 curies per day which was said to be a definite upper limit, based on unrealistic assumptions on the rate at which radon escapes from rock. It also presented a 'realistic' estimate of 0.98 curies per day. All these estimates are for a production rate of 3000 tonnes of U_3O_8 per year.

Increasing the production rate to 6000 tonnes per year would increase the rate at which radon was released by blasting and from broken rock lying in the pit, but would have no effect on the rate of release from the pit walls. Ranger's 'realistic' estimate of the total rate of release under these conditions was 0.87 curies per day, while the corresponding estimate of the AAEC was 1.4 curies per day. The AAEC 'upper limit' estimate was 9.8 curies per day. If, as Ranger proposes, work was started on mining the No. 3 ore body while the No. 1 pit was still being worked, there would also be an increase in radon release during the period of concurrent operation, since a greater area of pit wall would be exposed.

It was calculated that, if the rate of radon release in the pit were 0.54 curies per day and completely still conditions were to persist for twelve hours, then the radon decay product concentration in the pit would reach 0.75 WL. Any air movement would disperse the radon and also introduce disequilibrium between radon and its decay products, thereby reducing the decay product concentration. Using the same assumptions, the radon decay product concentration in the pit corresponding to the 'upper limit' radon emission rate of 7.6 curies per day would be 11 WL.

The highest radon decay product concentration reported from the Region is 23 WL; this was measured under still conditions at the bottom of a deep narrow trench in high grade ore, and concentrations in the open cut pits would be most unlikely to approach such a level. Typical values in the trench were less than 0.5 WL.

The rates of radon output from the ore stockpiles and waste rock dump would depend both on the grades of ore and the surface areas of the piles. Emissions would increase as the piles grew. The Ranger company has estimated that, at the end of the life of No. 1 pit, the total emission rate from all ore stockpiles and waste dumps would be about 2.6 curies per day. The AAEC concurred with this estimate.

In the ore treatment plant, radon would be released both from the crushing and grinding stage and from the leaching stage. Radon released during crushing and grinding would be extracted by the ventilation system, which would also be used to collect dust, and vented to the atmosphere through a stack. Ranger estimated that 0.20 curies per day of radon would be released in this way. The corresponding AAEC 'realistic' estimate was 0.46 curies per day and the 'upper limit' estimate was 2.3 curies per day. Doubling the rate of yellowcake production was expected to roughly double the rate of radon production from crushing and grinding.

Radon released from the leaching pachucas and counter-current decantation thickeners would escape directly to the atmosphere. 'Realistic' estimates of the rate of release were 0.40 curies per day and 0.34 curies per day by Ranger and the AAEC respectively. The AAEC's 'upper limit' estimate was 1.7 curies per day. Doubling the rate of production to 6000 tonnes of U_3O_8 per year would roughly double the rate of radon emission from this part of the mill.

The rate at which radon would escape from the tailings dam is even more uncertain than the rate of radon release from the pit. The rate of release from the tailings dam would be influenced predominantly by the moisture content, depth of covering water, particle size and density of the tailings, and by weather conditions in the area.

The AAEC estimated that, if the whole area of the proposed dam were covered with tailings which were saturated with water but had no covering layer of water, the rate of radon emission from the dam surface would be 3.9 curies per day. This was taken as an 'upper limit' estimate, and one-tenth of this rate, 0.39 curies per day, was used as a 'realistic' estimate.

Ranger proposes to maintain water to a depth of 2 metres over the tailings at all times during the life of the mine. This would have the effect of slowing the movement of atoms of radon gas released from the tailings to such an extent that the vast majority of atoms would undergo radioactive decay before reaching the water surface. The amount of radon from the solid tailings released into the atmosphere would be effectively zero. If the water surface were stirred up by strong wind, a small amount of radon would escape, but it is most unlikely that it would be as much as 0.39 curies per day.

For this water blanket method of reducing radon release from the solid tailings to be effective, it is most important that adequate water be available, even at the driest times. Ranger proposes to use bore water when necessary to retain sufficient water in the mill circuit. The Commission recommends that the adequacy of ground water supplies for this purpose be fully proved before mining is allowed to start. If supplies are not adequate, it may be necessary to make other arrangements for obtaining the necessary water. It is also important that the technique Ranger proposes to use for spreading the tailings uniformly over the dam should work effectively. An uneven spread could result in 'sandbanks' breaking the water surface in the dam, with a consequent increase in radon release.

The importance of water in and over the tailings can be seen by comparing the estimated radon release rates from the proposed Ranger tailings dam with the release that might occur if the tailings were allowed to become uncovered and dry out. On the basis of experimental measurements on dry tailings piles in the U.S.A., the Commission has estimated that 120 curies per day of radon might be released from the Ranger tailings if they were allowed to dry out.

Ranger proposes, when mining of No. 3 ore body has started and No. 1 ore body has been mined out, to raise the wall of the tailings dam, build a second tailings dam or place fresh tailings in the worked-out No. 1 pit. If the second or third option was chosen, there would be two water-covered bodies of tailings emitting radon. However, since the area of the pit would be less than the area of the tailings dam, use of the worked-out pit would result in a low radon release rate. The highest possible radon release rate would occur with simultaneous operation of two pits and a second tailings dam in use. This situation would prevail for a few years only.

AAEC estimates of radon emission rates did not explicitly allow for the fact that water lying over the tailings would contain on average about 40 picocuries per litre of radium (Table 9). Radioactive decay of this radium would itself produce radon, some of which, arising near the surface, would escape to the atmosphere. The Commission has estimated that the quantity of radon released from tailings dam water would be only about 0.2 curies per day. Likewise, the Commission has estimated that a further 0.2 curies per day would be released from the radium in the water in the retention ponds.

It can be seen that radon release rates are expected to be highest in the pits, and that the radon decay product concentration would be highest there. If the radon release rate was 1.4 curies per day (6000 tonnes of U_3O_8 per year production rate), it is possible that the decay product concentration might reach 2 WL in the pits if it were perfectly still for many hours. The maximum permissible radon decay product exposure is 4 WLM per year, which corresponds to an average concentration of 0.33 WL throughout the year. If mining proceeds, it will obviously be important to establish what the radon emission rates actually are, and also what levels of radon decay product concentrations are reached. The latter are likely to be low in the early years, but increase as the pits become deeper and air movements are reduced. Radon and radon decay product levels would have to be monitored when the mine was operating, and access to the pits or other areas restricted when high concentrations were found.

We recommended earlier in this chapter that the cabs of large mobile mining machinery be sealed and fitted with air conditioning, so as to reduce the levels of dust to which operators would be exposed. Depending on the type of filter it contained, an air conditioner could also be expected to reduce the concentration of radon decay products to some extent. It would be important to measure the levels achieved as soon as mining started. If more effective protection were required, it would be possible to ventilate the cabs with air free from radon decay products. However, we endorse the recommendation in paragraph 4.2.5. of the *Code of Practice* that operations in the pits be planned so as to avoid the need for habitual use of respiratory protective devices.

In the First Report we referred to studies in the U.S.A. which showed that uranium miners who smoked had a much higher risk of contracting lung cancer that those who did not. We draw attention to the recommendation of the *Code of Practice* that uranium miners should not smoke in underground mines. If the Ranger project proceeds, miners and other employees should be informed that radon increases the personal risk of lung cancer in cigarette smokers.

A number of special precautions have to be taken in underground uranium mines to prevent the accumulation of dangerous concentrations of radon.

Ranger has said that, if the lower part of No. 3 ore body is mined by underground methods, forced ventilation will be installed to blow fresh air through the mine. Should underground mining be used, very strict monitoring and supervision will be necessary to protect the health of miners.

Ore dust Earlier in this chapter it was explained that ore dust is a hazard both because it contains silica and because it contains the long-lived alpha-emitting elements uranium, thorium and radium. If inhaled in large quantities, this dust might cause silicosis and would also increase the risk of lung cancer.

Ranger's proposal provides for dust produced in the crushing and grinding operations to be collected by a ventilation system and for most of it to be removed before the collected air was vented to the atmosphere. The company estimates that the amount of dust released to the atmosphere from crushing and grinding would be about 1050 grams of uranium, containing 350 microcuries of uranium radioactivity, per day. Thorium and radium would each contribute a further 350 microcuries, if it is assumed that, in the ore, they are in decay equilibrium with uranium. Since it was not found possible to estimate the rate at which dust would be released by activities in each pit, Ranger assumed that the rate would be the same as the release rate from the ventilation system of the primary crusher. Dust in the pits would come from both ore and waste rock, so the average uranium content would be lower than that of dust from the crusher. The resultant estimated release rate from pit No. 1 is 100 grams (33 microcuries) of uranium per day. The AAEC agreed with these estimates. In view of the very uncertain basis for making the estimates, it would obviously be important for measurements to be made as soon as mining started. Doubling the rate of yellowcake production was estimated to increase the rate of emission of radioactive dust by a factor of about 1.6, since the plant would work longer hours. Some of the dust would be released at night, when atmospheric dispersion would usually be reduced.

The proposed and recommended procedures for controlling the release of dust were discussed earlier in this chapter. Since, in average Ranger ore, the silica is more toxic than the radioactive components, procedures designed to keep levels of silica dust well within safe limits should also provide adequate protection from radioactive dust.

Yellowcake dust Yellowcake dust contains very little thorium and radium, so the main radioactive component is uranium. Ranger estimated that this dust would be released at a rate of 2200 grams (730 microcuries) of uranium per day if the production rate was 3000 tonnes of U_3O_8 per year. Doubling the production rate was estimated to increase the release rate to 3800 grams (1300 microcuries) per day. We have already commented on this large release rate, and in Chapter 7 the possibility of reducing the rate of yellowcake dust emission is discussed.

Dissolved radium All water on the site would be contaminated with radium to a greater or lesser extent. However, it is proposed that water for drinking and washing be obtained from outside the site area, and this should not present any health problem so far as radium is concerned. Mill process water and tailings dam and retention pond water would contain relatively high concentrations of radium, estimated to be as high as 40 picocuries per litre (see Table 9), but it would normally only be a hazard to someone so foolish as to drink large quantities of it. This could conceivably occur after mining was completed.

Accidents The Commission was advised of various precautions that would be instituted to render plant malfunction harmless. As noted in our First Report (p. 90), none of the accidents that may occur in uranium mining that we were told about could create a significant radiation hazard. Nevertheless, we endorse the AAEC's proposal that the Radiation Protection Officer should establish a set of procedures to be followed in the event of an emergency. We note that the accidental fatality rate in underground uranium mines in the U.S.A. is reported to be about fifteen deaths per 10 000 man-years of mining. The value for open cut mining is said to be substantially lower.

Conclusions The estimates of expected levels of radioactive emissions from the various sources are only approximate. It is therefore important that, if mining proceeds, comprehensive monitoring start as soon as operations begin. Provided actual levels did not exceed those anticipated by a wide margin, radiation, radon and radioactive dust would be a set of relatively minor industrial health hazards.

Radiation off the site Radon and its decay products, ore dust, yellowcake dust and dissolved radium will be carried and dispersed by wind and water beyond the boundaries of the Special Mineral Lease application area if mining proceeds. Several estimates of the expected levels were submitted to the Commission. The values were usually presented in terms of the annual dose that would be received by a person located at the position of interest. These estimates give no more than an indication of likely levels; uncertainties about the ways the radioactive material would be distributed compound the uncertainties in the output estimates for the mine and mill. Releases would not present an instantaneous hazard. The potential hazard is from cumulative radiation doses, the effects of which might appear only after many years.

External radiation Direct radiation from the mining and milling operations themselves should not be detectable outside the site boundaries. However, ore dust and yellowcake dust deposited on the ground outside would build up over the life of the mine and would be a source of external radiation.

The AAEC estimated that radioactive dust from Ranger's operations would cause an increase in the external gamma ray dose of 0.6 millirem per year at the southern boundary of Mudginberri pastoral lease, 0.15 millirem per year at the proposed regional centre site, and 0.12 millirem per year at Mudginberri homestead. Ore dust contributes most of these estimated doses, which are averages for the whole life of the mine. Doses would be •.ighest in the last years of operations, and then would slowly decline as some of the deposited material was washed out of the soil.

The present background level of external radiation in lowland country near the Ranger prospect is around 90 millirems per year, which is only slightly higher than the worldwide average external background of about 80 millirems per year. (There is in addition an internal background dose of about 20 millirems per year, which is produced by naturally occurring radioactive materials contained within the body.) The estimated additional external dose caused by dust from Ranger's activities is very low in comparison with this external background and with the recommended whole body dose limit for members of the public of 500 millirems per year.

Radon and its decay products Measurements of the existing concentrations of radon in the atmosphere have been made beyond the S.M.L. area. The mean values obtained from observations conducted over a twenty-one-day period at the proposed regional centre site and at Mudginberri homestead were 0.006 WL and 0.005 WL respectively. The highest value recorded during this period at the S.M.L. boundary, was 0.032 WL. The two former values correspond to a concentration of about 1.0 picocuries of radon per litre of air. In regions distant from radioactive ore deposits, the average concentrations of radon in ground level air vary between about 0.04 and 0.4 picocuries per litre.

The dispersion of radon depends primarily on atmospheric conditions. The methods used to calculate the pattern of dispersion of airborne dust and contaminant gases were discussed earlier in this chapter under **Air pollution**. Several estimates of radon concentrations resulting from the Ranger operations, at sites outside the S.M.L. boundary and on the boundary at the point receiving the highest concentration (a location on the western boundary), were presented to the Commission. The differences between the estimates arise mainly from varying estimates of the rate at which radon would be released from the mine and mill area.

The radon release rates used in the calculations, 18.0 curies per day for the 3000 tonnes per year production rate and 24.3 curies per day for 6000 tonnes per year, were the AAEC 'upper limit' estimates referred to above. 'Realistic' estimates were about one-quarter of these. The estimates are based on the assumption that only one pit is being mined.

Because of biological variability, and because of variation in the quantity of radon decay products present with the radon, the factor which relates radon concentration to decay product lung dose is not known very accurately. It was assumed in the calculations that continuous exposure to air containing 1 picocurie of radon per cubic metre would, on average, give a lung dose of 1.5 millirems per year.

Table 17 gives the figures accepted by the Commission as being the most accurate upper limit estimates of radon and radon decay product doses to the lung at the S.M.L. boundary on the west side (the direction in which the highest annual dose is to be expected because of the prevailing wind direction), at the proposed town site and at Mudginberri homestead. These estimates are based on figures supplied by the AAEC for a production rate of 6000 tonnes of U_3O_8 per year. They were increased by a factor of 1.6 to allow for the concurrent operation of two pits and the existence of two tailings dams. As previously explained, this situation would prevail for, at most, a few years during the total life of the Ranger project.

The table shows that radon and its decay products would make by far the largest contribution to lung doses off the site if mining proceeds.

Except at the Ranger site boundary, where members of the public are not likely to spend much time, the estimated doses do not exceed 6 per cent of the allowable limit. As explained above, more realistic estimates of radon release rates and hence of doses received would be about one-quarter of these upper limit estimates. The table shows that children are slightly more at risk than adults. Although all the dose estimates are subject to considerable uncertainty, the Commission received no evidence that the calculated quantities are seriously in error.

Airborne radioactive dust

The radiation dose received internally from radioactive dust would depend on the solubility of the dust in body fluids. It is assumed that all airborne dust is taken in via the lung. If the dust was insoluble, the lung would be the organ receiving the highest proportion of allowable dose (the critical organ). If it was

Table 17

Estimated upper limit of annual radiation dose in the vicinity of the Ranger site as a result of Ranger's operations (doses quoted in millirems)

Yellowcake production rate (tonnes U_3O_8 per year)	Source material	S.M.L. boundary: For dust (assumed completely insoluble) and radon, lung dose	S.M.L. boundary: For dust (assumed completely soluble) bone dose	Town centre: For dust (assumed completely insoluble) and radon, lung dose		Town centre: For dust (assumed completely soluble) bone dose		Mudginberri homestead: For dust (assumed completely insoluble) and radon, lung dose		Mudginberri homestead: For dust (assumed completely soluble) bone dose	
		Adult	*Adult*	*Adult*	*Child*	*Adult*	*Child*	*Adult*	*Child*	*Adult*	*Child*
3000	Radon	235		54	54	—	—	46	46	—	—
	Ore	14	95	3	9	18	86	2.5	7	16	75
	Yellowcake	5		0.9	2.5	1.2	5	0.8	2	1.0	4.5
	Total	254	95	58	66	19	91	49	55	17	80
	Percentage of dose limit	17%	3%	4%	4%	0.6%	3%	3%	4%	0.6%	3%
6000	Radon	267	—	70	70	—	—	59	59	—	—
	Ore	18	166	5	15	34	150	4.5	14	29	128
	Yellowcake	6		1.6	4.5	2	9	1.4	4	1.7	8
	Total	291	166	77	90	36	159	65	77	31	136
	Percentage of dose limit	19%	6%	5%	6%	1%	5%	4%	5%	1%	5%

Source: Evidence of J. E. Cook, and calculations by the Commission.

soluble, the critical organ would be bone. In fact the dust is slightly soluble, so the actual dose would lie between the two sets of values.

A number of estimates of annual doses which would be received by persons at the S.M.L. boundary, Mudginberri homestead and the proposed town were presented. Estimates by the AAEC, which made allowance for variations in dust releases between night and day, for the inclusion of windborne ore dust from the dumps and stockpiles, and for the separate contributions of ore and yellowcake dusts, are probably the most accurate. The calculations were based on release rates of dust similar to those referred to above. The Commission extended the AAEC's calculations by interpolating and extrapolating some of the data to obtain the dose rate estimates shown in Table 17. We increased the AAEC dose estimates by a factor of 7 per cent to allow for the simultaneous operation of both pits. In the AAEC dose calculations, the contributions from thorium-230, radium-226, lead-210 and polonium-210, assumed to be present in ore dust in decay equilibrium with uranium, were included, as were contributions from an assumed 2 per cent of the radium-226 and thorium-230 originally present in equilibrium with the uranium and carried as a residue in yellowcake dust.

The results in Table 17 show dose estimates for ore and yellowcake dust for the two limiting cases of solubility. At one extreme, it is assumed that the dust is completely soluble in body fluids, in which case bone is the organ that would receive the highest dose. At the other extreme of complete insolubility, the highest dose would be received by the lungs. The dose limit for bone for members of the public is 3000 millirems per year, and the same limit applies to a child. The estimated doses resulting from dust from the Ranger operation, and the percentages these represent of this dose limit, are shown in the Table. It can be seen that the dose distribution pattern from dust is similar to that from radon.

It is estimated that children would receive a higher dose than adults from the same concentration of dust in the air they breathe. The reason, so far as lung dose is concerned, is that children, on average, breathe about three times as much air in relation to their lung volume as adults do, so the number of dust particles lodged in the lung per unit volume of lung would be about three times as high as it would be for adults. In the case of bone dose, there is an additional factor arising from the fact that, in growing children, a higher proportion of the radium taken into the body is lodged in the bones. Because of these differences, the figures show that children are more at risk than adults, but none of the estimated doses is more than 6 per cent of the annual dose limit. It should be emphasised that estimates of lung dose are very imprecise because of uncertainties associated with physiological characteristics such as the rate of breathing and, to a lesser extent, uncertainties about the nature of the particles.

The assessment of dust concentrations in air at different places neglected the effects of dry deposition of dust and removal by rain, and could, as a result, considerably overestimate the actual situation. It was estimated that allowance for dry deposition could reduce the dust concentration, and hence the radioactive dose received, at the town site by a factor of ten.

Deposited dust

The naturally occurring concentration of uranium in the soil of the Magela plains is about 0.5 picocuries per gram and that of radium about 1.0 picocuries per gram. The AAEC estimated that, over the life of the Ranger project, deposited ore and yellowcake dust would add about 0.17 picocuries of uranium per gram and 0.05 picocuries of radium per gram to the soil at the southern boundary of Mudginberri pastoral lease (the closest part of the pastoral lease to the Ranger site). Farther away from Ranger, the amounts of dust deposited would be much less; there would only be about one-fifth as much at Mudginberri homestead, for example.

Some of this additional uranium and radium would be taken up by plants, which might subsequently be eaten by buffaloes or cattle, leading to an increase in the levels of uranium and radium in meat. In the absence of more reliable data, the AAEC assumed that the additional uranium and radium would be incorporated into buffalo meat in the same way as the uranium and radium already in the soil. Thus it was estimated that, at the end of the Ranger project, the meat of buffaloes grazing at the southern boundary of Mudginberri would contain 34 per cent more uranium and 5 per cent more radium than similar meat does at present. Since the few measurements that have been made suggest that the levels of these radioactive contaminants in buffalo meat are relatively low, the increases should cause no problem. The estimates are upper limits, applicable only to buffaloes grazing at the southern boundary of the Mudginberri lease; for most buffaloes on Mudginberri and Munmarlary the effects of dust from Ranger would be very much less.

Some of the uranium and radium in deposited dust could also find its way into the bodies of persons living in the area, via buffalo meat and other foods. The possible consequence is best assessed by reference to the diet of the hypothetical critical group referred to earlier. Nearly half the radium in the diet of this group under present conditions would, according to the assumptions made, come from buffalo meat, vegetables and fruit, into which radium deposited in the soil could be incorporated. If this critical group's food is assumed to come from the southern boundary of the pastoral lease, and if the amount of radium incorporated in the food is assumed to be proportional to the amount of radium in the soil, then the additional radium in this part of the group's annual diet would be about 200 picocuries when mining ended. This is an upper limit estimate of the effect of deposited dust, since a large part of the radium in these foods comes directly from water used for drinking by animals and for irrigating vegetables and fruit. If mining proceeds, the amount of additional radium in the diet resulting from the increased concentration in Magela Creek water is likely to be very much greater than the increased radium resulting from deposition of dust. The Commission was told that the application of superphosphate fertiliser to improved pastures, of which there are a few thousand hectares on Mudginberri, would add up to twenty-six times more radium to the soil of those pastures than would come from dust produced by the Ranger project, if the fertiliser were applied at the maximum rate normally used in the Region.

Dissolved radium

As shown in Table 11, it is estimated that the Ranger project would cause an additional 0.05 curies of radium to be added to the Magela system each year. This is equal to the amount estimated to enter the system upstream of Jabiru under natural conditions and flow past the mine site, and half the total amount estimated to enter the whole Magela system naturally. It was explained above that the natural amount of radium in the Magela system was estimated to lead to the consumption of 8000 picocuries of radium per year in the diet of a hypothetical critical group. The additional radium would enter the food of the critical group mainly via irrigation or drinking water. In the absence of better information, a conservatively safe assumption would be that it would enter the diet in the same proportion as radium already present. If it is also assumed that food and water are taken from the whole Magela area, an increase of 0.05 curies of radium per year in Magela water would result in the consumption of an additional 4000 picocuries of radium per year by members of the critical group, because the additional radium would be half that naturally present. This annual consumption is half the maximum allowed by ICRP recommendations. If it is assumed that food and water of the critical group would come entirely from the vicinity of Jabiru, then the additional consumption of radium would be 8000 picocuries per year, because the additional radium would be equal to the quantity naturally present.

The assumption of proportionality is likely to considerably overestimate the effect of the additional radium for two main reasons. First, some of the experiments to determine the quantity of radium occurring naturally in the diet of the critical group used bore water which contained considerably higher concentrations of radium than occur in Magela water at present or are likely to occur during mining. Thus the figures for natural radium intake and the additional intake are both likely to be overestimates. Second, much of the additional radium released as a result of Ranger's activities would be in controlled releases at times of flood. As was explained earlier in this chapter, it is likely that most of the contaminants in these releases would be carried right through the Magela system to the East Alligator estuary. They would not therefore make a proportional contribution to the year-round uptake and consumption of radium by plants, animals and human beings in the vicinity of Jabiru or in the Magela area generally.

On the other hand, it was admitted that the assumed consumption of mussels by the critical group may be lower than the consumption by some Aboriginals now living in the area. Mussels have relatively very high radium levels. In the calculations, it was assumed that they make up only half of 1 per cent of the critical group's food intake. It was calculated that these mussels contribute nearly one-third of the group's annual radiation dose. Some evidence suggests that if mussels are exposed to water containing higher concentrations of radium, the concentrations of radium in mussel flesh may only increase slightly, but the results are not conclusive.

It will be obvious that the whole treatment of exposure to radium is unsatisfactory. Further sources of uncertainty in the estimates arise from the measurements of radium levels in soil, plants, buffalo meat, fish and so on, which may be in error by a considerable margin. The need for much more research is clear.

Comparing these estimates with the estimated additional radiation doses arising from radon and dust, it can be seen that the possible effect of dissolved radium is by far the largest. It should also be noted that the amount of radium consumed by the critical group would already be very high. Of course people living at the regional centre, if they followed the precedent of Darwin residents, would mostly eat food produced outside the Northern Territory. Therefore the amount of radium in their diet would be unlikely to differ greatly from the amount in the average Australian diet. Local Aboriginals not associated with mining activities are much more likely to be exposed to high levels of ingested radium.

The Ranger company has proposed that total annual releases of radium should be limited to an amount equal to the natural amount carried by Magela Creek past Jabiru each year, which it estimated to be 0.1 curies, twice the figure adopted by the Commission. That is, it proposes to limit releases to 0.1 curies per year. Using the same assumptions as above, it can be calculated that such a level of release would result in members of the critical group consuming 8000 picocuries of radium per year or more which would equal or exceed the ICRP recommended maximum. Having regard to the very great uncertainties in data concerned with radium uptake into food in this Region, the Commission finds the Ranger proposal for radium releases completely unacceptable. We recommend that various measures be taken to reduce the average release of radium, which is estimated to be 0.05 curies per year, along with releases of other contaminants. These measures are discussed in Chapter 7.

This discussion has taken no account of effects of dissolved radium on organisms other than man. The total amount of radium in the soil of the whole Magela plains is much greater than the total quantity which would be released into Magela Creek during the life of the Ranger operations. Therefore, even if all the additional radium remained in the soil, the plants and animals of the Magela flood plains, taken as a whole, would on average be exposed to only a slight increase in radium. However, in parts of the Magela system the additional exposure might be larger. It seems certain that, towards the end of the dry season, concentrations of radium in water and sediments in some billabongs now reach levels well above average. The effects on the plants and animals exposed to such transient high concentrations of radium are unknown.

Mention has been made (in Chapter 5 and earlier in this chapter) of the great uncertainties about the fate of contaminants in waste water from the Ranger project and about the effects of these contaminants on living organisms. It is obvious that investigation of the movement of radium in the Magela system will be an important part of the research program discussed in Chapter 17.

Transport It is proposed to transport the yellowcake, sealed in steel drums, by road from Jabiru to a port on the east coast of Australia. The *Code of Practice* requires that yellowcake be transported in accordance with the *Regulations for the safe transport of radioactive material* issued by the IAEA. The Code also requires that the transport container be of a type approved by the relevant statutory authority. For the Northern Territory, where there is no radiation protection legislation, this authority has yet to be defined. Elsewhere in Australia the State Health Departments are the relevant authorities. Although yellowcake is only mildly radioactive, persons in close proximity to large quantities would be exposed to significant doses of external radiation. It was estimated that the dose rate in the driver's cabin of a truck transporting yellowcake would be up to 2 millirems per hour. The statutory authority will be required to determine whether and under what conditions the drivers should be classified as radiation workers.

In the event of a traffic accident involving the escape of yellowcake, the major radiological hazard would be the possible inhalation of dust by the driver or by his rescuers. Calculations indicate that people would have to remain for an unrealistically long time in a dense cloud of dust to absorb a dangerous dose of radiation. The Commission therefore believes the hazard to be no more significant than other injuries which could be sustained in the accident. All transport personnel should be instructed in general emergency procedures and in the conduct of clean-up operations.

Conclusions The estimates of off-site radiation doses are subject to considerable uncertainty, and extensive measurements should be made, if mining commences, to see how valid they are. Provided doses from airborne material did not considerably exceed the estimates, if radium releases were kept to a minimum by the measures we describe in the next chapter, and if the other controls we recommend were implemented, radiation arising from the proposed Ranger project should not cause any significant detrimental effects to the Region and its inhabitants.

THE SITUATION AFTER MINING

Ranger proposes, after mining and milling have ended, to remove the mill except for some concrete structures which would remain. The mine pits would fill naturally with water. The tailings dam or dams (30 metres high) and the waste rock dump (100 metres high) would be revegetated and no ore stockpiles would remain. Retention ponds No. 1 and No. 2 would continue to collect initial runoff, discharge during the wetter months, and retain flow late in the wet season for as long as the embankments and other structures in the water management system remained intact.

If the restoration program were carried out as proposed, the most important continuing impacts on the environment would result from contaminated runoff and seepage, emission of radon from the tailings, and the permanent changes to the landscape. If revegetation was not successful, severe erosion could occur on the site and dust could blow from the waste rock dump.

Water pollution

It is clear that, if development proceeds according to the Ranger proposal, contaminant losses to the Magela system will continue for a very long time after mining ceases. The major sources of contaminants would be the tailings dam and the waste rock dump. The areas most at risk from waterborne contaminants would be the same after mining as during operations.

Ranger estimates that the quantity of runoff from the area after mining would be of the same order of magnitude as during operations. However, it expects that removal of the ore stockpiles and revegetation of the waste rock dump and tailings dam would reduce contaminant concentrations in the runoff.

The company submitted estimates, necessarily speculative, of contaminant concentrations in runoff and seepage from the mine site after mining (Table 18).

Table 18

Estimated waterborne contaminant concentrations after mining ceases

Contaminant	(1) *Runoff from buffer zone as it enters Gulungul Creek*	(2) *Runoff through retention pond No. 1*	(3) *Runoff through retention pond No. 1*	(4) *Runoff from tailings pipeline corridor*
Copper (μg/l)	8	38(18)	30(16)	15
Lead (μg/l)	50	27(26)	11 (8)	7
Zinc (μg/l)	13	30(24)	13 (8)	10
Uranium (μg/l)	3	45(39)	52(54)	2
Radium (pCi/l)	7	7(11)	15(11)	1
Manganese (mg/l)	20			
Sulphate (mg/l)	1 550			
Arsenic (μg/l)	550			
Mercury (μg/l)	2			
Cadmium (μg/l)	0.1			

Notes: Column (1) calculated using seepage concentrations in Table 8 and assuming a dilution of 6:1
(2) original (revised) estimates calculated assuming 150% of year 10 values
(3) original (revised) estimates calculated assuming 30% of year 10 values
(4) concentration from Table 9, column (6)

These were based on the following assumptions:

- Removal of the ore dumps and revegetation of the mill area would reduce contaminant concentrations released through retention pond No. 2 to 30 per cent of the levels in the tenth year of mining operations.
- Contaminant concentrations in releases through retention pond No. 1 would be 50 per cent higher than in the tenth year of mining because the waste rock dump would have more than doubled in size and contaminated water would no longer be transferred from this pond to retention pond No. 2.
- Seepage losses through and under the southern and western embankment of the tailings dam would be 120 cubic metres per day, about 30 per cent of the estimate for the twentieth year of mining.
- Contaminant concentrations in runoff from the tailings pipeline area would fall rapidly to pre-mining levels.

These assumptions seem reasonable, although there appears to be some conflict, discussed later in this section, between the estimates of contaminant output from retention pond No. 2 and seepage from the tailings dam.

In general, the evidence indicates that contaminant concentrations in runoff from the site after mining would be similar to those during the earlier part of the mining operations. Seepage from the tailings dam would be the main source of long-term losses of sulphate, magnesium, manganese, calcium, arsenic, molybdenum, mercury and possibly lead. The waste rock dump would be a continuing source of copper, zinc, uranium and radium. Production by bacteria of acidic seepage water from waste rock (discussed in the section **Comparison with Rum Jungle** earlier in this chapter) seems unlikely to be a serious problem after mining. However, small pockets of high sulphide ore could produce some local problems; we are unable to assess whether these might prove troublesome in the long term, though it seems unlikely.

Estimates provided by Ranger of the quantities of waterborne contaminants released annually after mining (see Table 19) are, like the concentration estimates, highly speculative. They indicate that, if the company's present proposal went ahead, long-term annual losses would amount to 55–75 per cent of those occurring in the tenth year of mining for copper, lead and zinc, 45–50 per cent for uranium and radium, and about 75 per cent for other contaminants such as sulphate, manganese and magnesium. Comparison with the quantities carried naturally by Magela Creek past Jabiru indicates that, in average climatic years, these losses from the mine would probably almost double the quantities of uranium and sulphate taken downstream. The quantities of manganese and radium would increase by about 50 per cent, and copper, lead and zinc by something less than 15 per cent.

The available bioassay data (see Table 13) indicate that runoff towards Gulungul Creek and overflow from retention ponds No. 1 and No. 2 after mining could kill fish in the immediate vicinity of the releases unless diluted some two to three times. Greater dilution would be needed to prevent sublethal effects on fish; for example, the data indicate that zinc in overflow from retention pond No. 1 could have harmful effects if the wastes were diluted less than some thirty times. The evidence suggests that there would be times when this dilution was not achieved. It should be noted that these estimates assume that all heavy metal contaminants are in their most toxic form; as discussed earlier, little is known about the likely chemical forms of contaminants leaving the Ranger site.

Table 19
Estimated total annual releases of waterborne contaminants from mine site after mining ceases

	Source					(6)	(7)	(8)
	(1)	(2)	(3)	(4)	(5)	*Percentage of total loads contributed at year 10 of operation*	*Percentage of load carried by Magela past Jabiru*	*Total load from tailings dam seepage*
Contaminant	*Retention pond No. 1*	*Retention pond No. 2*	*Gulungul buffer zone*	*Tailings pipeline corridor*	*Total*			
Copper (kg)	41	26	2	2	71	55	14	5
Lead (kg)	33	10	13	1	57	72	14	30
Zinc (kg)	38	13	4	2	57	74	5	8
Uranium (kg)	42	46	1	0.3	89	49	180	2
Radium (Ci)	0.009	0.013	0.002	0.0002	0.024	45	48	0.004
Manganese (t)			5		12[(a)]	75	48	12
Sulphate(t)			410		930[(a)]	77	190	930

Notes: Column (1) calculated assuming 150% of year 10 values
(2) calculated assuming 30% of year 10 values
(3) calculated using concentrations in Table 8 and volume of 44 000 m^3/year
(4) calculated using concentrations for Table 18, volume of 160 000 m^3/year
(a) Calculated using concentrations in Table 8, and assuming that the total volume of 100 000 m^3/year lost through and under the tailings dam embankments enters the Magela system.

After mining, contaminated water would enter the environment in a very much less controlled manner than during mining operations. Ranger stated that it would be possible, by appropriate design of the final stages of retention ponds No. 1 and No. 2, to keep the released runoff within the standards employed during mining, but we do not have evidence to vindicate this statement. In fact, the evidence suggests that after mining the situation may well be worse than during operations. Presumably the retention ponds would be filled during the wet season. Evaporation would concentrate contaminants as the dry season progressed, and in the early part of the following wet season the ponds would receive slugs of concentrated leachings and runoff from the tailings dam and waste dump. After mining, this water would not be removed for use in the mill as it would be during operations. Thus the first overflows from the two ponds might well be more concentrated than any controlled discharges made during mining.

Further, it seems unlikely that the retention pond dams would remain intact over the period of time (centuries) they would be needed to retain the early wet season flush and enable at least some dilution before release.

In assessing the possible impact of contaminants released during the mining operations we concluded that, provided correct management practices were adopted by the company, almost all the uranium and radium and 70–90 per cent of the copper, lead and zinc would be released via the retention ponds at times when there was a high probability that they would be flushed from the Magela system. We also expect that, if the company's present proposal was modified to allow seepage from the tailings dam towards Gulungul Creek to be collected and returned to the tailings dam, the greater proportion of other contaminants such as manganese, sulphate, arsenic and molybdenum would be similarly flushed from the system.

After mining, if the Ranger project goes ahead as planned, the uncontrolled runoff and seepage will probably cause dry season water quality to deteriorate in Gulungul, Djalkmara and Coonjimba billabongs, and contaminated runoff may enter Magela Creek at times when flow is inadequate to flush it through the system. There is a real possibility that other billabongs and swamp areas further downstream from Jabiru could be adversely affected. We believe the risks are unacceptable.

The situation with regard to radium is particularly disturbing because of the way in which radium taken into living organisms, particularly higher animals, tends to accumulate during the lives of the organisms. Ranger's proposal may lead to a steady accumulation of radium in the Magela system over many years, which could eventually increase the level of radium in the soil to twice its present value or even higher. For this reason the total amount of radium entering the Magela system is a more important consideration than the concentration of radium in Magela Creek water.

The Ranger company has considered the option of returning the tailings from the tailings dam to pit No. 1 after the completion of mining there. The company stated in evidence that it wished to retain this option and to decide on its feasibility in the light of environmental data obtained during the mining operation. Exercise of this option would almost eliminate seepage losses from the tailings after mining, and with them the major proportions of sulphate, manganese, magnesium, arsenic, mercury, molybdenum and possibly lead in runoff from the mine site. The changes in outputs of copper, zinc, radium and uranium would be less dramatic but still noticeable. Estimating the possible reductions in these latter four contaminants is made difficult by apparent inconsistencies in the data in Table 19. For example, although it is clear that after mining the main source of contaminants entering Djalkmara catchment and hence retention pond No. 2 would be seepage through and under the eastern embankment of the tailings dam, the estimates of the amounts released from that pond are considerably higher than the total losses expected in the tailings dam seepage. Disposal of the tailings in the pits is discussed in detail in Chapter 7.

Stabilisation of tailings

Stabilisation of the tailings would be necessary at the completion of mining if they remained in the tailings dam, to prevent erosion of the fine material by wind and reduce leaching of the residual radium and toxic heavy metals left with the tailings material.

Ranger has suggested that the most suitable alternatives available for stabilising the tailings are:

- physical stabilisation with a layer of waste rock up to 1 metre deep (cost estimated to be \$500 000–\$700 000); or
- the growth of a cover of indigenous vegetation directly on the tailings. To facilitate the establishment of this vegetation, a thin layer of topsoil or chemical modification and fertilisation might be required.

Ranger believes it would be feasible to revegetate the area directly, and favours this alternative. It proposes to study the details of the revegetation program during the operational phase.

Evidence presented to the Commission casts serious doubt upon the likely success of such a revegetation program. We were told that revegetation of tailings from uranium mining is virtually untried in Australia, and that successful revegetation may only be achieved, if ever, after a long-term (perhaps twenty to twenty-five years) research and development program aimed particularly at investigating establishment techniques, species types and fertiliser requirements.

Three factors were considered likely to make difficult the development of a successful revegetation program. These are:

- climate; the natural climatic features of alternate extremes of wet and dry seasons, and high temperatures, coupled with the likelihood that most of the revegetated tailings dam surface would be flooded for three to five months per year, would create difficult conditions for plant establishment and growth;
- toxic heavy metals and other contaminants in tailings material; these would be likely to limit plant growth;
- unsuitability of tailings material for root penetration; the evidence indicates that penetration of plant roots into tailings material usually does not occur unless the surface has been extensively modified by cultivation and the addition of organic or other bulking material such as soil.

The Commission does not share Ranger's confidence that direct revegetation of the tailings could be achieved. The evidence suggests to us that there is no guarantee of success, even if exhaustive experimentation were carried out over a number of years. Certainly the present state of the art is such that no guarantee can be given that successful revegetation of the Ranger tailings would be achieved with native species. Of course, we have no way of knowing what advances may be made in this field in the next ten to twenty years.

Radon We discussed in our First Report (pp. 90–91) the potential long-term hazards associated with the tailings from uranium milling. This material contains all the radioactive decay products of uranium. One of these, thorium-230, decays slowly to produce radium-226, which in turn decays to produce radon gas. The tailings continue to produce radon, in decreasing quantities, until all the thorium, which has a half life of about 76 000 years, and all of the radium, which has a half life of about 1600 years, have decayed away. The time taken for radon output to dwindle to insignificant levels could be 100 000 years or more (perhaps up to a million years), depending on a variety of factors. The Commission recommended in its First Report (p. 109) that the chance of health risks occurring as a result of long-term radon releases from tailings should be minimised by appropriate engineering methods of containment.

Ranger's favoured method of stabilising the tailings in the dam, direct revegetation, would involve, according to its proposal, raising the tailings in a series of embankments and hillocks, leaving intervening areas of 'upland swamp'. It is intended that vegetation be established on the raised areas, with the 'swamp' areas remaining under water continuously. We consider this proposal unsatisfactory not only because, as stated earlier, we are not convinced that satisfactory permanent vegetation could be established on tailings material. Even if revegetation were successful, some radon would escape from the tailings through the vegetation. If it were not successful, the rate of radon release would be much higher since the raised areas would be dry and bare for much of the year. Also, we are not convinced that the 'swamp' areas would not dry out in years of low rainfall, thereby allowing increased amounts of radon to escape.

The expected rate of radon release would be greatly reduced if the tailings were completely covered by earth or rock. The extent of the reduction would depend greatly on the moisture content of the covering material; the Commission was told that a 6 metre layer of dry earth would reduce emissions to 10 per cent, and a 6 metre layer of sand with a 15 per cent moisture to 0.015 per cent, of their original value. However, adoption of this approach to reducing radon emission from the tailings would still involve leaving the tailings in the dam. There would still be a risk that erosion or a dam wall collapse would expose the tailings at some time in the future. No system of covering and containing tailings stored above the level of the countryside could be expected to last for thousands of years.

The Commission regards the risk involved in this method of tailings storage as unacceptable. A method of eliminating these risks by returning tailings to the worked-out pit is discussed in Chapter 7.

Aesthetic features

The main long-term aesthetic impact of the mining operations would be the appearance of the very large waste rock dump. Reaching a height of 100 metres, it would be nearly half as high as the nearby escarpment, and would cover about 1 square kilometre.

Ranger proposes to revegetate it, and this should make it somewhat less obtrusive. The proposal is for revegetation to start as soon as sections of it acquire a permanent shape. However, the company has not presented details of how revegetation would be carried out.

Because of the apparent absence of large amounts of toxic elements in the waste rock material, the Commission sees no major difficulty in revegetating the dump. Wherever top soil is removed during construction and mine operations, it should be stockpiled for use as a seed bed on areas to be planted. Native shrubs and trees should be chosen which are capable of reproducing from self-sown seed and which could initially be established from nursery-raised plants with a minimum of fertiliser. The supervising authority should require that revegetation trials be initiated as early as possible if mining proceeds, and should be responsible for the final choice of species and procedures. It should only allow revegetation procedures which it is satisfied will give rise to an adequate, maintenance-free vegetation cover. We propose that the sides of the dump be terraced, with suitable drainage provisions, to enable vegetation to be established more densely on the sides. This is important for erosion control as well as appearance. The supervising authority should approve the design to be adopted.

The tailings dam, about 30 metres high and covering about 1 square kilometre, would also be an intrusion. However, its impact would be virtually eliminated if the tailings were replaced in the pits as recommended and its earth and rock embankments were spread over the floor of the dam site.

The company's proposal for revegetating the tailings dam has already been explained. It is also proposed that the tailings dam area be kept as a permanently restricted area afer mining has ended. For reasons already discussed, the Commission considers the whole of this proposal to be unacceptable.

If the tailings were returned to the pit and the embankments of the dam spread over its floor, revegetation of the dam area should not be a major problem. Areas around the dam where seepage had emerged through the soil might prove difficult to revegetate because of higher concentrations of heavy metals in the soil. However, if an impermeable membrane were placed over the dam floor before storage of tailings began, seepage would be largely eliminated and this problem would not arise. These alternatives are discussed in Chapter 7.

Many areas of bare ground would remain when mining ceased and buildings were removed. These should be included in the revegetation plan. The benefits of revegetation would include reductions in runoff and seepage as well as in erosion, and encouragement to wildlife to recolonise the site. Some concrete structures would remain at the mill site. It would appear desirable that the more unsightly of these be demolished.

Rehabilitation and continuing protection

Responsibility for some revegetation and rehabilitation work is acknowledged by Ranger, starting during mining operations and continuing for a period after the mine closes. We discuss elsewhere in this chapter the nature and extent of the work which in our view should be done to rehabilitate the mine, mill, dam and other areas. Particular matters which we emphasise are the need to provide for the permanent and safe containment of all radioactive material, and the need to continue for an indefinite time protection of the natural water system from mine effluents. Rehabilitation will itself be a considerable enterprise, and an expensive one. If, as we recommend, tailings are returned to the mine pits, the work involved will be reduced (see Chapter 7) and continuing security will not be necessary. If our recommendations are not followed, parts of the site will have to be maintained and secured from accidental or deliberate intrusion indefinitely.

It is necessary to ensure that all the required work will be done, at the expense of the enterprise. It may be done by the operator, but it is important to make sure that if it does not do all the work, and do it satisfactorily, funds supplied by it will be available when required for the purpose, and will be adequate.

It seems to us that there are three important matters:

- The operator should be bound from the outset, and any successor should become bound, by a legally enforceable obligation to do all necessary work. The obligation will have to be described in ample terms.
- The obligation should be readily enforceable at all times by an authority or by authorities which can be relied upon to enforce it.
- The performance of the obligation should at all times be fully secured, and the security should be available freely to the authority, or authorities, having the right (and duty) to enforce the obligation.

In considering the precise arrangements which have to be made, it is important to bear in mind that there are many reasons why the mining operation may stop permanently, indefinitely or for a substantial period before the planned termination of activities. These include overseas market considerations, competition between producers, industrial problems, government direction, domestic financial considerations or environmental problems, or a combination of some of these. Our view is that, having in mind the highly sensitive nature of the environment, and the presence of radioactive material, it is essential that adequate machinery exist at all times for the necessary work to be done. It follows from what we have said that various contingencies have to be provided for. It will also be necessary to have a periodical review of the work to be done, and, therefore, of the amount of the security.

Several witnesses suggested ways in which the necessary security can be calculated and provided, the two alternative forms of security suggested being a trust fund and a bond. Either would be satisfactory, providing all necessary ancillary provisions are inserted and the principles already mentioned are observed. The draft outline of an agreement at one time proposed between the Commonwealth and joint venturers, Peko Mines N.L. and Electrolytic Zinc Company of Australia Ltd, when the Commonwealth was not a participant in the mining venture, was submitted to the Inquiry. Amongst other things, it provides that:

(18) (11) (i) The Joint Venturers will furnish security for compliance with the rehabilitation provisions of this Agreement and in accordance with the relevant provisions of the leases by lodging with the Administrator a security deposit or providing a covenantor or surety in a form and on terms acceptable to the Administrator to cover the cost of rehabilitation of all areas granted under lease, licence or other title.

(ii) The amount of the security will be determined by the Administrator after consultation with the Joint Venturers and will be based on the estimated cost of rehabilitation of areas as they are disturbed in accordance with plans of development approved by the Administrator. The amount will be varied from time to time to take into consideration:

(a) actual extent of operations into new areas;

(b) completion of rehabilitation in some of the areas, as certified by the Administrator;

(c) revision of cost estimates.

(iii) The security or surety will be discharged upon obtaining the Administrator's certificate that all the necessary rehabilitation work in all areas under lease or licence has been completed.

(iv) If at any time the Joint Venturers do not carry out the necessary rehabilitation work the Security may be realised or called upon and the proceeds used by the Administrator for rehabilitating the relevant areas; provided that the realisation or calling upon of the security does not release the Joint Venturers from liability to carry out any residual rehabilitation work which remains to be done after the proceeds of the security have been applied in a reasonable manner to the agreed rehabilitation program.

These provisions seem to the Commission to go much of the way towards providing a satisfactory arrangement, but do not fulfil the requirements we have expressed. How applicable they will be to the Ranger proposal depends on whether the Commonwealth remains a participant in it. If it does do so, its obligation to carry out rehabilitative work, and the continuing protection of people and the physical environment, should be dealt with in legislation, with a charge on consolidated revenue for the expense involved.

ECONOMIC BENEFITS

An analysis of the potential economic effects of the Ranger project was included in Chapter 9 of the Commission's First Report (pp. 75–79). The calculations were based on financial estimates provided by Ranger which assumed that production would begin in 1979–80 and continue until 1989–90 at the rate of 3000 tonnes of U_3O_8 (about 2500 tonnes of uranium) per year, and that a constant average price of $A15.87 per pound of U_3O_8 would be received. The excess of revenue over expenditure, expressed in terms of January 1976 prices, is about $554 million under these assumptions. This represents a relatively high rate of return on capital invested. When discounted at the rate of 10 per cent per annum to the year 1976–77, the present worth of the net profits to 1989–90 is about $197 million.

To put the contribution of the project into a national perspective, we noted in the First Report that the present worth of estimated additions to national income from the project amounts to about 0.34 per cent of recent levels of Australian national income. We also noted that the employment opportunities offered by the project, estimated at about 600 people per year during the contruction stage and about 250 in the operating stage, would be small compared with the total size of the Australian workforce.

Expansion of production at Ranger to a rate of 6000 tonnes of U_3O_8 per annum would approximately double the economic effects. However, some economies of scale might further increase the net economic benefits. For example, the Ranger company estimates that employment opportunities would not double to 500 but would increase only to about 400.

The national economic effects of an expanded uranium industry in the Region were considered briefly in the First Report and are dealt with more fully in Chapter 8 and Appendix V of this Report.

Turning to effects on the Northern Territory's economy, the evidence indicates that the construction stages of the Ranger proposal would increase the present annual level of incomes received in the Territory by 2–3 per cent. Operations at the 3000 tonnes per year production rate would add between 4 and 5 per cent to the present annual income level, and at the higher rate they would add between 7 and 11 per cent. These estimates allow for some induced effects on other expenditure.

At the lower production rate, the Ranger operation would increase the existing workforce in the Territory by an estimated 0.8 per cent, and at the higher level of output by about 1.25 per cent. These estimates take account of employment opportunities likely to be created in the mining town, but do not make allowance for any new industries which might be started in the Territory because of Ranger's operations, except the provision of lime for the Ranger mill.

The potential contributions of uranium mining to the Territory's income and employment are considered in detail in Appendix V, and are summarised in Chapter 8. The economic effects of a delay in the commencement of the Ranger project are also dealt with in Chapter 8.

7 POSSIBLE CHANGES TO THE RANGER PROPOSAL

In our assessment, in the previous chapter, of contaminant losses from the Ranger site both during and after mining we stressed the unreliability of many of the base data used. Doubt must therefore attach to conclusions based on those data so far as concerns environmental consequences of the proposed mining operation. We were told many times that the true picture would only become apparent when, and if, mining proceeded.

It is normal practice in those circumstances to prepare contingency plans to provide for unforeseen developments. The Ranger company has mentioned a number of changes to its proposal that will be made if necessary. It has argued that the precautions it proposes should keep environmental damage to an acceptably low level, but has stated that, if future monitoring and surveillance show that deterioration is occurring, appropriate modifications will then be introduced.

The extreme difficulty of detecting adverse long-term changes in aquatic ecosystems has been discussed in Chapters 5 and 6. It was the subject of much expert evidence. Uncertainty exists also about the possible effects of the deposition of airborne contaminants on the soil and water. Because of the environmental value of the Region in which mining is proposed, the difficulty of determining the cause of any adverse environmental effects detected, and the consequent difficulty of applying a remedy, the Commission believes that the Ranger company should be required to incorporate in its scheme of operations all practicable modifications which would materially contribute to reducing to the absolute minimum the release of contaminants to the environment. If at some time in the future it is proved that there is scope for relaxing the restrictions, that is the time for the change to be made. In simple terms, we advocate the adoption from the outset of the best practicable technology to prevent environmental pollution and degradation.

The term 'best practicable technology' does not refer to a level of pollution control technology representing the economic optimum between the cost of investment in equipment and the cost of environmental damage. The way in which cumulative and insidious environmental effects tend to be produced by successive minor increases in pollution makes it doubtful that such an economic optimum could be determined before major pollution actually occurred. Even then it might not be possible to determine the cause of the observed environmental damage.

By 'best practicable technology', we mean the best technology developed anywhere which can be applied to the uranium industry in Australia. In the case of the Ranger proposal where there is a combination of the prospects of a highly profitable venture with an environment of great sensitivity and value, interpretation of the term should not be restricted to technology used in other industries in Australia or in the uranium industry in other parts of the world.

Reduction of waterborne contaminants

It is clear that there are two main areas where alternative strategies or modifications to existing plans would be most effective at minimising waterborne contaminant losses. These are the control of seepage from the tailings dam and the provisions in the water management plan for deliberately releasing contaminated water.

Options for reducing seepage

The options available for reducing seepage from the tailings dam fall into two categories–those that can only be implemented easily during construction (e.g. lining the dam floor or blocking entry of water to fault zones under the embankment), and those that may be introduced at any stage if the need arises (e.g. building seepage collector drains downstream of the embankment, or placing an impervious lining over the tailings).

Briefly, the measures Ranger has proposed to control seepage from the dam include:

- using the lowest permeability earth materials available on the site to construct a clay core within the embankment;
- constructing a cut-off barrier below the dam embankment consisting of a trench, filled with compacted clay material, extending down through the relatively pervious surface soil into the underlying relatively impervious weathered rock;
- drilling from the cut-off trench to depths of about 40 metres in areas known to contain faults or shear zones of relatively permeable material, and pumping cement through the drill holes into the foundation (a process known as grouting) to hinder water movement;
- placing a blanket of compacted semi-impervious earth fill 2 metres thick over the floor of the tailings storage area, to a distance of about 30 metres from the clay core of the dam embankment, in areas where faults or shear zones exist. This blanket would lengthen the seepage path and hence tend to reduce the rate of seepage through the foundation of the dam.

Evidence was provided on the following alternatives available to reduce seepage and hence contaminant losses from the tailings dam:

- placing the tailings in the worked-out mine pits;
- more extensive grouting of fault zones than proposed by Ranger;
- redesigning the tailings dam embankment;
- constructing an impervious blanket on the floor of the dam;
- installing systems for collecting seepage; and
- placing an impervious blanket on top of the tailings.

These are considered in turn.

Replacement of tailings in the worked-out pit

The discussion in Chapter 6 of dispersal of contaminants from the mine site after mining ceased identified tailings dam seepage as the continuing major source of contaminants such as sulphate, manganese, magnesium, mercury, molybdenum, arsenic and possibly lead. The Commission concludes that there is a high probability that long-term uncontrolled releases of this seepage would cause adverse changes in the aquatic ecosystems downstream of the mine site, particularly in Gulungul Creek.

If, at the completion of mining, the tailings were replaced in the mine pits, the quantity of contaminants in water entering the environment from the tailings over the long term would be very much reduced. The Commission was told that it was estimated that, in the first year after No. 1 pit was filled with tailings, about 100 000 cubic metres of contaminated water would flow out of the tailings, but after twenty years the quantity would fall to about 10 000 cubic metres per year. Much of this water would flow out near the bottom of the pit, from where it would be most unlikely to reach surface waters. In comparison, it was estimated that seepage losses from the tailings dam would be about 115 000 cubic metres per year for an indefinite period after mining ended: most of this contaminated water would enter Magela Creek and its tributaries (see Chapter 6 and Table 10).

If the tailings were returned to the pits, worries relating to the long-term stability of the tailings dam and the tailings would be largely overcome, and the long-term release of radon from the tailings would be almost eliminated because they would be permanently submerged. Also, the Aboriginals' preference for filling the pits with earth and rock rather than water would be more easily realised.

Ranger told the Commission it did not oppose in principle the placement of tailings derived from ore dug from pit No. 3 into pit No. 1. However, it argued that decisions on whether to place the tailings in the pits should be delayed until more factual information became available from monitoring programs undertaken during mining.

If a decision were taken to replace the tailings, the following sequence could be followed. For at least fifteen years a tailings dam would be operated to store all the tailings from No. 1 pit together with tailings from No. 3 pit produced prior to the cessation of mining No. 1 pit. After mining stopped in No. 1 pit, the tailings from the processing of No. 3 ore body could be deposited directly into No. 1 pit. A considerable cost saving would result, since it would not be necessary to pump these tailings to the tailings dam or to raise the tailings dam or build a second dam to accommodate them. The tailings from No. 3 pit would approximately half fill No. 1 pit. Concurrently with this operation, the tailings in the dam could also be transferred to No. 1 pit, filling it to within 15 metres of the surface. Some 4 million tonnes of tailings would be left over to be put into No. 3 pit. No. 1 pit could then be filled to the surface with waste rock. A layer of waste rock could also be placed over the tailings in No. 3 pit. This scheme is unlikely to be more costly, and may be cheaper, than the company's proposal. The additional cost of transferring the tailings back into No. 1 pit would be offset by the savings mentioned above.

Ranger stated that a decision to replace the tailings would almost certainly make impracticable the future reworking of the tailings or ore remnants left in the pit walls, should circumstances make such operations otherwise economic in the future. This argument clearly applies only to the period after the completion of pit No. 1, some fifteen years after the start of mining, since up to that time reworking of the tailings or further mining of the pit walls would be possible. After that time, removal of higher proportions of the uranium from the ore from pit No. 3, and any subsequent pits, could be carried out during normal milling operations if world uranium prices made this desirable. Reworking of the pit walls would also be possible up to the time they were submerged in tailings or groundwater. The likelihood of this reworking being necessary or desirable is small, as Ranger proposes in any event to mine low grade ore, below the normal cut-off grade of 0.05 per cent uranium, down to 0.02 per cent, for stockpiling and use if economic conditions or technological developments make it worthwhile. With respect to reworking the tailings, the transfer of tailings from the dam to No. 1 pit would, for economic reasons, be spread over a number of years, and the option of reworking some proportion of them would remain until the transfer was completed. The cost of reworking would also be reduced by the amount that it cost to remove the tailings from the dam.

We conclude that any economic penalty associated with replacement of the tailings in the pits would be, at the worst, small. It seems more likely, almost certain, that an overall economic benefit would be derived from this alternative.

In making this statement, we have not considered the alternative of leaving permanently the tailings from pit No. 1 in the tailings dam and placing the tailings from pit No. 3 into pit No. 1 as soon as they were produced. This would clearly be the most economic solution from Ranger's viewpoint. It is not, in our opinion, an acceptable proposal because it fails to cope with the major problems associated with the tailings dam—its stability over hundreds of years, continuing seepage from the dam, and the continuous release of radon from the tailings in the dam.

The Commission recommends that the project be permitted to commence only if there is a firm, legally binding undertaking by Ranger to replace the tailings in the mine pits. We recommend elsewhere the provision of a security or surety to provide finance for this operation even in the event of the failure of the Ranger company or of it ceasing to carry on for any reason. Any stockpiles of low grade ore remaining after milling ceased should be placed with the tailings in one or other of the pits.

Many of the long-term environmental effects of the project are unpredictable. It is probable that many may be undetectable and that, even if a change is detected, it will not be possible to ascribe a cause to the apparent change, even after mining has proceeded for some time. Some of the effects, such as the escape of radon from tailings in a tailings dam, can be predicted to a low order of accuracy. Both these categories of effect would be ameliorated by the placement of the tailings in the worked-out pits, below groundwater level. For this reason we recommend that the supervising authority should not have the ability to relax the requirement that the tailings and unused ores be returned to the pits.

It was suggested in evidence that, after all the tailings had been removed from the dam, the embankments should be spread over the dam floor. The Commission has not received sufficient evidence to enable it to decide whether this would result in any further overall reduction in the quantity of contaminants leaving the site after the completion of mining. We suggest that this proposal be further investigated by the supervising authority.

Grouting

Evidence presented to the Commission by the Snowy Mountains Engineering Corporation (SMEC) generally supported the technical adequacy of the measures proposed by Ranger to minimise seepage from the tailings dam. However, some modifications to the grouting provisions were suggested. These included, in addition to the drilling and grouting of defects detected in the cut-off trench as proposed by the company, the drilling and water pressure testing of about 600 metres of additional test holes to intersect the anticipated joint systems in unfaulted areas. The results of these tests would be used to estimate seepage losses more accurately. SMEC suggested that the possible need for additional control measures should be considered on the basis of these estimates.

The Snowy Mountains Engineering Corporation also pointed out that the high sulphate content of the seepage could be expected to cause disintegration of hardened cement (the material Ranger proposes to use for grouting) as a result of chemical reactions. A major consequence could be the loss of effectiveness of the grout material and a subsequent increase in seepage rates. Extensive testing of the cement grout was recommended. SMEC suggested that, if this testing showed a loss of effectiveness, a different type of grout, resistant to attack by the dissolved chemicals likely to be present in the seepage water, should be used.

This evidence raises a serious issue. The Commission believes that there is reason to doubt the long-term effectiveness of the grout material proposed. Further, we have no evidence that other types of grout material which might be available would be any more resistant to chemical attack. Ranger stated that the possibility of using other materials would be considered in depth, but because of their proprietary nature details would only be available during the tender phase.

We conclude that, if this project is to proceed and the dam walls and floor are not to be sealed with an impervious membrane, the supervising authority must ensure that adequate testing of the grout material is undertaken, before dam construction begins, to ensure its long-term stability. This condition is to be interpreted in the context of our major recommendation that the tailings be returned to the mine pits. Evidence that the grout would remain intact for the period (only decades) during which the tailings were stored in the dam would be adequate. In the event that that testing gave unsatisfactory results, other methods of reducing seepage losses would have to be incorporated in the dam structure.

Embankment redesign

Supervision of the construction of large dams has the primary objective of ensuring that structural integrity of the dam is attained and can be maintained. In water-retaining dams, some losses as a result of seepage through the embankment are accepted as inevitable and, provided the quantity of water lost is small and the dam's stability is unaffected, inconsequential. However, a most important additional objective must be recognised as essential during the construction of the Ranger tailings dam—that of reducing seepage losses to an absolute minimum. It may well be necessary for the supervising authority to secure the services of a competent and independent group, such as SMEC or the Commonwealth Department of Construction, to supervise the tailings dam construction.

The estimates before the Commission indicate that about half of the seepage losses from the tailings dam would occur through the embankment, in spite of the fact that Ranger's plans provide for it to be built with a relatively impervious clay core. A general rule is that the wider the core, the less the seepage. However, there is a limit to the width of the clay core, beyond which an increase in width produces a negligible reduction in seepage.

The estimates of embankment seepage losses depend very largely on the permeability of the core material. Ranger told the Commission that sufficient material of the required low permeability was believed to exist on site. Close supervision of the embankment construction would be necessary, particularly to ensure that material of the correct specification was in fact used for the core.

One witness suggested that a 50 per cent reduction in seepage through the embankment could be achieved if a clay–bentonite core zone was used (bentonite is a type of clay with particularly low permeability). Another witness said that, if excessive embankment seepage was noted in the early stages of operations, it would be possible to use bentonite to reduce the permeability of the core zone in subsequent embankment construction. The Commission was told that another technically feasible method by which excessive embankment seepage could be reduced would be to construct a vertical bentonite slurry cut-off wall from the embankment crest to foundation level. Evidence was not received on the cost of either of these alternatives, although there appear to be many technical difficulties inherent in such operations, with commensurate costs. During the operation of the mine, excessive embankment seepage could probably be more practically handled by the incorporation of a seepage collector system, which is discussed below.

One witness suggested that very fine tailings material filling interstices in the rip-rap (or broken rock) used to protect the upstream face of the dam wall against erosion due to wave action might reduce seepage losses by 30–40 per cent. The Commission understands that Ranger's seepage rate estimates do not take account of this possibility. If the suggested reduction in seepage did occur, a significant reduction in contaminant levels entering the environment could be expected.

Ranger has stated that, if the tailings did not effectively penetrate the rip-rap, it would take corrective action by removing the rip-rap and allowing the tailings to be placed directly against the embankment. The embankment would be protected against wave action by raising the level of tailings nearest the wall.

This proposal would not, in our view, be acceptable. The band of tailings above the water level would be essentially uncovered. Its moisture content would depend on rainfall, wave action and the amount of water absorbed by the tailings band from the dam water. In the dry season much of the band could be expected to dry out. This would lead to unnecessary additional emissions of radon to the atmosphere and would enable dust to be blown from the tailings.

Seepage collector systems

The possibility of greatly reducing contaminant inputs into Gulungul Creek and significantly reducing the inputs into retention ponds No. 1 and No. 2 by intercepting seepage from the tailings dam and returning it to the system was referred to in Chapter 6. Ranger provided details of three alternative seepage collector systems, and suggested that their introduction should be dependent upon the results of monitoring programs established during the early operational phase. The Commission finds, however, that a high probability exists that this seepage would cause adverse ecological effects, particularly in Gulungul Creek and its billabongs. We therefore believe that, if mining is to proceed, a seepage collection system should be installed before mining commences, unless seepage is prevented by the installation of an impervious membrane on the walls and floor of the dam.

The first of the alternatives considered by the company was a system of collector pipes placed within the embankment at the base of its earth rock filter zone. The company rejected this system on the grounds that it would create a long-term hazard to the embankment stability and that there would almost certainly be rapid blocking of the pipes due to precipitation of calcium sulphate present in the seepage water. This alternative, if effective, would collect only the seepage from the tailings through the embankment and rainwater percolating down from the top of the embankment. Water collected by such a system could be directed towards a sump from where it could be pumped back to the tailings dam. It is estimated that, by the tenth year of operations, the annual volume collected by a system covering all four embankments would be just under 50 000 cubic metres. This could possibly lead to a reduction by about half in the quantities of sulphate, manganese, magnesium, arsenic, mercury, molybdenum and radioactive elements including radium entering the surface environment from the tailings dam area.

A second option which was suggested is to place an open trench or pipe drain at the toe of the embankment. This system would avoid leaving a pipe in the final embankment, but has the disadvantage, at least in the initial stages, that it would be collecting mainly rainwater. It is estimated that the volume collected by a toe drain along the southern and western embankments would be around

170 000 cubic metres per year in the first year of mining and would rise to 380 000 cubic metres per year at year twenty. The collected water could be disposed of in the tailings dam or retention pond No. 2. Ranger estimated the completed cost of such a pipe system to be $1.2 million. If the water were discharged to retention pond No. 2 and thence to Magela Creek, there would not be much change in the overall amounts of contaminants entering the Magela system. If it were returned to the tailings dam, there would be some reduction in the burden of dissolved contaminants entering Magela Creek. However, the main beneficial effect would be on Gulungul Creek. The evidence indicates that such a toe drain system would reduce contaminant releases to Gulungul Creek by perhaps 70 per cent.

The third option considered by Ranger was to place a collector trench downstream of the southern and western embankments to trap runoff from the area between the dam embankment and Gulungul Creek. A much greater volume of water would be collected by this system (450 000 cubic metres per year at year ten assuming an average climatic year). The collected water could be recirculated back to the tailings dam or to either retention pond for release when adequate dilution was available. This system should trap any silt eroded from the embankments or the ground downstream of them.

We have considered these options in the context of the initial adoption of a 'no release' water management system (see **Modification to the water management program**, later in this chapter) and the return of tailings from the dam to pit No. 1, both of which we recommend. We conclude that the first option, a pipe collector system at the base of the filter zone in the dam embankment, should be adopted, unless an impervious membrane is used to seal the dam walls. The first objection to the proposal to use a pipe collector system, that it would adversely affect the dam stability, is not supported by any detailed evidence. We received evidence that pipe collector systems have operated successfully in many water-retaining dams of design and size similar to those of the tailings dam. We conclude that such a system, if designed with the degree of engineering competence demonstrated in Ranger's existing dam design, would not jeopardise the stability of the dam structure. The second objection, that the system would rapidly be clogged by the deposition of calcium sulphate, would be of less importance if the dam were required to retain tailings for only a comparatively short time, as we recommend. It seems probable that a system could be designed, using large diameter collector pipes, which would remain operative for some years. If the system did become clogged, then the second option which we have just discussed should be adopted. We recognise that this might increase the quantity of water collected by the system to the extent that a 'no release' policy would no longer be practicable. This does not appear likely, since techniques for increasing evaporation which we discuss in this chapter could be implemented. However, even if it were the case, our recommendation would not be different for reasons which are discussed later in this chapter under the heading *Modifications aimed at segregating the most contaminated runoff water.*

An impervious blanket on the floor of the dam

A number of witnesses raised the possibility of 'sealing' the floor of the dam with an impervious blanket. Such a measure would reduce seepage losses under the embankment and through the dam floor to deep aquifiers. Together, these represent about half of the total seepage losses expected to occur. Another proposal put forward was to seal both the wall and the floor of the dam with an impervious membrane.

Ranger maintains that, in an overall context, the expected seepage losses are insignificant and the installation of an impervious blanket would be both expensive and unwarranted.

Evidence was presented to the Inquiry on the cost effectiveness of three alternative forms of 'impervious' blanket. A low cost alternative, a 1 metre compacted layer of material of the relatively impervious clayey type proposed for use in the core of the dam embankment, was excluded from serious consideration because it was estimated that only a very small reduction (less than 5 per cent) in total seepage losses would be effected. Two other alternatives, the use of a 0.3 metre layer of a mixture of that clay material and bentonite, and a butyl rubber membrane, appear to offer greater possibilities. It was estimated that the former would cost about $2.5 million at 1976 prices and should reduce seepage under the embankment and through the dam floor by 35–50 per cent if it covered the floor of the tailings storage area. It was estimated that a butyl rubber membrane covering the same area would cost about $5 million and produce close to a 100 per cent reduction in seepage via those routes. If the blankets covered both the floor and walls of the tailings dam, they should reduce total seepage from the dam by the same percentages. The estimated cost of a bentonite–clay blanket covering the walls and floor is $3 million, and that of a butyl rubber membrane $6 million. The use of other membrane materials, such as Trinidad asphalt or bitumen, was not the subject of evidence before the Commission. In the chemical–physical environment of the proposed tailings dam, they might have advantages, and we suggest that their suitability be investigated by Ranger and the supervising authority.

It might be possible to achieve some reduction in the cost of constructing the dam walls if it were decided to install a butyl rubber or other membrane over the floor and walls. However, the dam walls would still have to be designed to minimise escape of tailings liquor, and to remain stable, in the event that the membrane became perforated. This has not been the subject of detailed evidence.

Some concern was expressed to the Commission that the blanket materials might not prove durable in the long term. If, as we recommend, the tailings were placed in the pits, this concern would become much less important.

We conclude that the use of an impervious membrane to seal both the walls and the floor of the tailings dam should be investigated further. If it proved practicable, cost savings in foundation grouting, construction of seepage collector systems and possibly construction of the embankment would be achieved. Since the tailings dam site is gently sloping, the tailings would cover only the lower part of the dam floor during the first few years. This would allow the installation of a membrane to extend over several years, thereby reducing the burden of the capital cost.

An impervious membrane over the tailings

It was suggested in evidence that seepage from the tailings dam could be reduced substantially by placing an impervious membrane, probably butyl rubber, over the top of the tailings either during mining or when no further tailings were required to be placed in the dam. The membrane would achieve the reduction by preventing rainwater falling on the dam from leaching through the tailings.

The major advantages of this concept over a similar membrane placed under the tailings are that the membrane would be placed on a relatively flat, level surface, where mechanical damage would be unlikely, and the expense of the membrane would not be incurred unless and until it was shown to be warranted.

A major disadvantage is that it would not be as effective at reducing seepage. Also, placing the membrane over the saturated tailings might be quite difficult and, for reasons already discussed, the need for the membrane might not be demonstrable even if environmental damage was occurring. The cost of initially constructing the dam proposed by Ranger and providing an impervious membrane later would probably be higher than that of the alternative of an initially membrane-sealed dam, with an intended life of perhaps fifty years.

We note that the long-term problems of the structural integrity of the dam and its contents, and of radon emission from the tailings, would not be reduced by a membrane either on or under the tailings, unless the membrane had a virtually unlimited life and was capable of retaining water above the tailings indefinitely. Membranes of this type have been in use only for decades, and reliance on their durability over centuries would be unjustified. We also note that if, as we recommend, the tailings were removed from the dam and replaced in the pits, placing a membrane over the top of the tailings would do little to reduce the amount of seepage during the time that they were in the dam.

Modifications to the water management program

The essential features of the water management program proposed by Ranger were discussed in Chapter 6. A number of alternatives and modifications, aimed mainly at reducing the total amounts of contaminants released to the environment, were suggested during the Inquiry. The company appears reluctant to accept modifications, evidently because it believes its scheme is flexible enough to accommodate any problems should they arise once operations commence. We noted earlier some of the difficulties expected in this approach.

The suggested modifications fall into the following three groups:

- Changes aimed at reducing the volume of water to be discharged, by the introduction of spray evaporation, evaporation ponds or a combination of spray evaporation and extra ponds.
- Changes aimed at collecting the most contaminated seepage and runoff flows closer to their sources and using these in the mill circuit. This might include segmentation of the catchments into areas with varying degrees of contamination, provision of means for separate manipulation of the runoff from each, and special treatment of the more highly contaminated early wet season runoff and seepage flows from the waste dump and ore stockpiles.
- Chemical treatment of the most highly contaminated wastes before discharge.

Modifications to reduce the volume discharged

Alternatives designed to reduce or eliminate the need to release runoff from the mine area aim at disposing of the runoff by evaporation rather than release. The two most feasible methods appear to be spray irrigation and the construction of a series of evaporation ponds.

With both these methods the contaminants would be largely retained on the site, either on the areas spray irrigated or in the evaporation ponds. As a result, contaminant releases to the Magela system during the life of the mine would be much below those presently proposed.

Problems could arise after mining ceased. For example, some contaminants retained in the spray irrigated areas might subsequently be leached out and released to the environment in a less controlled manner than presently proposed. This problem would be eliminated if spraying was confined to the surface of the tailings in the dam. Problems could also arise with the evaporation ponds, particularly with the disposal of residual water and decontamination of the area prior to rehabilitation. A large measure of decontamination could probably be achieved by removing the contaminated top soil layer and placing it in the mine pits. In any case, the anticipated problems in decontaminating and rehabilitating evaporation ponds after some thirty years of use are likely to be quite minor in comparison with the problems associated with the tailings dam.

The Commission accepts that Ranger's calculations indicate that it would probably not be feasible to utilise on-site evaporative techniques to entirely eliminate releases over the life of the mine. We note, however, that those calculations are very sensitive to assumed rates of runoff, evaporation and seepage, and conclude that it is quite conceivable that a 'no release' strategy could prove practicable, especially if efforts were made to increase evaporation. Even if this proved not to be the case, we believe that it would be desirable to segregate highly contaminated water and to promote its evaporation. The residual water, in which contaminants would be very concentrated, could then be placed in the tailings dam. The less contaminated water would be released through the retention ponds. Such a procedure would eliminate the most highly contaminated controlled releases and should significantly reduce the total quantities of contaminants entering the Magela system. Ranger estimates that spraying over the surface of the tailings in the dam could increase the amount of water evaporated by up to 150 000 cubic metres per year.

We recognise that some radon would be released to the atmosphere as water in the spray evaporated, and have calculated an upper limit to the amount released. In this calculation we assumed that all the radon contained in the very fine spray droplets would emerge unimpeded. At Ranger's estimated maximum spray evaporation rate of 150 000 cubic metres per year, a total of about 6 millicuries of radium would pass through the spray system in a year if the tailings dam water contained the estimated 40 picocuries per litre. The amount of radon produced by this radium would be about 1 millicurie per day.

Because of the high solubility of radon in water, this amount of the gas could readily remain dissolved in the water until it evaporated. However, it is unlikely that all would be released to the atmosphere. If the total of 1 millicurie per day was released, it would represent less than 1 per cent of the amount of radon expected to be released daily by the tailings dam water (0.2 curies per day). Hence spray evaporation is acceptable from considerations of radon emission.

In summary, we find that some use of evaporation ponds and/or spray irrigation of contaminated water would result in at least a short-term reduction in contaminant releases to the Magela system. After the cessation of mining, an unknown proportion of the retained contaminants would be leached into the environment at an unpredictable rate, unless they were transferred to the worked-out mine pit No. 3. Possible long-term environmental effects would be dependent upon the feasibility of such a transfer. If a transfer did not prove feasible, the effects would depend on the total quantity of contaminants leached out and the rate of leaching.

Modifications aimed at segregating the most contaminated runoff water

Modifications to the water management program have been suggested which would allow further segmentation of at least Coonjimba and Djalkmara catchments into areas of varying degrees of contamination, by the construction of additional walls or drainage trenches. The intention would be to contain the most contaminated runoff and seepage closer to its source and before it was diluted. This water would be either used in the mill, disposed of on site by evaporative means or chemically treated before release to the Magela system.

Ranger agreed during the Inquiry to modify its water management program so that the runoff from the stockpile of ore ready for milling (the surge ore stockpile) would be directed to retention pond No. 3, rather than retention pond No. 2, for use in the mill circuit. It also stated that early wet season runoff from the waste rock dump would be diverted to the mill via retention pond No. 2 if monitoring indicated that this was desirable, and that in the event of excessive contamination occurring from the waste dump or the low grade ore stockpiles, these areas could be isolated and runoff pumped via retention pond No. 3 into the mill circuit or the tailings dam.

However, Ranger was reluctant to agree to major changes to its water management program before mining commenced, when the real situation would become known as a result of monitoring. It argued that adequate options were available to modify the scheme should the need arise.

The Commission believes it most important, if mining proceeds, that the supervising authority monitor closely all aspects of the water management program and require Ranger to implement all practicable modifications that would reduce the quantities of contaminants released. We conclude that the system should be established initially in a manner allowing no intentional releases to the environment, and that this system should be maintained until it was shown, as a result of the monitoring of pit seepage, evaporation and runoff rates, that releases of contaminated water would have to be made.

We recognise that this recommendation is related hydrologically to other recommendations we have made, namely that the practicality of installing an impervious membrane over the dam floor and walls be investigated and that, if this is found not to be practicable, a seepage collector system be installed in the dam embankment. We realise that the retention on site of contaminated water which would otherwise be lost by seepage would reduce the possibility that, in the later stages of development of the project, releases of contaminated water could be avoided entirely. Our view, in summary, is that the first aim of the water management system should be to reduce the uncontrolled release of contaminated water (by seepage) to the practicable limit. The second aim should be to reduce controlled releases of contaminants as much as possible, by the use of spray evaporation, evaporation ponds, the segregation of areas of different levels of contamination, and the ultimate disposal of highly contaminated wastes in the mine pits.

Ranger proposes that waste water releases be confined to periods when the flow of Magela Creek exceeds 20 cubic metres per second. Its estimates indicate that, because of the requirement for process water, there would not be releases in years of low rainfall. The Commission recommends a further constraint, that if releases have to be made, they should occur only at times when water is flowing through to the river estuary. The evidence indicates that this requirement could be met in most years of above-average rainfall, and that the time taken by the pulse of contaminated water to reach the estuary would, in the specified conditions, be about five to seven days. Nevertheless, this might mean that there would be no opportunities for releases in years of moderate rainfall. In this event, it would be necessary to store water until the next wet season. We propose that this possibility be examined closely by the supervising authority, in conjunction with the hydrological–meteorological model of the Magela system that we propose in Chapter 6. If necessary, the project design should include provision for additional waste water storage.

The Commission proposes one further constraint. It is on the length of the period of water release allowed at any one time. This constraint is aimed at reducing the time of exposure of aquatic organisms to contaminated water. The actual periods should be defined by the supervising authority in the light of the data obtained from early monitoring.

Chemical treatment of the most highly contaminated water before discharge

The Commission was assured by Ranger during the Inquiry that, if contaminant levels in runoff and seepage water were found to be excessive, the water could be treated chemically before release to improve its quality.

Four possible methods were suggested–dosing with lime to raise the pH, thus precipitating some heavy metals, treatment with adsorbent clays such as bentonite, precipitating radium by adding barium chloride, and using ion exchange resins to remove contaminants. No evidence was presented on the likely effectiveness of these chemical treatment methods in reducing contaminant levels in the waters in question.

Ranger's claim that suitable chemical treatment methods are available and could be introduced if necessary was not supported by evidence that such treatment would be practicable on a large scale. Because of the large volumes of water and the generally low contaminant levels involved, this seems doubtful. In our opinion, no reliance whatever should be placed on the contingency value of such methods in determining the processes which should be built into the operation to avoid adverse environmental effects.

Reduction of airborne contaminant losses

Our assessment of air pollution in Chapter 6 indicated two aspects of the Ranger proposal which should be modified to reduce the emission of airborne contaminants. The first relates to sulphur dioxide and the second to yellowcake dust.

The evidence indicates that the possibility of sulphur dioxide emissions from the proposed acid plant causing damage to vegetation, particularly in the wet season, cannot be ruled out. The Commission therefore recommends that, if Ranger adopts the option of building a mill of 3000 tonnes of U_3O_8 per year capacity to start with, the acid plant be modified to reduce sulphur dioxide emissions by the installation of a stack gas scrubber. We appreciate that, in the event that the acid plant was initially constructed with a capacity to provide for a uranium production capacity of 6000 tonnes of U_3O_8 per year, and the double catalysis process was used, the rate of emission of sulphur dioxide would be about equal to that of the smaller acid plant without either double catalysis or scrubber. However, our recommendation that stack scrubbers be installed recognises that such an emission rate may be unacceptable in any case. It is based on the policy of adopting the best practicable technology in all circumstances, the approach taken throughout this Report. The need for the best practicable technology approach flows from the lack of knowledge of the biological systems of the Region and of the effects of contaminants on them. It follows that, if a well-proved and reasonably cheap technology such as stack gas scrubbing is available to reduce contaminant levels, it should be employed.

The Ranger proposal as it stands involves the emission to the atmosphere of several kilograms of yellowcake dust per day from the mill. It would not be difficult to reduce this rate of loss by installing additional gas-cleaning equipment, and Ranger has indicated that, having regard to the value of yellowcake, it will examine the possibility of reducing losses of yellowcake dust when detailed designs for the mill are prepared. The Commission recommends that the necessary equipment be installed regardless of whether the cost of doing so could be completely offset by the value of the yellowcake recovered.

Reducing the risk of damage caused by blasting

The results of theoretical calculations indicating that the blasting procedure proposed by Ranger, involving sequential firing of the charge, may result in air blasts of sufficient energy to cause damage to the Mt Brockman cliff face are a matter of some concern. We therefore recommend that, if mining is to proceed, tests be undertaken immediately to provide experimental verification of the energy of the air blasts. These tests should be overseen by the supervising authority. If the results confirm the theoretical calculations, an alternative blasting procedure should be adopted. The Commission is aware that such a course of action would not reduce the more severe blast which would result in the unlikely event of simultaneous detonation of the whole charge.

Detonation of all the explosive stored in the magazine at the mine site is probably even more unlikely. However, it was not demonstrated that this could never occur, either accidentally or deliberately. In view of the possibility that such an explosion might damage the Mt Brockman cliff face and cause considerable damage to the tailings dam embankment, we recommend that the main magazine be relocated to a site at least 8 kilometres from the tailings dam and Mt Brockman.

Conclusions

We recommend that, if mining is to proceed, Ranger be required to adopt a 'no release' water management system for the first few years of operation. Excess water, if any, accumulated in that period should be stored in the tailings dam which should be constructed initially to a level which would provide adequate storage. If data on seepage, runoff and evaporation rates gathered during those years indicated that retention of all contaminated water would not be feasible throughout the life of the operation, even using such techniques as spray evaporation and evaporation ponds, then a system similar to that proposed by Ranger should be adopted. Such a system, based on the maximum practicable dilution of contaminants and their progressive release to the environment at times when they would be least likely to accumulate and concentrate in water bodies and organisms, should be modified to provide for the maximum practicable retention of contaminants after the completion of mining by techniques such as returning the contaminated water to the mine pits.

Ranger has considered, and rejected, the possibility of using an almost completely impervious artificial membrane to seal the dam floor and walls. The idea was rejected principally because of doubts about the permanent integrity of the membrane, but also because the company maintains that seepage from the dam would have negligible environmental effects even if such a membrane were not used. It was not contested that such a membrane, if protected from mechanical perforation, would provide almost complete containment of seepage during its lifetime. We recommend that the practicality and cost of installing a membrane of this type be investigated further and that, unless it can be shown to have inherent insoluble disadvantages, it be installed on the floor of the tailings storage area and on the dam walls before any tailings are produced. If the installation of such a membrane is found to be impracticable, a seepage collector system should be installed in the dam embankment at the base of the filter zone.

We also recommend that Ranger be required to return all tailings from the operation to the mine pits. Tailings should be removed from the tailings dam when pit No. 1 is worked out and replaced in that pit, concurrently with tailings from pit No. 3 ore. This recommendation is based largely on the evidence pointing to possible long-term adverse ecological effects due to continuing seepage losses from the dam, to doubts about the integrity of the dam over centuries, and to the problem of radon emission from the tailings if they were not submerged. If this recommendation is to be implemented it may be financially advantageous to Ranger to completely redesign the tailings dam to provide somewhat lower long-term integrity, although the tailings dam might be required to act as an evaporation pond for the whole period of operation of the Ranger mine, which could be fifty years or even longer. Considerations related only to the protection of the environment from waterborne contaminants would have led us to make this recommendation. Taking other factors into account, such as the long-term release of radon, the expressed wish of the Aboriginals that, if mining is to proceed, the mine pits should be backfilled, and the relatively low costs involved, we conclude that return of the tailings to the pits should be an absolute condition of allowing mining to proceed.

We also recommend modifications to the Ranger proposal to reduce air pollution by sulphur dioxide and yellowcake dust, and to reduce the risk of damage caused by the explosives used in mining.

8 PROPOSALS FOR DEVELOPMENT OF THE URANIUM INDUSTRY

We describe briefly in this chapter the three proposals, besides Ranger, which have been made for uranium mining and milling operations in the Region, and examine suggestions put to the Commission that one yellowcake mill serve all the uranium mines which may be developed. We continue the examination, begun in the First Report, of the economic benefits and costs of a national uranium industry, and we examine a regional uranium industry which would form a major part of it. We also assess the economic effects of a delay in the development of the Ranger proposal and, separately, of a national uranium industry.

Proposals for uranium mines

Jabiluka

The Jabiluka uranium deposit discovered by Pancontinental Mining Ltd is about 20 kilometres north of Jabiru and 12 kilometres west of the boundary of the Arnhem Land Aboriginal Reserve. Pancontinental owns a 65 per cent interest in the deposit, the remaining 35 per cent being held by Getty Oil Ltd, which is a U.S. company with no Australian equity. The ore, in two ore bodies, lies inside the boundaries of Mudginberri pastoral lease and of the 1975 proposal for the Kakadu National Park. The smaller ore body, Jabiluka One, is estimated to contain about 3000 tonnes of uranium. The estimated uranium content of the other, Jabiluka Two, is at least 170 000 tonnes, and as the ore body has not yet been fully defined the quantity may be even larger. The ore also contains gold in commercial quantities which the Pancontinental company proposes to extract.

The Jabiluka ore bodies are partially overlain by sandstone hills remaining after erosion of the main sandstone plateau of the Region. They lie just east of the Magela flood plain. Pancontinental's present proposal, which may undergo some modification, is to mine both ore bodies by open cut methods. The Jabiluka No. 1 pit would be only a few hectares in extent, but No. 2 pit, when complete, would cover 150 hectares. Very large quantities of sandstone, estimated at about 350 million tonnes, would have to be removed to expose the schistose rock in which the ore is found; much larger quantities of waste rock would be produced than at Ranger, where there is no overlying sandstone. The company proposes to dump the sandstone and schist waste separately in two large waste rock piles on flat ground a few kilometres north of the open cut pits. The total area occupied by the waste rock dumps would be about 250 hectares, and they would be about 100 metres high.

Pancontinental's proposal provides for ore to be crushed and stockpiled close to the open pits. Then it would be transported by conveyor belt to the mill area, located in a shallow valley about 2 kilometres north of the mine.

The average grade of ore at Jabiluka is somewhat higher than at Ranger, so less ore would have to be mined to produce the same amount of uranium. An initial annual production rate of 3000 tonnes of U_3O_8 (about 2500 tonnes of uranium) is planned, rising to 4500 tonnes of U_3O_8 and thence to 9000 tonnes of U_3O_8 (7600 tonnes of uranium) after a few years, subject to market conditions. Most major mill components would be built from the outset to provide the larger production capacity.

Plate 19. An aerial view of the Jabiluka mine site, showing the areas of the ore bodies. The proposed sites of the mill, dumps and ponds, including the tailings pond, are off the photo to the left.

A sulphuric acid leach and solvent extraction process, similar to that proposed by Ranger, would be used to produce yellowcake from the ore. On one day a week, gold-bearing uranium ore would be delivered to the crushing and grinding plant. It would be treated to recover the gold using a standard process employing cyanide, washed to remove residual cyanide, and then pumped to the acid leaching stage of the treatment plant for uranium extraction.

It is proposed to produce the required sulphuric acid from sulphur at the site in a double catalysis sulphuric acid plant with a capacity of 335 tonnes of acid per day. Pancontinental say that, at full capacity, this plant would emit 1.12 tonnes of sulphur dioxide per day to the atmosphere at a concentration of 2.5 grams per cubic metre as it emerged from the stack. That is about half the concentration envisaged from the proposed Ranger acid plant if a single catalysis process is used and stack gas scrubbers are not installed there by Ranger. Ranger could achieve a lower output concentration by the use of scrubbers, which we have recommended.

Pancontinental's estimates of radon emissions from its operations are somewhat higher than the estimates for the Ranger project, while its estimates of dust releases are lower than those for Ranger. Meteorological calculations indicate that, because of the pattern of prevailing winds, sulphur dioxide, radon and dust from Jabiluka would make only small additions to the quantities reaching Mudginberri homestead and the proposed regional centre site from the Ranger operations.

Tailings from the uranium mill would be neutralised using slaked lime before being pumped to a tailings dam located about 1 kilometre north of the mill between the two waste rock dumps. The roughly rectangular dam would have a water surface covering 168 hectares when full. It would be completely surrounded by an embankment, which on the north and west sides would run along the edge of the Magela flood plain. This embankment would be built up progressively as the quantity of stored tailings increased. On the north and west sides, the final toe of the dam would be 10 metres above mean sea level, and 1 metre above what is said to be the maximum flood level in Magela Creek. The embankment is envisaged as reaching its maximum height, 39.5 metres, twenty-seven years after the start of mining, if the company's proposed production program is followed. As with the Ranger proposal, Pancontinental proposes that the tailings remain in the dam permanently.

Since No. 2 ore body is so much larger than No. 1, almost all the tailings would arise from milling ore from No. 2 ore body and, conversely, No. 1 pit when mined out would only be able to accommodate a small proportion of the total amount of tailings. This means that only a small quantity of tailings could be returned to the mine pits for final storage until after No. 2 ore body was mined out—that is, after mining and milling of the presently known reserves of ore at Jabiluka had ended. This would make the transfer a more costly operation than at Jabiru, where Ranger would be able to carry out much of it while No. 3 ore body was being mined (see Chapter 7).

Pancontinental has estimated the maximum rate of seepage from the dam as 420 cubic metres per day after eight years of operation and 1000 cubic metres per day after eighteen years. This contaminated water would pass into Magela Creek. During the life of the mine, at least 1 metre of water would be maintained over the tailings to reduce radon emission.

For purposes of water management, it is proposed to divide the whole area into a series of clean and contaminated catchments. Because of the large areas of the contaminated catchments, particularly the mine, mill and schist waste dump areas, the volume of contaminated runoff would be considerably greater than evaporation from the storages holding the water. Contaminated runoff would be held initially in control ponds, before being directed either to the mill as process water or to the tailings dam or, if the concentration of contaminants were below a set maximum permissible level, to a large dilution pond to be built between the mill and Magela Creek. The contaminated water would be diluted in this pond with water collected from the clean catchments, and then discharged to Magela Creek. The possibility of adopting a system of concentrating and storing contaminated water, as opposed to diluting and dispersing it, has not been investigated by this Commission. Pancontinental estimates that, in an average year with 1350 millimetres of rain, a total volume of 1 to 1.5 million cubic metres of contaminated water would be discharged. This compares with discharges in an average year of about 1 to 2 million cubic metres from retention pond No. 1 and about 0.5 to 1 million cubic metres from retention pond No. 2 envisaged in the Ranger proposal.

Pancontinental's estimates of the maximum total quantities of copper, lead, zinc, uranium, radium and sulphate that would be released to Magela Creek in controlled discharges from the dilution pond, and in seepage from the tailings dam, in a year of average rainfall, are comparable with the corresponding estimates for the Ranger operation. Pancontinental has estimated that there are also likely to be fairly large releases of cadmium. No information is available about possible releases of cadmium from Ranger. The Commission is not in a position to confirm or reject the estimates made by Pancontinental of quantities of water releases and of the contaminants in them. Downstream from Jabiluka, the waterborne contaminants released by Pancontinental would be added to the contributions from Ranger's operations. This would be particularly important in relation to billabongs, sediments and living organisms where concentration of contaminants such as radium and heavy metals might occur.

Pancontinental has estimated that the number of construction workers would be about 600 to 700 during the expected three-year construction period which would precede the start of mine and mill operations. Further development of the No. 2 ore body would continue after this time, employing a construction workforce estimated at fewer than 250. During initial construction work associated with the mine and mill, workers would be housed in a construction camp 2 kilometres east of the proposed mill site. However, it is proposed that, once the mine and mill commenced operating, workers would live at the regional centre. Pancontinental expects that the production workforce would be about 350 during the first year of production, rising to 700 in the fifth year if the production rate of 9000 tonnes of U_3O_8 per year were achieved, and eventually reaching a maximum of between 800 and 900.

A witness for Pancontinental stated that the company could commence construction within a few months of receiving approval to do so. Bearing in mind the proposed size of the development and its very important environmental implications, there can be no doubt that such approval could not be given for some time.

Koongarra

Noranda Australia Ltd's uranium ore discovery at Koongarra is about 20 kilometres south of Jabiru (33 kilometres by road) and well inside the boundaries proposed in 1975 for the Kakadu National Park. It is about 4 kilometres from Nourlangie Rock and is in an area of high national park value. Although the size of the ore body has not yet been fully determined, the company is planning for a production rate of 2000 tonnes of U_3O_8 (about 1700 tonnes of uranium) per annum. It proposes to build a treatment plant at Koongarra to produce yellowcake, but all workers at the mine and plant would live at the proposed regional centre if it were established.

The uranium extraction process envisaged is largely similar to those planned for Ranger and Jabiluka. However, sulphuric acid would not be produced at Koongarra but would be imported.

An important difference from the Ranger and Pancontinental proposals is the method envisaged for treating the tailings. Noranda at present proposes to pump the unneutralised tailings to a tailings dam to be built in a natural gully near the mine. The solids would settle out in the dam, where it is envisaged that they would be stored permanently. Some of the clear acid liquid over the solid tailings would be returned to the mill for use in the leach circuit; the remainder would be neutralised with lime and treated with barium chloride, and then discharged to an evaporation pond.

These arrangements mean that the mass of settled solids in the tailings dam would remain in an acid condition. Hence seepage from this dam would probably also be acid, with a correspondingly high concentration of dissolved heavy metals. The whole Koongarra area, including the tailings dam, lies in the catchment of Nourlangie Creek which drains into the wetlands of the Woolwonga Reserve. Thus any water pollution arising from operations at Koongarra would be a potential threat to the very valuable wildlife of the Woolwonga wetlands. The proposal to build the tailings dam in a natural drainage system gives further ground for concern since it means that, over the long term, as the dam wall and other protective works deteriorated, the tailings would probably be subject to erosion.

It was stated that production of uranium could commence within two and a half years of receipt of the necessary approvals.

Nabarlek Queensland Mines Ltd's Nabarlek deposit is inside the Arnhem Land Aboriginal Reserve about 28 kilometres by road east of Oenpelli. It is within the catchment of Cooper Creek, which is a tributary of the East Alligator River, flowing into it near its mouth. The deposit is small but of very high grade. The company's present proposals envisage extracting all the ore by open cut methods over a period of eight years at a production rate of 1050 tonnes of U_3O_8 (about 890 tonnes of uranium) per annum.

Uranium would be extracted from the ore by the methods proposed for the Ranger, Jabiluka and Koongarra mills. The yellowcake product would be transported by road to a barge landing at Point Laterite, 82 kilometres by road to the north of Nabarlek. This route would also be used to bring in materials required for operating the mill, such as sulphuric acid, which would not be manufactured at the site. Since the company does not intend to upgrade the road crossing of the East Alligator River, the route via Point Laterite would be the only road access to Nabarlek during the wet season. The proposal has the advantage that heavy road traffic would not pass through Oenpelli.

Because of the lower rate of production and smaller total quantity of ore, the pit, mill and waste rock dump would all be considerably smaller than those of the other proposed mines. Tailings and contaminated runoff water would be discharged to an evaporation tailings dam. No discharge of contaminated water as part of normal operations is envisaged, so seepage should be the only path by which such water would reach the environment in the absence of accident. The company plans to refill the pit with tailings and waste rock after mining is completed.

The location of the Nabarlek ore deposit inside the Arnhem Land Aboriginal Reserve places the proposal in a different category from those already discussed. Queensland Mines Limited has been holding discussions with the Northern Land Council about the proposed development, and believes it will receive the Council's agreement to its plans. An important aspect of the plans is the intention to provide permanent housing in Darwin for all the Europeans working at Nabarlek during the mine's production life. Employees would spend two twelve-day periods out of a thirty-five day cycle at Nabarlek, and would be transported between Darwin and Nabarlek by air. While at Nabarlek, they would stay in construction camp quarters. Queensland Mines Ltd claims to be as advanced in its preparations to develop its site as any other mining venture—perhaps more so.

Conclusions There is insufficient evidence on which to base any definite conclusions about the extent of environmental impacts which would be felt from proposals other than Ranger's for uranium mining in the Region. Detailed study of each proposal in its environmental context will be required. However, some fairly basic conclusions can be drawn about the proposals as they have been put to the Commission. They are:

- The Pancontinental mine and mill at Jabiluka would be substantially larger than those of Ranger. It is proposed to release large volumes of slightly contaminated water from the operation each year. Since the mine site is within the Magela catchment, the effects of these releases would be cumulative with those of Ranger, downstream of Jabiru. We have made no assessment of the possibility of reducing or eliminating such releases. It is proposed to store tailings permanently in a tailings dam. We have not investigated the possibility of returning the tailings to the pits; however, we believe that this should be a condition of allowing mining to proceed, as we have recommended in relation to the Ranger proposal. The Jabiluka site is in one of only two areas in the Region where the flood plains extend virtually to the foot of sandstone outliers of the plateau.
- The mine and mill proposed by Noranda for Koongarra would be smaller than Ranger's. They would be in an area of high national park value. It is proposed to store tailings permanently in an acid condition in a tailings dam in a natural gully. Seepage from this dam, eroded material, and any release of contaminated water would enter Nourlangie Creek and would threaten the uniquely valuable Woolwonga wildlife sanctuary.
- Queensland Mines Ltd's proposed development at Nabarlek in Arnhem Land Reserve is small, with an expected life of eight years. Because of its size and location, its projected life, and the intention to return tailings to the pits and to avoid intentional release of contaminated water, its effects on the ecology of the Region should be small if it proceeds. The effects on Aboriginals would be reduced by the proposal to avoid construction of permanent housing in the area.

The evidence is clear that the adverse environmental effects of uranium mining would be increased by an increase in the number of centres of European activity in the Region. Each new development would entail additional roads, communication lines, power supplies and other components of infrastructure, as well as the structures and excavations of the developments themselves. The number of sources of pollution would be increased and spread geographically, and monitoring and control would be made more difficult. The adverse visual effect on the natural character of the Region as a whole would be increased. The Aboriginals have expressed great concern over this matter, and have requested that only one town be developed in the Region. We have recommended accordingly in Chapter 12. For all these reasons we believe that the number of mines operating at one time in the Region should be kept to a minimum and should be geographically contained, preferably within one catchment area.

Proposals for a common mill

Several witnesses suggested to the Commission that a single yellowcake mill to process ore from the proposed Ranger, Jabiluka and Koongarra mines should be built instead of separate mills at each mine site. Two distinct proposals were advanced.

One, put forward by consultants on behalf of Northern Pastoral Services, envisaged a mill located 9 kilometres north of Munmarlary homestead—about 40 kilometres west of Jabiluka and 50 kilometres north-west of Ranger. This mill would process ore from all the mines in the Region operating at any time. The other proposal, advanced by Mr W. C. Wentworth, M.P., was for a mill located on high ground as close as possible to the coast. Point Farewell at the mouth of the East Alligator River was mentioned as a possible site. It is more than 60 kilometres from Jabiluka and nearly 80 kilometres from the Ranger site. Mr Wentworth's proposal involved working each ore body in the Region in turn so that at any one time only one mine would be operating. When that was mined out, operations could be shifted to the next ore body.

Evaluation of the Northern Pastoral Services proposal

The rationale for one large mill (termed a central mill, although the locations proposed are not at or near the geographical centre of the proposed mines) is that the environmental benefits gained would be sufficient to offset the additional costs which would arise chiefly from the need to transport ore over considerable distances.

Submissions on behalf of Northern Pastoral Services Ltd contained cost estimates for three versions of the proposal to establish a processing plant 9 kilometres north of Munmarlary homestead.

In one version, the waste rock dump would be at the processing plant site. Alternatives considered were either to use another site 44 kilometres from the Ranger mine for the dump, or to site the dump at the mine. Calculations were submitted of the costs of transporting ore and waste rock by four different methods (rail, conveyor, combined slurry line and road, and road only).

The cost data on which the submissions relied were compiled in 1973, and an upward adjustment of 30 per cent was made by the consultants to allow for the cost increases which they estimated had taken place between 1973 and late 1975. Evidence on behalf of Ranger suggested that the actual rate of price increase experienced by mining ventures in northern Australia over this period was much greater than that used by the consultants.

Some important deficiencies in the approach adopted by the consultants were pointed out to the Commission. One is the fact that the cost figures omit any interest charge on capital, either during the construction period or to cover the opportunity cost of capital tied up during the period of operation. Whether or not interest was actually paid on funds borrowed to finance the operation would depend on the financing arrangements. However, a suitable rate of interest should be assumed when evaluating the national economic implications of any major development, since that part of the capital investment financed from Australian sources could be used elsewhere in the economy. The data used by the consultants also omitted some substantial capital costs associated with transport, including loading facilities and access roads, and with water containment works and housing for employees.

As would be expected, the costs associated with the options involving transport of waste rock are much greater than those associated with the option under which waste rock would be dumped at the mine site. While the omission of some costs (including interest) clearly means that the consultants' cost figures involve substantial under estimates, the data suggest that the rail system would be the least expensive method of transport, followed by road transport and a conveyor system. The cost figures for the slurry pipeline option are similar to those for a conveyor system, but evidence was given to the effect that a slurry system may not be technically feasible.

The Ranger co-venturers submitted revised cost estimates for the option providing for the dump at the mine site. They include considerably higher estimates of capital costs, as a result of the additional capital investment that Ranger considers would be required. Interest charges included in these estimates are partly offset by lower annual capital charges resulting from the longer lives assumed for the rail, conveyor and pipeline alternatives. Since the operating costs assumed are similar to those used by the consultants to Northern Pastoral Services, the differences between the two sets of estimates are almost wholly attributable to the differences in capital charges.

The Ranger data indicate that a road system would be the least expensive method of transport to the central mill, mainly because the capital investment and associated interest charges are estimated to be much lower than for the other alternatives. However, Ranger said at the Inquiry that, if a common mill were established, it would prefer the rail alternative because of its lower fuel requirements.

Ranger's estimates of the additional costs associated with the rail alternative amount to about 9.5 per cent of the costs of mining and milling at the Ranger site (using the cost estimates given in Table 10 of the Commission's First Report).

It was submitted that the proposed common milling operation would make some economies of scale possible. In support of this claim, the consultants to Northern Pastoral Services presented data from an American firm of consultants relating to the construction cost of sulphuric acid plants. The data suggest that the capital cost of one plant of 720 tons per day capacity would be just over half that of four separate plants with the same total capacity and about three-quarters of the cost of two separate plants capable of the same total output. The data also suggest that some economies in operating expenditures, particularly labour and maintenance costs and, to a lesser extent, water and power costs, could be expected with a single, large acid plant.

The Commission received no detailed estimates of the overall costs of a combined yellowcake mill, and we are not able to reach any definite conclusion about whether such a plant would give cost savings which might substantially offset the additional costs of transport and associated activities. However, Ranger and Pancontinental argued that, because ore from different deposits would be of different quality, its grade would have to be established before treatment and the different grades would have to be put through the plant in batches. Considerable cost penalties would result, and time would be lost in cleaning bins and hoppers unless these facilities were duplicated. Ranger and Pancontinental further submitted that ores from their proposed mines were so different that separate mills would be required to handle them, particularly as Pancontinental intends to recover gold from its ore. However, Ranger agreed that some facilities might be shared, and said a proposal for a common acid plant for the two mines, located in the vicinity of the mines, was being considered.

On the basis of this general evidence, it seems unlikely that any very substantial cost savings would result from establishment of the proposed common mill. Consequently, the additional costs of transporting ore would probably result in a net increase in overall costs. This has to be compared with the environmental benefits, if any, of the proposal.

It was argued that a single yellowcake mill at the site proposed would have a much less deleterious effect on the environment than separate plants at Jabiru, Jabiluka and Koongarra. The prevailing wind would carry sulphur dioxide from the acid plant and radon and dust from other parts of the mill complex across a small area of Munmarlary Pastoral Lease and then out over the South Alligator River estuary and the sea. Releases of contaminated water and seepage from the tailings dam could be expected to flow fairly directly into the South Alligator estuary and then drain directly into the sea where it was expected to have negligible effects on marine life. In contrast, it was argued, if separate mills were built at the Ranger and Pancontinental sites polluted water would enter the Magela wetlands on Mudginberri Pastoral Lease, which contain the main pastoral areas used by Northern Pastoral Services. Similarly, dust and sulphur dioxide could be expected to fall out on the Magela wetlands and on lowland areas around Mudginberri homestead where improved pastures are being established. (These aspects are discussed in detail in Chapters 6 and 7.)

In arguments against a common mill, it was pointed out that water pumped from the mine pits would be among the largest contributors to the total burden of contaminated water, and that the present proposals provide for it to be used in the mills. New water management schemes, involving either pipelines to the common mill or systems of evaporation ponds at the mines, would be needed to reduce pollution from this source to the level that could be achieved with the integrated water management systems associated with the present combined mine and mill proposals. Retention ponds would still be needed at both the common mill and the mines, plus a source of water for the mill if the pipeline scheme was not adopted. It was also pointed out that separating mine and mill would make it more difficult and expensive to return tailings to the mine pits, which appears to be the most effective way of reducing and eventually eliminating the impact of contaminated seepage water from tailings dams and of avoiding the long-term hazards of radon emission from them. We recommend in Chapter 7 that returning tailings to the pits be an absolute condition of allowing the Ranger project to proceed.

The Commission was told that juvenile stocks of prawns in the estuaries of the Alligator Rivers and adjacent coastal waters are believed to be important for replenishing the stocks harvested by the prawning industry, and that the release of contaminated water directly into the South Alligator River estuary might interfere with the life cycle of the prawns and might increase their metal content to such an extent that they would be unfit for human consumption. Contaminated water releases into watercourses remote from the coast would be less harmful to prawn stocks, because the heavy metal content would be diluted, and some would probably be immobilised in the flood plains, sediments and mangrove stands.

The additional handling of material and the increase in transport facilities involved in the common mill concept would have adverse environmental effects which would have to be balanced against any environmental benefits. In particular, the transport of at least 1 million tonnes of ore a year between the mines and mill would cause environmental disturbance over a large area. Also, the construction of a common mill would add an additional centre of European population in the Region, with consequential environmental effects.

Conclusions

The Commission concludes from the foregoing evidence that a common yellowcake mill as proposed by Northern Pastoral Services would reduce the impact of dust, sulphur dioxide and contaminated water on the Mudginberri pastoral lease area. However, the overall impact on the natural environment as a whole, including the sea, would not be reduced significantly, if at all. Since there is likely to be a substantial cost penalty associated with the common milling proposal, without overall environmental benefits, we conclude that the Ranger proposal to have the mill at the mine site would be preferable to the Northern Pastoral Services proposal.

A single sulphuric acid plant, to serve all the uranium mills in the Region, appears to have economic advantages. If there is to be a regional plant, it would be logical to locate it at the site of the first mine to start production, so as to minimise the number of industrial sites established in the Region and to economise on labour and service costs. However, if this were the Ranger site, the economic advantage might be offset by the cost of the more efficient pollution control technology which would be needed to reduce the level of sulphur dioxide emission from such a large plant to below the level Ranger proposes to emit from its considerably smaller plant (see Chapters 6 and 7).

Evaluation of the W.C. Wentworth proposal

Under this proposal, ore would be taken by rail to the common mill near the coast. Waste rock would be dumped alongside the pit, while tailings would be stored near the mill in such a way that any contaminated water which escaped would drain directly to the sea rather than into a wetland area. If it was preferred to put tailings back into a mine, they could be transported back by rail. Supplies, such as fuel and sulphuric acid (rather than sulphur), would be brought in by sea. It was stated that the principal economic advantages of this proposal are that costs of change-over from one ore type to another would be minimal, and larger plant could be used in both the mining and milling operations for a given rate of production of uranium from the Region. Mr Wentworth contended that the consequent savings would more than offset additional costs arising from the transport of ore to a mill remote from the mine, and that there would be environmental benefits.

No detailed evidence was received on the economic or environmental merits of this proposal. An important difference from the proposal by Northern Pastoral Services is that it contemplates development and operation of mines in strict sequence, so that production from the second mine in the Region would not commence until production from the first had virtually ceased.

Certain conclusions about the proposal can be drawn from the detailed evidence received in relation to the Northern Pastoral Services proposal. These are:

- The additional cost of transporting ore to the yellowcake mill would probably be greater than any savings derived from economies of scale in the construction and operation of the mill.
- The release of contaminated water directly into the sea might not be of overall benefit to the regional environment.

- The additional cost of returning the tailings to the mine pits would be substantial.
- Environmental and economic costs would be involved in either disposing of contaminated water at the mine sites or in conveying it to the mill for use in the mill circuit.

The only evidence regarding economies of scale achievable from sequential operation of mines (as opposed to mills) was the statement by Mr Wentworth that they would be substantial and the statements by Ranger representatives that they would not be. We are not in a position to arrive at a conclusion on the matter.

Mr Wentworth proposed that acid would be imported from outside the Region, using port facilities which might be constructed near Point Farewell. This would obviate the necessity of having an acid plant in the Region and eliminate the emission of sulphur dioxide. However, evidence from the Northern Territory Port Authority cast doubt on the feasibility of developing a port in the vicinity of Point Farewell. The nearest deep water (13 metres) is 11 kilometres from the shore and the site is exposed to north-west winds which would make operations particularly difficult during the wet season.

It was pointed out by Mr Wentworth that sequential working of mines, with a single yellowcake mill, would concentrate geographically the environmental impact of uranium production. The area affected by dust, noise and visual intrusion would be reduced. If larger plant were used, the total workforce required for a given uranium output would be reduced and geographically concentrated. This was seen as facilitating the control of European activity in the Region and lessening the social impact on Aboriginals. Evidence presented by Ranger indicated that a mine and mill designed for an initial production rate of 6000 tonnes of U_3O_8 per year would employ 20 per cent fewer workmen than would two mines and mills with the same total production capacity. However, in the case of geographically separate mines and mill, this saving would be reduced, because of the additional personnel needed for loading and transporting the ore from the mine site to the mill. This arrangement would entail two centres of industrial activity, as would two mines operating concurrently, each with its own yellowcake mill as part of the one industrial complex. The rail line would in itself represent an additional industrial development in the Region.

Mr Wentworth proposed that uranium mines in the Region should be operated by a consortium of those companies which have discovered uranium deposits in the Region. While admitting that there were administrative difficulties in the way of operating mines on such a basis, he said that the various advantages which would accrue from such an arrangement made it preferable to any other. Representatives of both Ranger and Pancontinental stated that the companies would not voluntarily form a consortium.

Conclusions

It is by no means clear that the proposal has environmental advantages, when all factors are taken into account. We can form no definite conclusion as to whether it would reduce overall costs, for a given uranium output, or increase them. Certainly substantial additional costs would be involved in transporting ore from the mines to the mill, in returning tailings to the pits, and in disposing of contaminated water from the mine sites or conveying it to the mill for use in the mill circuit. The proposal was not acceptable to either Ranger or Pancontinental.

Economic benefits and costs of a national uranium industry

A great deal of uncertainty exists about future rates of expansion in world demand for uranium (see Chapters 7 and 8 of our First Report). It is difficult to forecast accurately future electricity requirements and the extent to which nuclear power will be used to meet them. Because of these uncertainties, and the lack of information about sources of supply of uranium in countries other than Australia and about where purchasers will choose to place their orders, the potential income from uranium mining in Australia cannot be forecast with any degree of precision.

In Chapter 9 of the First Report we assessed the economic benefits and costs of a potential Australian uranium mining and milling industry, assuming figures for prices and costs which, although far from certain, appeared reasonable. In order to illustrate the maximum probable economic benefits which might be foregone if it were decided not to export Australian uranium, rates of production and export were used which were assessed as being near the limit of what could be achieved without causing a noticeable decrease in the price of uranium. Again for illustrative purposes, in Appendix V of this Report we present a further assessment, using a range of possible revenue and cost figures, and lower production levels than in the First Report. These levels reflect the application of deliberate restraint to the rate of development of the uranium mining industry, which we believe will be necessary if uranium mining is to proceed at all. The effects of a possible uranium industry in the Region on the economy of the Northern Territory are also assessed in Appendix V. The assessments are summarised here.

Principal assumptions

In order to estimate the gross revenue from uranium sales, we assumed in Chapter 9 of the First Report that a total of 2500 tonnes of uranium would be sold by Australian producers in 1980–81 and that sales would increase by that amount each year until they reached a total of 30 000 tonnes in 1991–92. Sales were then assumed to remain at 30 000 tonnes per annum until 1999–2000.

The bases for assuming these rates of sale were outlined in the First Report. The potential rates of sale until 1985 were assessed from consideration of evidence before the Commission on future world demand for uranium and anticipated world uranium production capacity. These estimates were derived from many international sources, including the OECD-NEA/IAEA, the U.S. ERDA, and British Nuclear Fuels Ltd, as well as from Australian sources such as the AAEC and the Australian Uranium Producers' Forum. Our consideration of these estimates took into account other factors, such as the probability of the U.S.A. wishing to restrict the contribution of imports to its total uranium consumption and possible maximum rates of penetration of the world market commensurate with maintaining stable uranium prices. However, no account was taken of environmental or strategic considerations regarding Australia's contribution to the uranium and nuclear power industries.

Estimates of possible rates of sale after 1985 were recognised as being very uncertain. Our assumption that annual sales would continue to increase by 2500 tonnes of uranium per year until 1991–92 and then remain constant until the end of the century was adopted to illustrate the potential size of the Australian uranium industry if the only criteria determining the rate of production were, again, potential markets, known Australian uranium resources and the desire to avoid causing a reduction in world uranium prices.

As we said in the First Report, recent analyses suggest that nuclear power may become less competitive in the future, in which case total uranium requirements and markets for Australian uranium would be limited accordingly. We recommended that policy respecting Australian uranium exports, for the time being at least, should be based on a full recognition of the hazards, dangers and problems of and associated with the production of nuclear energy, and should therefore seek to limit or restrict expansion of that production. In this Report we examine the environmental aspects of a uranium industry in the Region. It is clear that the adverse effects of that industry can be controlled effectively only if its absolute size and its rate of development are limited. We anticipate that this will be done.

There are very many possible and plausible variations in rates of sale of Australian uranium for the rest of the century, and we have not attempted to calculate the costs and benefits associated with each of them. For illustrative purposes, and without in any way implying that the rates of sale embodied in the calculations are consistent with environmental criteria, or are in fact the most probable rates of sale, we show in Appendix V the net benefits which would be achieved if national production and sales rates were 60 per cent of those used in the First Report. It is assumed that construction work on the first project will commence in 1977–78, and that production and sales will begin in 1981–82 at an average rate of 1500 tonnes of uranium and then grow by 1500 tonnes per year until they reach a rate of 21 000 tonnes in 1994–95, which will be maintained to the end of the century.

Revenue calculations in the First Report were based on one average price, US$20 per pound of U_3O_8 (expressed in January 1976 price levels), which was converted to Australian currency at the rate of $A1.00 to US$1.26. In this Report, low and high average prices are assumed, to show the effects of possible variations in both the price of uranium and currency exchange rates. For reasons explained in Appendix V, a price range of US$15 to US$30 per pound of U_3O_8 is used, together with a range of conversions from U.S. to Australian currency of from $A1.00 equalling US$1.00 to $A1.00 equalling US$1.50. This means that the price of U_3O_8 in Australian currency is assumed to range from $10 to $30 per pound.

Of course, it can be expected that large variations in uranium prices will occur from time to time. These will arise from many factors influencing the demand for electricity and for nuclear power, including variations in the level of economic activity, the rate of discovery and development of uranium resources around the world, the effect of government decisions regarding nuclear energy and energy conservation, the development and effect of environmental attitudes to nuclear power and energy use and the economic competitiveness of nuclear power. Intervention by national or international authorities, or monopolistic practices by uranium producers (about which the Commission heard a number of allegations), could tend to stabilise prices at high levels. The absence of such intervention or practices could result in lower or less stable prices. It is possible that the cessation of any price-fixing arrangements which might exist could cause sudden, extensive reductions in prices. We have made no attempt to calculate the effects on benefits and costs of any such variations.

The cost estimates used in the calculations are based on expenditure estimates submitted to the Commission by Ranger and are stated in January 1976 price levels. Pro rata adjustments are made to estimate the annual expenditures associated with the construction and operation of all projects. Figures 15 per cent below and above these estimates are used to indicate the effects of cost variations arising from exchange rate changes or other causes. Detailed cost estimates for the other uranium mining and milling proposals were not provided to the Commission. It can be assumed that there would be some variations in costs between projects, but these would probably be covered by the range of costs used in the calculations.

No estimates of costs required to meet the environmental provisions recommended in this Report, or of governmental or other expenditure not included in Ranger's cost estimates, have been incorporated in the expenditure estimates. However, it is not expected that inclusion of those costs would alter significantly our conclusions. We have not attempted to allow for inflation since January 1976 in estimating either costs or revenue. Such a re-estimation would not alter the real values involved.

Expenditures and revenues

Under these assumptions, total revenue begins to exceed total expenditure in 1981–82 and net revenue thereafter grows rapidly (see Table E in Appendix V). The estimates show substantial increases in profits in the 1980s, reaching maximum levels when full production capacity is achieved in the mid 1990s.

Gross revenue over the period from 1981–82 to 1999–2000 would range, under the assumptions made, from $6825 million to $20 475 million, and total costs from $3682 million to $4973 million. Therefore a low estimate of the excess of revenue over expenditure, calculated by subtracting the minimum cost figure from the minimum revenue figure, is $3143 million. This would reflect a situation in which the average price received was equivalent to US$15 per pound and the Australian dollar maintained its highest assumed level against the U.S. dollar. The high estimate, obtained by subtracting the maximum cost figure from the maximum revenue figure, is $15 502 million. This result would be achieved if the average price received equalled US$30 per pound and the Australian dollar maintained the lowest assumed level against the U.S. dollar.

National benefits and costs

Benefit–cost analysis is used in Appendix V to assess the net economic benefits which may accrue to Australia if uranium mining proceeds at the rate assumed. We also describe there, in a little more detail than in the First Report, the methodology of benefit–cost analysis. Some of the deficiencies of this approach were discussed in the First Report.

Taking account of the possible effects of foreign participation in the industry, the undiscounted total of estimated net benefits over the whole period, from 1977–78 to 1999–2000, is calculated to range from a low of $2859 million to a high of $15 502 million. When discounted at the rate of 10 per cent per annum, the present worth of the low estimate is $574 million and the present worth of the high estimate is $3591 million.

Conclusions

These calculations indicate that the establishment of a large-scale uranium mining industry in Australia is likely to provide high rates of return on capital invested. In these circumstances, the industry would benefit shareholders in mining ventures (through after-tax profits), Australians as a whole (principally through taxes on profits, or a share of direct profits if the Commonwealth Government participates directly in the industry, which might be used to provide additional governmental services or reduce other taxes), and firms supplying the industry. If royalties were paid to Aboriginals, they could be an important source of finance for Aboriginal advancement in the area. Under the assumptions used in the calculations, the addition to national income resulting from the industry's activity would rise throughout the 1980s, and by the early 1990s would be between about 0.2 and 1.3 per cent of the projected levels of national income. Sales of uranium would become a major source of foreign exchange earnings if the assumed increases in exports occurred; earnings would possibly be comparable to recent levels of exports of iron ore and black coal.

The uranium industry would be highly capital intensive. It could provide, directly and indirectly, employment opportunities for several thousand people, but this would not make a very important contribution to total employment opportunities in the economy as a whole. In a national context, the industry's contribution thus seems more likely to raise incomes rather than to create many additional employment opportunities. Employment and income effects on the economy of the Northern Territory of a large uranium mining industry in the Region would be relatively much more important.

Economic aspects of a Northern Territory uranium industry

The data used to estimate the national economic effects of uranium mining are also used, in Appendix V, as a basis for estimating the effects on the Northern Territory economy. In these calculations, it is assumed that uranium output in the Territory reaches a maximum of 12 500 tonnes per annum, which is about the maximum total rate of output from Ranger and Pancontinental, under their existing proposals.

Effect on incomes in the Northern Territory

As indicated in Chapter 6, if all the local expenditure associated with construction at Ranger for an output of 3000 tonnes of U_3O_8 (about 2500 tonnes of uranium) per year, including wages and salaries, were added to the incomes of Territory residents and spread evenly over the projected construction period of about four years, it would add, according to the calculations, about 2.5 to 3.0 per cent to the estimated annual income of people living in the Territory. These figures include an estimate of 'multiplier' effects from increased incomes in other parts of the Territory economy generated by the spending of income derived directly from the uranium industry. Although effects of this type are not normally regarded as national economic benefits, they may result in higher local incomes if the expenditure would not otherwise have occurred in the region concerned.

To illustrate the potential effect of construction activities associated with an enlarged regional uranium industry on the Territory's income, we assume that construction for the total expected annual production capacity of 12 500 tonnes of uranium is spread over twelve years. Under such an arrangement, annual expenditure in the Northern Territory could be expected to reach a maximum of between $18 and $22.5 million (in January 1976 prices). If estimated additional effects on consumer spending are added, the maximum total increment to annual incomes comes to between $20 and $25 million, which would be between 5 and 6¼ per cent of the estimated recent level of total incomes of people living in the Northern Territory.

Evidence relating to the expected operations of the Ranger project suggests that about 40 to 50 per cent of annual running costs would result in increased incomes for people living in the Northern Territory. A similar percentage would probably apply for other uranium ventures. Unrecovered governmental expenditure associated with the establishment of services related to the mining ventures would provide an additional stimulus to local expenditure. Including an allowance for this factor, we estimate that, when construction was completed and Ranger was producing 3000 tonnes of U_3O_8 (about 2500 tonnes of uranium) per year, operating expenditures, including induced effects on other consumer expenditures, would add about 3.5 to 5.0 per cent to the total present incomes of people living in the Territory (that is, slightly more than the addition during the construction phase). There would be commensurate increases for higher levels of output in the Region; if output reached 5000 tonnes of uranium per annum, about 6.5 to 10 per cent would be added to incomes, and if output reached

12 500 tonnes per annum the percentages would rise to between 16 and 26 per cent of estimated present income.

We have not attempted to estimate the effects on income of further industrial development which might occur in the Northern Territory as a result of the uranium developments. If the estimated higher levels of production eventuate, the uranium industry might provide the stimulus for the establishment of significant additional distributive, commercial and government services in the Territory. It was suggested in evidence that some small-scale manufacturing might also be established to service the mines' requirements. However, because of the relatively small market which would continue to exist in the Territory for manufactures, it seems unlikely that such developments would be of major importance.

Effects on employment in the Northern Territory

If the Ranger mill were built for an initial capacity of 3000 tonnes of U_3O_8 (about 2500 tonnes of uranium) per year, the construction stage would involve the employment of about 600 workers, about 1.5 per cent of the Northern Territory's labour force of about 40 000. If the initial annual capacity were 6000 tonnes of U_3O_8 (about 5000 tonnes of uranium), the construction workforce would be about 1000. Work on town and other facilities associated with the development would create additional employment opportunities. Evidence was given to the effect that construction of the Pancontinental mine and mill would employ a maximum of about 700 workers. Additional jobs might be created in servicing the construction activities, but these seem unlikely to add significantly to the total.

Ranger estimates that about 250 people would be employed during operations for an output of 3000 tonnes of U_3O_8 (about 2500 tonnes of uranium) per year, and about 400 for an output of 6000 tonnes of U_3O_8 (about 5000 tonnes of uranium) per year. These figures represent about 0.6 per cent of the current labour force in the Territory for the lower rate of production and about 1 per cent for the higher rate. It was suggested by the proponents of uranium mining that the lower rate of output would provide, in addition, local employment opportunities for about seventy people, and the higher rate similar opportunities for about 100.

Higher rates of uranium output would make greater contributions to employment opportunities. If Ranger and Pancontinental were together producing 12 500 tonnes of uranium (about 15 000 tonnes of U_3O_8) per annum in the Territory, it is estimated that employment opportunities, including those associated with the provision of local services, would probably increase to between 1250 and 1500, or about 3 to 3.5 per cent of the present labour force.

These figures, like those for the construction phase, do not include any indirect effects of mining on employment in the Northern Territory. It is not possible to calculate accurately those effects. However, the magnitude of the estimated effects on income of higher levels of uranium output suggests that very important additions to employment opportunities in the Territory could occur, particularly in the supply of consumer goods, provision of business and community services, and construction of dwellings and other buildings. It was stated in evidence that concurrent development of more than one mine in the Region could place excessive demands on the Northern Territory's human and physical resources, and that this might adversely affect other industries, businesses and services in the Territory. Conversely, at the end of construction, there could be a surplus of construction manpower in the Territory, which might lead to serious social problems. Evidence was presented to show that only a fraction of construction workers would be employable in the operations of the mines and mills.

The Commission accepts that these are important factors. Because of them and of others mentioned elsewhere in this Report, we recommend that, if mining is to proceed, construction of uranium mines in the Region should be commenced sequentially at appropriate intervals.

Alternative patterns of mine development

In addition to the issues considered in the Commission's First Report, the principal matters that need to be taken into account in deciding on the most appropriate pattern of mine development are economic. Economic benefits or costs could reinforce or detract from the other considerations which caused the Commission to take the view that sequential development would be desirable.

If all uranium mining proposals were at the same state of preparedness, the optimal development strategy, from a national economic viewpoint, would be to develop the lowest cost mine first, and other mines later according to the average costs likely to be incurred.

The Commission was not provided with sufficient information about costs associated with the various uranium mining proposals to determine an economically optimal development sequence. However, as the evidence indicates that labour and capital costs do not increase in proportion to increased production capacity, average production costs are likely to be lowest if one mine is developed to full efficiency before others are brought into operation.

Another advantage of sequential development of mines in the Northern Territory is that it would avoid the strong competition for available resources which might arise if more than one mine was developed at a time. Competition of that type would tend to increase costs.

The evidence indicates that, provided no export income was lost, the policy that would maximise economic returns would be to proceed with full-scale development of one mine followed by the mining of other areas when demand expanded. This development strategy seems particularly appropriate in the Region as it should also minimise adverse environmental effects.

Although the evidence does not enable the Commission to say that the Ranger venture would be the lowest cost project, either in a national or a regional context, the advanced stage now reached in the examination of its effects and the likelihood that it would be a profitable venture suggest that, if mining is to go ahead, Ranger should proceed first. The marketing authority recommended in Chapter 19 would be in a position to monitor market trends, making it possible to identify appropriate times for increasing the rate of production in Australia and bringing other mines into operation.

The Government may wish to consider the possibility of compensating the shareholders of companies which experience delays in achieving returns on earlier investments. Initially, this could be done by providing for some share of profits from the Ranger venture to be distributed to other companies. However, this is a matter of government policy and the Commission has not received any submissions on which it can base further comments, although our attention was drawn to undertakings given by the previous Government concerning possible compensation. The Government may wish to give consideration to such undertakings in deciding on any appropriate action on this matter.

Conclusions

Our calculations show that a regional uranium industry producing up to 12 500 tonnes of uranium per year would substantially enlarge the Northern Territory's economy and could provide the stimulus for a much faster rate of economic growth in the area than would otherwise occur. However, it must be emphasised that economic factors, particularly the rate of increase of demand for uranium, may not support such an expansion. The Commission recommends that, if more than one mine is developed, they be developed in sequence so that unnecessary economic and social pressures are avoided. Environmental considerations could also limit the rate of expansion of the industry. Development of uranium mining and milling is discussed in the context of a land use plan for the Region in Chapter 16, and in relation to impact on the Aboriginal people in Chapter 13.

Economic effects of delay

In this section, we consider the economic effects of delaying the development of uranium mining in Australia by periods of 2 and 5 years.

Delaying Ranger

If development of the Ranger proposal to produce 3000 tonnes of U_3O_8 (about 2500 tonnes of uranium) per annum is delayed, the most important economic effects are likely to arise through the postponement of the times at which revenues and expenditures occur, although major changes in the real price of uranium over lengthy periods are possible.

We estimate the economic effects of postponements of 2 and 5 years of that part of the Ranger proposal embodied in the financial estimates submitted by Ranger and incorporated in Table 10 of the First Report. In that table, it was assumed that construction would commence in 1976–77.

As it now seems likely that construction could not commence before 1977–78, this is taken as the base condition against which the effects of postponement are measured. In order to be consistent with estimates of the value of the Ranger proposal and an enlarged uranium industry which were included in the First Report, we have used January 1976 price levels throughout. This means that, although we assume for the base case that construction starts in 1977–78, instead of 1976–77, the estimated present worth of that part of the Ranger proposal embodied in Table 10 of the First Report remains unchanged at $197.2 million, expressed in 1976 prices.

The following estimates are shown in more detail in Table M, Appendix VI.

(a) A delay of two years, which causes all anticipated revenue and expenditure to be postponed by two years, causes the present worth of net benefits (discounted to 1977–78) to fall from $197.2 million to $162.8 million, a net loss of present worth of $34.4 million or 17.4 per cent of the original estimate.

(b) A delay of five years, causing all anticipated revenue and expenditure to be postponed five years, causes net present worth to be reduced from $197.2 million to $122.4 million, equivalent to a net loss of present worth of $74.8 million, or 37.9 per cent.

These results would be affected if changes in real revenues and/or costs occurred, or if the timing of benefits and costs were affected in ways other than those assumed above. For example, some of the estimated loss of present worth would be reduced if sales and/or real prices in later years were at higher levels than originally anticipated. This might be particularly relevant if output from other uranium projects could be used to help make up for sales lost in earlier years. Consequently, national economic losses from possible delays are most appropriately considered in the context of the overall development of uranium mining in Australia.

Delaying development of national industry

The economic effects of delaying the start of a national uranium industry can be estimated by varying the assumptions used in the calculations of national economic effects in Appendix V.

The estimates in Columns (2a) and (2b) of Table N illustrate the effects of a 2-year delay in all anticipated net benefits, with the other assumptions made in Appendix V unchanged. There would be no reduction in the undiscounted totals, but the present worth of net benefits, on both low and high estimates, would fall by about 17 per cent, from $574 million to $475 million in the low case, and from $3591 million to $2967 million in the high case.

Columns (3a) and (3b) illustrate the effects of a delay of 5 years, assuming that all annual revenues and expenditures are lagged accordingly, but are unchanged in total. In present worth terms, the low estimate falls from $574 million to $355 million, and the high estimate from $3591 million to $2229 million, a reduction of approximately 38 per cent.

These results are based on very simplified assumptions. If delays were instrumental in reducing the total level of sales which Australia makes to the rest of the world, either because of increased competition from other suppliers, or because of increases in the real costs of production of Australian uranium output, there would be losses in the total undiscounted net benefits which would accrue over time, and, in these circumstances, discounted net benefits could fall further than the estimates shown in Table N. Lower revenue from sales would seem more likely to occur if demand for uranium expanded at relatively slow rates, in which case the low estimates of net national benefits would be more relevant in assessing the impact of delays.

If the demand for uranium continued to expand, it seems unlikely that there would be any significant reductions in the total quantities of uranium sold by Australia. As well, a strong possibility could exist that the effects of any delays in commencement of mining could be reduced by faster expansion of sales after production commenced. If this happened, it would reduce the extent to which the present worth of net benefits would be affected by delays. For example, if the only effect of a delay of two years was that the sales of 4500 tonnes uranium originally expected in 1981–82 and 1982–83 were postponed until the year 2000–01, so that sales began in 1983–84 and continued until 1999–2000 at the levels shown in Table E, the reduction in present worth would be only about 4 per cent (compared with 17 per cent in the case discussed above, where all sales are lagged two years behind the original schedule). In the case of a 5-year delay, it would seem unrealistic to assume that sales could commence at 9000 tonnes per annum after the delay and then proceed as originally anticipated. However, if it is assumed that sales began at a level of 3000 tonnes after a 5-year delay and then rose by 3000 tonnes per annum until the initial schedule was reached, with reduced sales in early years being made up by sales in the year 2000–01, there would be a loss of approximately 15 per cent in present worth terms (compared with 38 per cent in the case where all sales are lagged 5 years behind the original schedule).

Conclusions

If the effect of delaying the start of the Ranger proposal to produce 3000 tonnes U_3O_8 per annum by 2 years was to delay all benefits and costs by the same period of time, it would cause a net loss in present worth terms of approximately 17 per cent of the estimated net economic benefits. A 5-year delay would cause a reduction of about 38 per cent in the present worth of net benefits. Based on the estimates of economic effects used in the Commission's First Report, the reduction in present worth would amount to about $34 million at 1976 price levels in the case of a 2-year delay, and about $163 million in the case of a 5-year delay.

A 2-year delay in the development of a national uranium industry, accompanied by an equivalent delay in the incidence of benefits and costs, would cause a loss of approximately 17 per cent of the present worth of estimated net economic benefits. This would be equivalent to a reduction in present worth of $99 million at 1976 price levels, in the case of the low estimate contained in Appendix V, and $624 million in the case of the high estimate. A delay of 5 years, accompanied by an equivalent postponement of all future benefits and costs, would reduce the present worth of net benefits by about 38 per cent. This would amount to approximately $219 million in the case of the low estimate of net benefits, and approximately $1362 million in the case of the high estimate.

These losses would be substantially reduced if the delay in the start of uranium development were followed by higher rates of production in later years, or if higher average real prices were received for uranium exports as a result of the delay.

A two year delay, with sales lost in those two years being made up at the end of the century, and with sales in all other years unchanged, would result in only a small reduction (about 4 per cent) in net present worth. On the other hand, any losses of sales or lowering of average prices attributable to the delays would increase the amount of the losses.

9 RURAL AND FISHING INDUSTRIES

In this chapter we discuss the existing pastoral and fishing industries in the Region, their prospects, and the prospects of other rural industries. The interrelationship of these industries, uranium mining and a regional national park is examined. In order to assess the relative economic value of alternative uses for the land occupied by the pastoral industry in the Region, the economics of the existing pastoral industry are reviewed, and its possible future value is compared with those of uranium mining and the tourist industry.

Pastoral activities

Before World War II, the main basis of the pastoral industry in the Region was the hunting of buffaloes for their hides. When prices for hides fell after the war attention was given to the production of meat from buffaloes, first for pet food and later for human consumption. Mobile abattoirs were used initially, but hygiene and inspection requirements led to the establishment in 1973 of an export standard (Form 8) abattoir at Mudginberri. This processes animals from Mudginberri and Munmarlary mainly, but also some harvested from other areas in and outside the Region. A second export standard abattoir slaughtering buffaloes exists at Jimmy's Creek, west of the Region, and one for supply within Australia only operates at Oenpelli.

The buffalo is adapted to the Region, especially to the wetlands and their margins. Uncontrolled, their numbers fluctuate with seasonal conditions, increasing in good years to levels that impose severe stress on pastures in dry years, when substantial losses of animals occur.

At present, feral buffalo meat is still the most important product of the pastoral industry in the Region and is the source of cash flow on which other pastoral proposals and developments have been based. These consist of:

- attempts at domestication and controlled management of buffaloes;
- the introduction of cattle, especially Brahman-cross animals, and their production under intensive forms of controlled management;
- combinations of these, with hunting of feral animals still providing the initial source of income;
- provision of better nutrition through improved pastures.

While the domestication of buffaloes has been demonstrated to be feasible, controlled management over large areas has not yet been accomplished despite many prolonged and costly attempts. Opinions of expert witnesses differed concerning its feasibility and economic viability, especially in relation to fencing and control in wetland areas, high manpower requirements, and the fact that reproduction rates apparently fall when buffaloes are domesticated. Although one witness, from Northern Pastoral Services Pty Ltd, the operators of Mudginberri and Munmarlary stations, claimed a large domesticated herd could be run economically, others expressed strong doubts about this.

Buffalo and cattle production in the Region is limited by the availability of suitable pasture. Lowland pastures are satisfactory for only short periods during the wet season and immediately afterwards. The pastures of the flood plains provide more feed during the dry season.

On the native pastures, cattle gain weight during the wet season, but lose most of this increase during the subsequent dry season. Their reproduction rates are low. Under uncontrolled conditions buffaloes use a greater variety of dry season forages than cattle and are competitive with them. The pastures of the flood plains and the flooded drainages are largely unavailable during the flood period, although buffaloes can utilise some areas by wading and feeding on flooded vegetation.

The stocking capacity of native pastures is low. Figures quoted in evidence for cattle were of the order of one beast to 16 hectares in lowland country and one to 4 hectares on the wetlands. The areas required by buffaloes are slightly smaller.

Pasture improvement programs adopted on parts of the lowland country consist mainly of introducing the legume Townsville stylo (*Stylosanthes sp.*) and fertilising with superphosphate at a rate of 125–250 kilograms per hectare at planting time with subsequent annual or two-yearly applications. This superphosphate application reduces the area required per beast to about 2 hectares of native pasture and one of Townsville stylo. Because of clearing and cultivation costs, and of the sensitivity of the soil to erosion, improvement is generally restricted to aerial distribution of seed and fertiliser over flat and gently sloping land without heavy vegetation.

Improvement of flood plain country as pasture has involved the introduction of para grass *Brachiaria mutica* and the replanting of a native grass, *Hymenachne*, which has been reduced by heavy buffalo grazing. Both species require controlled management of livestock to maintain them.

Taking the possibilities and limitations into account and assuming all suitable lands were developed for this purpose, the Animal Industry Branch of the Northern Territory has estimated that the Region could carry about 130 000 head of cattle and/or buffaloes. The development of this potential would take many years, and would involve the control of grass fires (itself a formidable task) and co-ordinated management of the lowlands and flood plains. The economics of such land utilisation have not been examined in any detail.

The Commission was told that an extensive program of pasture improvement had been planned and initiated on Mudginberri station, with the object of progressively developing a Brahman-cross cattle herd. However, this program had been inhibited by increased costs, such as for superphosphate, and by the slump in beef markets.

The current plan is to intensify production of controlled and domesticated buffaloes rather than beef cattle, with little further pasture improvement on lowland country but progressive improvement of the flood plains with para grass. A favourable market for buffalo meat in Europe was an important factor influencing the adoption of this plan. The change in plan illustrates the susceptibility of pastoral development in the Region to cost and market changes. For reasons discussed later in this chapter, the Commission is not convinced that the present plan is economically viable, especially if it is required to be self-financing.

The Commission was not informed of any other proposed pastoral developments in the area, other than the possibility of some production by Aboriginals in the Arnhem Land Reserve.

We received evidence on the national program of bovine tuberculosis eradication, which aims at achieving complete eradication in cattle and buffalo herds by 1984. If areas in which buffalo herds exist are to be declared free of the disease, it will be necessary either to bring all animals under control for testing or to exterminate the feral animals. Failure to achieve eradication of the disease from an area is expected to result in restriction of exports from that area and possibly from adjacent areas where adequate barriers do not exist. The Commission was disturbed to hear that a detailed program of eradication of the disease from the Region does not yet exist, and that there is no assurance that the disease can be eliminated in the Region within the stipulated time limit. The evidence suggests that failure to achieve TB eradication would have serious consequences for the future of the buffalo pastoral industry in the Region, and also for the managment of any national park, or Aboriginal land, which may be determined.

Environmental impact of the pastoral industry

As the pastoral industry involves the presence of an exotic animal foraging on vegetation in a manner different from that of native animals, it must have significant environmental impact.

In the Region vegetation changes have occurred where the buffalo grazing intensity has been high. Changes have been particularly noticeable on the flood plains, where the native grass *Hymenachne* and the reed *Eleocharis* have become much less common. On the lowlands and the slopes fringing the flood plains, some ground level and mid storey plants, including pandanus, have been destroyed. Damage to ground fauna and waterfowl habitats has resulted (see Chapter 5).

The changes caused to aquatic habitats have not been defined, but some modification to light supply and nutrient recycling has inevitably occurred as a result of buffaloes grazing, defecating, trampling and wallowing in and around swamps and billabongs.

Erosion on slopes caused by the activity of buffaloes has produced hydrological changes on both flood plains and lowlands, leading to the drainage of some wet areas. It is also a cause of the spread of weed species on the lowlands. Hydrological and ecological changes have been caused by buffalo pads being eroded into channels, leading to drainage of wet areas and permitting the flow of salt water from river estuaries onto the flood plains. Vegetation is destroyed where buffaloes wallow and where they congregate in numbers and trample the ground surface.

The environmental changes resulting from grazing are inevitably most severe under uncontrolled conditions when herd population sizes fluctuate according to the amount of food available. When a series of good years for pasture production is followed by a poor year, the large herds put severe pressure on the diminished pasture supply. Many animals die as a result of starvation or inadequate water supplies. Controlled management, with the containment of animals in paddocks and movement of livestock from place to place according to pasture conditions, is aimed at reducing these environmental effects as well as improving livestock conditions.

In the Region, recovery of vegetation has been observed after the intensity of stocking has been reduced, and there is evidence, for example on the Daly River flood plains, of serious changes not occurring where the stocking rate is low. However, intensive controlled stocking for a long period has not been practised in the Region, and little is known about its cumulative effects on the environment.

The use of fertilisers on pastures can adversely affect adjacent land or water bodies, because of leaching and drainage of nutrients. The evidence indicates that these influences are not important at the present level of pasture improvement in the Region, but should be monitored if the level is substantially increased.

As the pastoral industry requires large areas of land, it can significantly limit other land use options. Mining, and forms of agriculture such as rice growing and market gardening, might not be seriously affected, as relatively small areas are involved. The recreational use of land could be affected to a much greater extent.

In this Region recreational resources to which access by the public is restricted by the use of areas for pastoral activities include billabongs and streams suitable for fishing and swimming. Also people are denied the sight of large bird populations on flood plain areas included in pastoral leases, and access to the northern flood plains is restricted. Aboriginals retain rights to hunt on pastoral land.

The main local contributions made by the industry are by way of supply of meat and opportunities for employment. The freezing, storage and packing facilities of the abattoirs at Mudginberri are used by the small commercial inland fishing industry in the Region.

Other possible rural industries

Rural industries other than pastoral production possibly suitable for the Region appear to be limited to rice production, market gardening and fruit growing. Rice production has been shown to be possible on the Adelaide River plain, but has not developed as an industry because of market constraints, high costs and problems of water control. If it proved economic, areas nearer Darwin would probably be at least as suitable as this Region. Market gardening could be practised if irrigation were available during the dry season, but would be likely to suffer from high costs and market constraints and be limited to supplying local population centres. The better forests of the Region are small in area and have a high conservation value. Their commercial exploitation does not appear to be warranted, nor does there seem to be any urgent need to use lands of the Region for forest plantation.

Fishing industry

Commercial fishing is practised in the estuaries of the Wildman and Alligator Rivers, extending inland to a point determined by the Fisheries Authority. In the East Alligator River, this point is near the mouth of Cooper Creek, and in the other rivers commercial fishing is permitted north of a line running due east from Point Stuart homestead to the east bank of the South Alligator River, about 12 kilometres north of Munmarlary homestead. Recreational fishing is permitted throughout the Region except in Woolwonga Aboriginal Reserve, and is practised widely.

Commercial fishing is mostly for barramundi. In 1976 thirty-two commercial fishermen operated in the Region under net and line licences. The catch from the Region during the last five years contributed between 14 and 32 per cent of the total commercial barramundi yield in the Northern Territory. The value of the total catch was $1.6 million in 1975–76. Studies indicate scope for further expansion of the industry, but evidence was given concerning the need for controls on both commercial and recreational catches if the resource was to be protected.

As indicated in Chapters 6 and 7, if mining proceeds and is controlled in the manner recommended, the amounts and concentrations of contaminants reaching the East Alligator estuary will represent only a very small increase on those present naturally. They are unlikely to affect the fishing industry significantly. 'Catch and effort' data collected by the industry would serve a monitoring function as they would reveal any major decline in catch per unit effort.

Data for heavy metal levels in fish of the estuaries were not provided in evidence, but it was postulated that natural levels could be high. The proposed investigation and monitoring program should include the collection of such data.

As prawns spend their juvenile stages in river estuaries, serious pollution could affect this resource farther afield. Although it is known that prawns are able to concentrate contaminants in their tissues, factors such as dilution of any contaminated waters which may reach the estuaries and the ability of muds of the river banks and mangrove swamps to immobilise contaminants suggest that, if the measures proposed in this Report are adopted, this resource is unlikely to be significantly affected as a result of mining by Ranger.

Concern was expressed by a representative of the fishing industry that granting Aboriginal land rights claims might result in interference with existing commercial fishing rights and that, even if it did not, it could lead to uncontrolled over-fishing, by Aboriginal or non-Aboriginal people, upstream of the commercial areas, thus endangering the downstream resource. The impact of granting land claims is discussed in Chapters 14 and 15. If the land becomes part of a national park, protection of the fishery resource should be provided for in the plan of management of the park. It is unlikely that commercial fishing inside the national park would be permitted, and in our view it should not be. We recommend that it continue to be confined to the areas in which it is presently permitted, which we have described above.

Possible adverse impacts of mining on the pastoral industry

The possible impacts of the Ranger project on the pastoral industry fall into two categories: direct effects of mining and associated operations and indirect effects from secondary developments occurring as a result of the establishment of a uranium mining industry.

Direct effects

The only pastoral leases close enough to the Ranger project to be subjected to any direct impacts are Mudginberri and Munmarlary. As Mudginberri is in the Magela drainage system, parts of the property would receive floodwaters carrying contaminants discharged in waste water from the project. Both properties would receive fallout from atmospheric emissions.

The proposed Ranger development is wholly outside these pastoral leases, so it would not cause direct interference by disturbance of property. The Jabiluka ore bodies, however, are within Mudginberri, and their development would cause direct disturbance. Other radiometric anomalies, some of which may indicate the presence of substantial uranium ore bodies, have also been discovered on the leases, but we were not told of any present intention to exploit them.

Concern was expressed about the possibility of contaminants released from the Ranger operation causing pollution of surface waters and pasture. Witnesses suggested that this could adversely affect the marketability of meat produced as well as the health and productivity of livestock.

It was argued that radioactive materials in water and in dust could raise the radioactive levels of pasture plants, and of the meat of animals consuming them, to an unacceptable level. The evidence indicates that this is unlikely. Estimates, discussed in Chapter 6, indicate that dust from Ranger would raise radium levels in the meat of buffaloes which grazed at the point on Mudginberri station closest to the mine by about 5 per cent. The effect of discharged radium in water drunk by buffaloes has not been estimated, but would probably also be small.

It was also argued that, even if radioactivity levels remained acceptable, markets would be reluctant to accept meat produced in an area close to a uranium mine. The Commission agrees that there could be some reaction in a specialised market, such as that which Mudginberri at present enjoys in the Federal Republic of Germany for buffalo meat sold as game meat. While quality control standards set by both exporting and importing authorities should ensure that any meat which is exported is fit for human consumption, it is not possible to predict what the reaction would be of consumers in foreign countries to the knowledge that food had been produced downstream of a uranium mine and mill.

If the Commission's recommendations in this report concerning releases of contaminants from the Ranger project are applied, significant effects on pasture plants and the livestock grazing on them are unlikely. Nevertheless, because it is not possible to predict all possible happenings in such a complex hydrological environment, the Commission believes that some aspects should be subject to regular checking as part of the environmental monitoring which we recommend be undertaken in the Region if uranium mining proceeds.

These are:

- The possibility of local build-ups of contaminant concentrations in soils, plants and livestock. The Mudginberri Corridor (see Chapter 5) is one area which should be comprehensively monitored to check for increases in concentrations in soils.
- The possible occurrence of copper deficiency in livestock. This might be induced if excessive amounts of molybdenum were added to the system. Molybdenum makes copper less available to livestock. Increased sulphur in the diet aggravates this effect, but additional sulphate in the soil diminishes molybdenum uptake by plants and so tends to offset it. It could also be partly offset by copper in the discharged waters and by the fact that livestock graze over a variety of soils, only some of which would be affected by floodwaters. Pasture samples and the blood of livestock should be analysed regularly.
- The influence of increased amounts of manganese. These may have the beneficial effect of increasing livestock reproduction rates, but excessive amounts may have adverse effects.
- Radioactivity levels of the meat produced in the area.

Contaminated water would continue to leave the mine site in runoff and seepage after mining ceased (see Chapters 6 and 7). The proposals put forward in Chapter 7 for limiting these discharges, if adopted, should ensure that this contamination remained well below levels that could affect pastures or livestock.

It was suggested that some contaminated seepage could travel along fault lines to bores providing water for livestock or abattoir operations on Mudginberri station. While this possibility cannot be completely ruled out, evidence from the Northern Territory Water Resources Branch concerning the discontinuous nature of these fault lines and local hydraulic gradients suggests that it probably would not be a problem.

Contamination of near surface aquifers and sand beds could occur from seepage, runoff and planned discharges. The intended restriction of discharges to periods of flood would reduce the likelihood of contaminated water entering the already full aquifers, but contaminants in seepage flushed from the soil early in the wet season could enter these aquifers more readily. It is not possible to specify the nature or magnitude of this effect. However, the measures we propose in Chapter 7 for reducing seepage from the tailings dam and runoff from around it would eliminate the risk of serious contamination of these aquifers and sand beds.

The possibility that sulphur dioxide emissions from the Ranger acid plant might affect pastoral production was raised during the Inquiry. The evidence indicates that, if the entire 400 tonnes of sulphur expected to be emitted annually as sulphur dioxide were deposited uniformly within the Peripheral Impact Zone defined in Ranger's Environmental Impact Statement, the build-up of sulphur in the surface soil would be insignificant. This zone includes most of the Mudginberri and Munmarlary leases. The build-up would amount, over the expected twenty-eight-year life of the mine and acid plant, to no more than that resulting from one dressing of superphosphate at the usual maximum rate for pastures of 250 kilograms per hectare. Even if restricted to the smaller area defined by wind patterns during inversion periods, the annual deposition of sulphur would still be of the same order as that received in rainfall by much of non-urban Australia. The Commission recommends, however, that the pH of selected soils be monitored to check that the sulphur does not cause harmful increases in acidity.

The amounts of contaminants which might be deposited on pastoral land in dust from the Ranger project have been compared with quantities of the same contaminants applied as impurities when land is top-dressed annually with superphosphate. The figures for dust assumed that the Ranger project was producing U_3O_8 at the maximum planned rate of 6000 tonnes per year. Those for superphosphate assumed an annual application rate of 125 kilograms per hectare. The data indicate that the dust would deposit much less cadmium, copper, molybdenum, lead, zinc and radium than the superphosphate, but that uranium deposition would be about double that from the fertiliser. However, the uranium in the dust would be likely to be in a less soluble form than that in the superphosphate, and therefore less readily taken up by vegetation.

The evidence indicates that the levels of contaminants deposited in dust would be too low to have important consequences to the pastoral industry, either directly or as a result of accumulation over the period of mine operations.

The possibility that a catastrophic event at the Ranger site might harm the pastoral industry was referred to in evidence. Possible events mentioned included failure of the tailings dam or retention ponds, explosion of the magazine, and accidental or deliberate release of excessive wastes.

We conclude from the evidence that the tailings dam would be a competently designed structure with margins of safety common to similar water-retaining structures built throughout the world, often immediately upstream of highly populated areas. The risk of the dam failing would be very low, provided it was properly constructed, and would be restricted to the period during which mining continued if our recommendation that the tailings be returned to the pits were adopted.

Little evidence was presented on the stability of the retention ponds. Retention pond No. 1 would retain a maximum of 300 000 cubic metres of slightly contaminated water. We were told that it would be carefully designed and constructed. A single failure, even in the dry season, would not, we believe, result in sufficient downstream contamination to cause problems for the pastoral industry. Retention pond No. 2 would contain a maximum of 500 000 cubic metres of contaminated water, and we were told that it, also, would be designed and built with care. Its failure during the dry season would contaminate downstream water bodies, but probably only for one season. There should be no effect on pasture. Livestock might be affected by drinking the contaminated water, but it seems unlikely that the duration of the contamination would be sufficient to allow serious effects to develop.

We have recommended that the magazine be moved 8 kilometres to the north-west of the proposed tailings dam so that structures would not be affected if it exploded. If this were done, risk to the pastoral industry would be limited to the immediate vicinity of the magazine.

Much of the evidence and a large part of this report have dealt with the control of wastes from the proposed mine and mill. If the proposals we have made for environmental control were adopted, the risks of repeated accidental or deliberate release of excessive wastes would be very low. And, as we have said, the effects on the pastoral industry of a single unauthorised release should not be serious.

Indirect effects

Northern Pastoral Services Pty Ltd indicated that it regarded the prospective change in the nature of the Region from its present relatively undeveloped state as the major indirect effect of the Ranger proposal. Its representatives spoke of the change from an area where land is used on an extensive scale for pastoral and wildlife sanctuary purposes to a mining province with a greatly increased population, a regional centre, and all the activities which would accompany these.

This raises the question of whether the prior development of part of a region for some economic purpose, in this case pastoral use, should be a determining factor in permitting or developing, in another part of the region, another form of land use which might lead to socio-economic changes in the total regional environment. Many pastoral areas in Australia have been confronted with such changes resulting from progressively more intensive land use. A land tenure gives certain rights to the holder concerning the use of a parcel of land. It does not necessarily place restrictions on the use of other parcels of land, nor does it provide for the existing stage of development in the area to be sustained.

The Commission does not regard the fact that the socio-economic character of the Region might change as a result of mine, tourist or conservation developments as cause for opposing that development. It does consider, however, that all those alternatives, or multiple uses of land, should be evaluated within the framework of a regional land use plan. This is done in Chapter 16.

The pastoral industry fears that an increased resident population in the Region would lead to more trespassing on the grazing properties, interference with livestock and facilities, uncontrolled traffic on and off property roads, soil erosion, and spread of noxious weeds and possibly animal diseases—all contributing to the difficulties and cost of property management. The proposed site for the regional centre is close to the southern boundary of Mudginberri station. Witnesses contended that restrictions on entry to the proposed national park area, as well as to the Woolwonga Aboriginal Reserve, would result in many people trespassing on the pastoral properties, making control impracticable.

It is evident that, whether or not mining proceeds or a regional centre is established, changes are likely in the Region as a result of increasing tourist and recreation activities. The Commission was advised by the General Manager of

Northern Pastoral Services that as many as 400–500 people camp, fish and shoot on Mudginberri and Munmarlary stations on long weekends in the dry season, and perhaps 100 in the wet season. He said that on normal weekends in the dry season 100–200 people visited the two stations and this added to management problems. With the further growth of Darwin, and greater awareness of the area and easier access to it, tourist and visitor interest is likely to increase. Mining would increase the pressure of visitors on the pastoral industry above the level that will develop in any case.

A national park could be expected to provide facilities for tourists, but the park management plan would restrict their freedom of movement and activity. Pressure on uncontrolled areas would therefore be likely to increase.

A possible consequence of the development of mining and a regional centre would be competition for labour. There could be a disparity in wages to the disadvantage of the pastoral industry, and this could lead to industrial problems. Whether the influx of a labour force to the Region would include a sufficient proportion with a preference for a pastoral property way of life rather than mining industry employment cannot be predicted. At present the pastoral company has about forty people regularly employed on the properties during the dry season, reducing to fifteen in the wet season. In addition, subcontractors providing other services employ a yearly average of about twelve people. Seven Aboriginals are employed in both the wet and dry season. Concern was expressed during the Inquiry that the establishment of a regional centre could lead to a reduced interest by Aboriginals in remaining in the workforce if alcohol was as a result made more freely available to them.

Advantageous impacts

Not all impacts of the proposed developments in the Region would be to the disadvantage of the pastoral industry.

The regional centre would provide a local market for meat, better educational and medical facilities and cultural, recreational and social opportunities, and a source of supplies. It would also provide a local base for regional administration and law enforcement, and pastoral properties could receive greater protection with a regional centre established than under conditions of accelerating but uncontrolled tourist and visitor pressure. General regional development could provide better transportation, communications and a power supply. Also tourist interest in buffaloes and pastoral activities could be exploited commercially in an organised manner.

Effects of uncertainties on station planning

Because the effects of mining on Mudginberri and Munmarlary cannot be assessed with a high degree of certainty, doubt exists in the minds of the station operators about the wisdom or otherwise of embarking on expensive property development. A director of Northern Pastoral Services expressed this doubt with particular reference to the possibility of fallout of radioactive material following blasting and its effect on the marketability of meat, and to the unpredictable effects of more people in the Region. He said the board of the company had decided that, if mining is to proceed, it would prefer to sell its undertaking rather than invest further money. He submitted as evidence a letter which the board had sent to the Minister for National Resources to that effect in March 1976.

If Northern Pastoral Services ceased operations through resumption or sale of their properties, decisions would be required concerning the future of the abattoir on Mudginberri and the buffaloes on both properties. It was suggested in evidence that closure of the abattoir could have an impact on other suppliers who sell animals to the abattoir. As another abattoir exists not far away at Jimmy's Creek, it is unlikely that this would be a long-term problem. If the properties were purchased with the intention of converting them into conservation reserves or a national park, as we recommend in Chapter 16, eradication of the buffaloes or a reduction in their numbers would be necessary. As this could take some years to achieve and it would be desirable to process the carcases, the abattoir could usefully be maintained for this operation. Such an arrangement would give outside suppliers time to adjust to its eventual closure. This question is discussed in the context of a regional land use plan in Chapter 16.

Economic aspects

In order to evaluate the economic implications of a termination of pastoral operations at Mudginberri and Munmarlary, the Commission has examined the financial and economic aspects of those operations.

Past operations of Northern Pastoral Services

The stated objective of Northern Pastoral Services' operations is to generate funds from current and projected operations, including the capture and domestication of feral buffalo, the slaughter of both domesticated and feral buffalo, and the production of buffalo meat at the company's abattoir, to finance its longer term program involving buffalo domestication on a larger scale and increased buffalo meat production.

As disclosed by its accounts, the company's abattoir operation experienced considerable difficulty in covering its direct costs in the three fiscal years up to 1974–75. Reasons advanced for this result included the general decline in meat prices, revaluation of the Australian currency, unexpected expenditure required to upgrade the abattoir to meet government requirements, removal of the superphosphate bounty and the rail freight subsidy, and some additional costs associated with the reduced availability of servicing and other facilities in Darwin following Cyclone Tracy.

The interim accounts for the period 1 July 1975 to 30 April 1976 suggest some improvement in the operating results, which was attributed by the company's manager to a higher throughput and a decline in 'teething troubles'. It was also stated that the level of activity at the abattoir in the 1976 dry season indicated that total sales in 1976–77 would substantially exceed the budgeted estimates. The attainment of a substantial net surplus from abattoir operations is essential if the group as a whole is to achieve overall profitability; general operating and administrative costs exceeded $450 000 in the period from July 1975 to April 1976. Although a budget for 1976–77 was submitted, the Commission was not able to make an accurate assessment of the financial outcome for the year, particularly because of the effects of inflation on costs and the possible effects of devaluation on sales revenues.

In addition to expecting a considerable profit from abattoir operations, the company indicated that it would receive a substantial sum from the sale of Export Diversification Credits which it had earned and expected to earn from sales of buffalo meat to Germany. These credits generally allow exporters to sell beef to the restricted United States market in return for making sales of approved types of meat to non-U.S. markets. The credits may be sold and transferred to other exporters if the recipients do not wish to export to the U.S. themselves. Transactions of this nature do not affect the national economic returns from the operations of the company, since the income from them is a transfer from the purchasers of the credits to Northern Pastoral Services. No additional export income is generated. The company has contracts for the continued supply of buffalo meat to Germany, and indicated that it hoped the scheme would bring substantial benefits to it in subsequent years as a result. However, the Commission understands that buffalo meat no longer qualifies for Export Diversification Credits, so any financial gains from this source would be temporary.

The accounting figures relating to the beef cattle operations illustrate the difficulties associated with this aspect of the enterprise. Some gains were recorded in each year by valuing the natural increase at 'replacement' prices; this action was justified on the grounds that the herd was for breeding purposes and not for sale. However, these accounting gains generally were not sufficient to offset the expenditure—associated with stockmen, improved pastures, feed etc.—necessary to maintain and build up the herd. Because of the procedure adopted in valuing the cattle, the company will presumably record substantial accounting losses when it disposes of them, unless cattle prices rise considerably above recent levels.

Northern Pastoral Services has experienced considerable operating deficits, which may exceed \$500 000 in 1976–77, even though interest which would have been payable on unsecured advances from shareholders has been waived and the advances converted to ordinary shareholdings. Even if the company manages to cover its costs in 1976–77, it seems unlikely that substantial profits will be made for some time unless there is a significant increase in the price of buffalo meat compared with increases in production costs.

Assets and liabilities

According to the consolidated financial statements of Northern Pastoral Services Ltd at 30 April 1976, the book value of the company's assets was made up of the following items:

	\$ thousands
Leasehold land and improvements (at valuation or cost)	1163
Buildings, including abattoirs (at valuation or cost, less depreciation)	737
Pasture improvements	247
Other fixed assets	319
Total fixed assets	2466
Livestock: Cattle (at replacement cost)	303
Buffalo on Munmarlary station	86
Other	3
Stocks on hand	36
Other current assets	37
Total fixed and current assets	2932
Intangible items	747
	3679

External liabilities at that date amounted to \$1 850 000, leaving the book value of the shareholders' funds (including a small minority interest) at \$1 829 000. Capital made available to the company, including the advances which have been converted to ordinary shareholdings, totalled \$3 200 000. Hence the book value of shareholders' funds at 30 April 1976 represented about 57 per cent of the total amount provided by the owners.

The financial position of Northern Pastoral Services appears more precarious when the accounting values of its assets are critically examined. No amortisation of expenditure on the leases and improvements was provided for in the accounts. The values of most fixed assets were arrived at by the standard accounting practice of providing for depreciation based on original cost. This means that the accounting values of these assets are probably understated in terms of current replacement cost. However, the realisable value of the assets is more conjectural, and would depend on the circumstances prevailing at the time of any attempt to dispose of them.

The procedure adopted for valuing the cattle, together with the implication that substantial losses may occur when they are sold, has already been mentioned. The value of the buffaloes on Munmarlary station, put at \$86 000 in the accounts, is also conjectural. In addition, no current value can be attached to the intangible items, represented in the accounts by the capitalisation of goodwill and preliminary expenses associated with the formation of Northern Pastoral Services.

If the accounting values for fixed and current assets (including livestock) are taken as reasonable indicators of their real worth, the interest of the shareholders at 30 April 1976, calculated by deducting external liabilities from the accounting value of these assets, would have been approximately \$1.1 million. This means that about two-thirds of the capital invested would be lost if the enterprise were wound up at this stage, provided the accounting values of tangible assets were realised.

It was submitted to the Commission that the company's difficult financial situation is temporary, and that improvement can be expected as its plans mature. It was argued that it is not unusual for agricultural enterprises to go through periods of low returns before reaching acceptable levels of profitability.

Prospects for the buffalo enterprise

The Commission was presented with an estimate of the possible profitability of buffalo and abattoir operations in 1981–82 by an experienced agricultural consultant. When the data are adjusted to 1976 price levels to make them broadly comparable to financial data for recent periods, they suggest an annual profit level of about \$400 000 in the early 1980s. An abattoir throughput of 9500 animals per year was assumed. The consultant suggested that the company could substantially augment its income by packaging and marketing barramundi as an adjunct to its abattoir operations, and that it might also make further profits by providing facilities for tourists.

Comparison with the cost data provided by Northern Pastoral Services suggests that costs may be underestimated in the consultant's calculations, unless it is possible for substantial operating economies to be effected. On the other hand, the estimates of the prices which would be received for buffalo meat and possibly for beef could prove to be underestimates, though future meat prices are difficult to forecast.

No detailed estimates of the capital required for the profitable operation of the buffalo enterprise were submitted, but it was suggested that a considerable increase in working capital would be necessary. If it continued with its plans for this operation, the company would presumably dispose of its present holdings of cattle, but it was not made clear whether any other substantial reductions in capital investment would be possible. However, the company's representatives indicated that they believed a reasonable rate of return on capital could be achieved if the enterprise reached the projected level of operations.

Evaluation of existing proposals

Although it has been operating for some time, the buffalo enterprise is still in an early stage of development and still has considerable uncertainty associated with it, particularly in regard to operating costs and market prospects. At present it appears likely that the market for buffalo meat will expand sufficiently to enable the company's production to be sold at remunerative prices, although the continuation of exports may depend on the success of the national TB eradication program. The company's prospects will depend to a large degree on whether the initial difficulties associated with its operations are overcome. If they are, the enterprise appears capable of yielding a reasonable rate of return on capital invested, after adjustments made necessary by the disposal of cattle on the properties are effected.

However, the overall rate of return on resources invested in the enterprise seems unlikely to be very high, not only because of the negative returns in the early years of operation but also because it seems to be difficult to secure high economic returns from pastoral developments in the Top End of the Northern Territory. Studies carried out by the Bureau of Agricultural Economics suggest that there is little likelihood of high economic returns being obtained from new pastoral ventures in the Top End unless a major increase occurs in beef prices compared with prices of other commodities. Beef prices have declined since the studies were made, and at present a price increase for beef which would substantially improve the profitability of beef production in this area seems very unlikely, although the long-term supply–demand situation for meats is difficult to forecast. There is probably a greater prospect of 'specialist' meats, like buffalo meat, continuing to yield higher prices. At present buffalo meat is regarded as having desirably low fat levels, and this contributes to its overseas market prospects. Although some compensation is paid, implementation of the national TB eradication program nevertheless would add to the cost of managing a property running buffaloes and, if unsuccessful, could lead to a reduction in returns. These costs have not been quantified, or allowed for in the consultant's estimates, but could be considerable.

Whether the Northern Pastoral Services buffalo enterprise proceeds or beef cattle production is eventually substituted for it, there is no doubt that the national economic returns from pastoral activities in the Region will be much lower than those which may be achieved from uranium production. Because higher levels of beef production can be achieved in other parts of Australia, it is difficult to see that any substantial national economic loss would result from beef production not proceeding at Mudginberri and Munmarlary. However, some export income could be lost through the cessation of buffalo meat exports to specialised game meat markets. The Mudginberri abattoir now supplies about half of these exports. Any loss would be small in relation to the prospective returns from uranium production.

Possible tourist use of the pastoral land

The relatively low average rate of return expected from the activities of Northern Pastoral Services raises the question of whether, from an economic viewpoint, the national interest would be better served by including the areas covered by the pastoral leases in a national park and terminating pastoral operations. The number of tourists visiting the Region has increased substantially in recent years (see Chapter 11), and the evidence suggests that this trend will continue although not at the rates projected some years ago.

If there were no conflict between increased tourism and pastoral production, it would not be necessary to consider them as alternative uses of the area. Clearly the two complement each other in some respects. For example, roads built primarily for the benefit of one can also benefit the other, and construction of a regional centre could bring advantages for both. Also the pastoral company might make some profits by providing meat and facilities for tourists.

However, there is evidence that net economic returns from pastoral activities would be reduced by further increases in tourist activity. Control of tourism, designed to minimise the effects on pastoral production, could therefore involve costs to the company which would make the eventual profitability of the pastoral operations even less certain than it is now.

The value of the area for recreational use, from an economic point of view, depends to a large extent on the value attributed to it by people who might visit the area. Money spent by visitors provides income for tourist operators and businesses supplying accommodation, meals, souvenirs and so on. Considerable research would be needed before an attempt could be made to quantify the economic benefits from use of the area for recreational purposes.

One factor that would need to be considered is the environmental damage caused by buffaloes, which might reduce the attraction of the area for tourists. On the other hand, the presence of buffaloes might attract some visitors. Possibly the best course would be to reduce the numbers of buffaloes, which may involve abandoning the buffalo industry in the Region, and to confine some to specific areas where tourists could see them. Such procedures would in any case be necessary in order to implement the TB eradication program.

Use of the area for beef cattle production might result in less environmental damage than the proposed intensification of buffalo production, but the national economic returns from this activity would almost certainly be small. Also other areas are available on which the same amount of beef could be produced at no more, and possibly less, expense.

The evidence does not provide conclusive proof of the economic desirability of favouring tourist use over pastoral activities. It indicates, however, that if proper control measures were undertaken, use of the area for recreation and related activities could well yield higher national returns.

Conclusions

The evidence indicates that development of a uranium-mining industry in the Region would add to the costs of the local pastoral industry, with small compensating benefit to that industry. The pastoral enterprises on Mudginberri and Munmarlary have, generally, not been profitable in the past and it seems unlikely that they would generate substantial profits in the foreseeable future, even if uranium mining did not proceed. Implementation of the national bovine TB eradication program could have serious adverse economic consequences for the buffalo industry. Whether the industry were based on beef or buffalo production, the national economic returns from pastoral activities in the Region would be much lower than those which might be achieved from uranium production.

While the land on which Mudginberri and Munmarlary are situated has no outstanding natural characteristics, it includes one of the few local areas in which the flood plains extend virtually to the foot of the sandstone outliers of the plateau. It has values as a conservation/national park area and, in economic terms, this may exceed the value of the local pastoral industry.

The pastoral industry involves deliberate changes in the local environment. Whether it is based on hunting feral animals or on the concentration of controlled livestock, some environmental damage through changes in vegetation and modification of wildlife habitats is inevitable.

There does not appear to be any pressing reason for utilising the modest forest potential of the Region or its agricultural possibilities. The commercial fishing industry is unlikely to be affected by the Ranger project. We do not know what the added effect of mining elsewhere in the Region would be.

Plate 20. Part of Waterfall Creek Reserve on the upper South Alligator River. The reserve, proclaimed in 1971, is set aside 'for the recreation or amusement of the public' (photo: Australian Information Service).

Plate 21. A flock of magpie geese near Cannon Hill in the wet season (photo: Australian Information Service).

10 PROPOSALS FOR A NATIONAL PARK

A strong body of evidence supported the establishment of a large national park in the Region. Witnesses contended that, because of the remarkable qualities of the area, it would be desirable to set aside a large park area for conservation, recreation, education and scientific research purposes before further alienation of land for other purposes occurs. This proposition was supported in substance by a proposal from the Northern Land Council acting on behalf of the Aboriginals of the Region.

National park objectives

There is no universally accepted concept of what a national park should be.

In 1970 a conference of Ministers responsible for national parks in each State and the Commonwealth defined a national park as:

> A relatively large area set aside for its features of predominantly unspoiled natural landscape, flora and fauna, permanently dedicated for public enjoyment, education and inspiration, and protected from all interference other than essential management practices so that its natural attributes are preserved.

Witnesses generally endorsed the view that a national park should both provide for the enjoyment of people and promote conservation and preservation of the natural environment. They agreed that different parts of a park might serve different functions and be managed accordingly. There were different opinions about whether conservation objectives necessarily required all habitats included in a park to be contained within one continuous area. Those favouring one large area said that it could be managed more effectively than several separate ones and that on ecological grounds it was important that contiguous and interacting ecosystems should be contained in the one reserve. They extended this reasoning to argue for the inclusion of a whole catchment in one reserve. They emphasised the importance of interaction between headwater and downstream ecosystems, pointing out, for example, that many fishes and birds migrate in different seasons from one to the other and that interference with one section could have a significant impact on the other.

The divide between two catchments was seen by some as a logical and effective boundary for a national park. Others saw virtue in adopting river courses as boundaries, as these are generally more easily inspected and administered than catchment divides, which are often isolated and inaccessible.

Many witnesses opposed the conduct in national parks of mining, pastoral or any other economic activities not essential for park management. They claimed that these activities were incompatible with the aims of national parks because they tended to change the natural environment, whereas national park management aimed at preserving it. Others argued, on the other hand, that if economic ventures had to proceed in areas with national park values it was best that they be included within the park reserve and made subject to the control of the park management. They argued that this should minimise the adverse effects of the activities. The *National Parks and Wildlife Conservation Act* 1975 and some State legislation permit mining in national parks.

There was general agreement that buffaloes should be excluded from any national park in the Region. However, some witnesses felt that, because of the difficulty of exterminating these animals over large areas, controlled management was as much as could be achieved. The feral pig was seen as even more difficult to exterminate or control. A question raised in evidence was what importance should be placed on the inclusion of wetlands of the Region in a national park, in view of the fact that they have been substantially changed by the buffalo and pig and no longer constitute natural ecosystems, whereas less disturbed wetlands of a similar kind occur in other parts of the Northern Territory.

The Region's national park qualities

The Interim Review Report of the Alligator Rivers Region Environmental Fact-finding Study summarised as follows the qualities of the area favouring the establishment of a national park:

1. The region has a wide variety of landscape, vegetation and wildlife types which are not to be found elsewhere in the continent.
2. The important land type features which are well represented in the Alligator Rivers region are the Arnhem Land plateau, the escarpment and outliers, the flood plains, the permanent lagoons and swamps, and the major tidal river systems.
3. Biological features of importance are:
   (a) a wide range of aquatic and terrestrial vegetation types;
   (b) an abundance and considerable diversity of plant and animal species, including birds and fishes;
   (c) the occurrence of relic communities and species, such as the rain forests and semi-deciduous forests, some birds, insects, fishes, and one species of turtle;
   (d) the occurrence of rare species well represented in the region, and some endemic races and perhaps species and certainly many new records of species.
4. The region has a wide range of attractive scenic features including the escarpment formations, the contrast of escarpment and lowland, vistas across the dissected plateau, and from it across the lowlands to the plateau outliers and the flood plains. In addition, there are specific scenic sites of considerable beauty such as the numerous waterfalls, rock formations, gorges, ravines, caves, rock pools, streams, springs, lagoons and swamps, the different vegetation types associated with the various landscape features and the concentrations of aquatic birds that occur in the swamp lands during the dry season.
5. The region has an abundance of Aboriginal relics and features, especially Aboriginal art, of which there is no equivalent in any other part of Australia.
6. It provides scope for scientific study in many disciplines, including geology, geomorphology, botany, zoology, ecology, limnology, archaeology and Aboriginal culture.
7. It presents a variety of opportunities for organised and unorganised recreational and educational activities such as sightseeing and lecture tours, bird and animal watching, natural history study, swimming, bush walking, photography, and wilderness exploration for those experienced and qualified in this kind of activity in such a region and climate.
8. The foregoing features exist in close to natural state, in a very diversified but relatively compact region.

9. Although individual sites may have a limited capacity at any one time, a representative national park in the region could collectively serve a large number of visitors with varying interests providing it was comprehensively organised and specifically managed for the purpose.

History of proposals

A number of proposals for the establishment of a national park in the Region have been made since 1965.

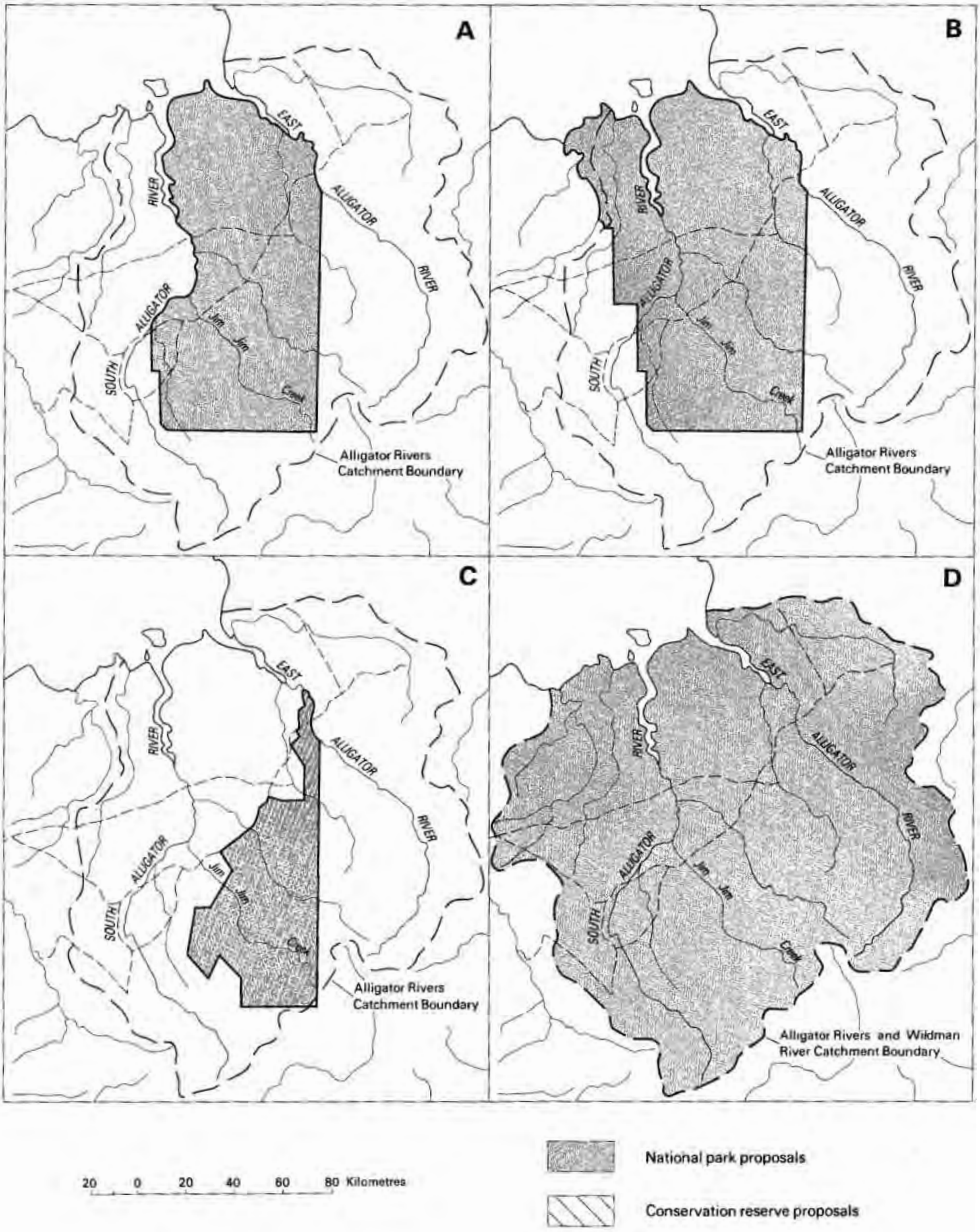
The first, put forward by the Northern Territory Reserves Board, covered an area of about 6410 square kilometres, bounded on the north by the coast, on the west by the South Alligator River, on the south by Goodparla and Gimbat pastoral leases and on the east by the Arnhem Land Aboriginal Reserve (see Map 13A). It included the area then constituting Woolwonga Aboriginal Reserve (its boundaries have since been revised) and the areas now occupied by Munmarlary and Mudginberri pastoral leases. This put the proposal in conflict with the commercial buffalo operations then proceeding at Mudginberri and Munmarlary under temporary licences, and with the objectives of the authorities responsible for the Woolwonga Reserve. No government decision was made on the proposal. The Minister Representing the Minister for Territories in the Senate, Senator Gorton, said in April 1966: 'The Government is sympathetic to the creation of more national parks, but in this case the reservation is complicated by an Aboriginal Reserve, a wildlife sanctuary, special purpose leases and pastoral and mining activities in the area. No decision will be possible until these have been investigated further.'

Various modified proposals were made in 1967. One, covering 2850 square kilometres, excluded Woolwonga, Munmarlary and most of Mudginberri. A portion of Mudginberri was included in a corridor to the East Alligator River in the Cannon Hill area. The proposal excluded those parts of the land in the western part of the 1965 proposal which lie south of Woolwonga. However, consideration was given to a proposal from the Wildlife Advisory Council that this area should be managed as a restricted game hunting reserve.

In 1968 Mr Sam Weems, Parks Advisor to the U.S. Department of the Interior, was asked by the then Australian Minister for the Interior, Mr Nixon, to visit the area and report on the proposals. He recommended that a national park eventually covering the 8300 square kilometres area shown in Map 13B be established. Following an evaluation of his report, the Minister in June 1969 approved in principle the reservation for a national park of an area of about 2590 square kilometres and proposed that a planning committee should examine the question of extending the area. The proposed area was similar to the modified proposal described in the previous paragraph, but restricted the East Alligator River corridor to the crown land east of Mudginberri. The Administration appointed a Pre-planning Committee 'to enable planning and establishment of the national park to be put in hand at the earliest possible date'. The Committee reported the same year.

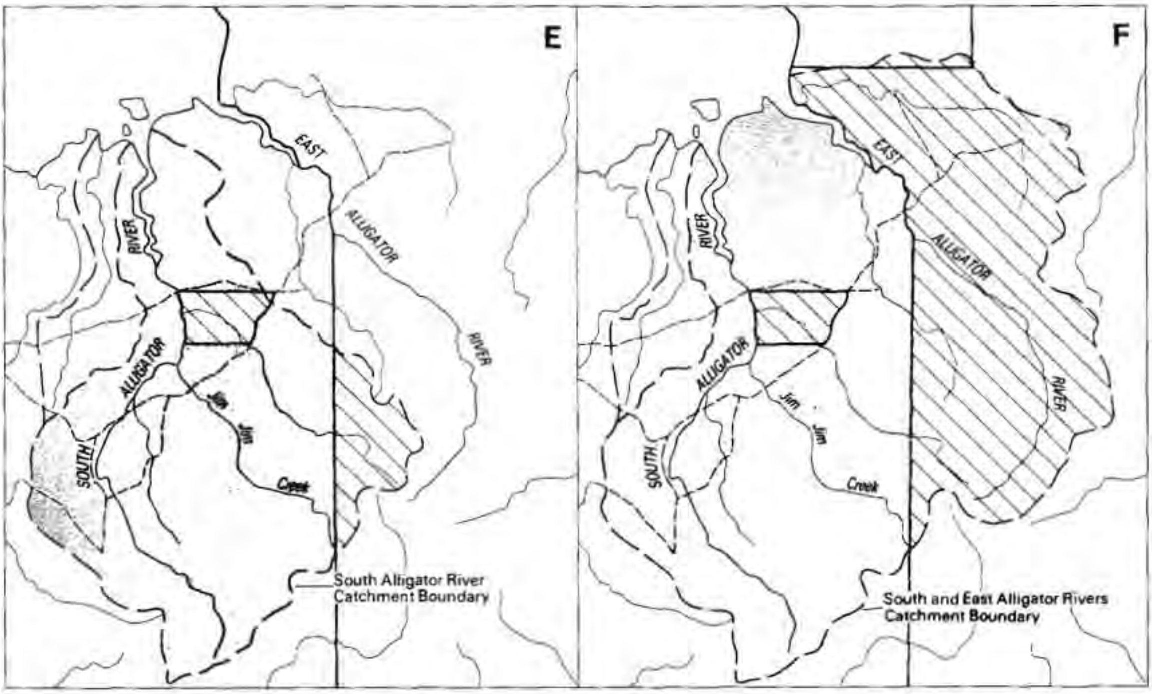
In 1969 pastoral leases were granted for Munmarlary and Mudginberri, which had been held since 1965 under Occupation (Development) Licences and before that under Grazing Licences. Granting of the leases followed presentation of the report of a Select Committee of the Territory Legislative Council which investigated the potential for more intensive development in the coastal plains area, and the introduction of an ordinance which gave holders of Occupation (Development) Licences preferential rights to the granting of pastoral leases. Mining prospecting authorities (later exploration licences) were issued for most of the proposed park area between 1967 and 1971.

MAP 13



National Park and Conservation Reserve Proposals

NMP 76/221.5



Following a recommendation of the Pre-planning Committee, a Planning Team was appointed to prepare a master plan for the park. This team, led by Mr J. Bosward of the New South Wales National Parks and Wildlife Service, proposed in 1971 an area of about 3840 square kilometres (see Map 13C). This differed from the area approved in principle by the Minister in 1969 in the following respects:

- A small section of Mudginberri pastoral lease was added, to include plateau outliers beside the Magela flood plains. The uranium deposits discovered later at Jabiluka are in this area.
- An area around the already discovered Ranger uranium deposits was excluded. The Planning Team reported that 'this land has no natural features to necessitate its inclusion within the National Park'. It recommended that, if mining proceeded, the conditions of mining 'should stress that no pollution whatsoever of the watercourse will be permitted'. It said very stringent and carefully considered conditions would be necessary to control the visual and operational aspects of the mining activities so as to ensure reasonable protection for the national park and nearby wildlife areas.
- The southern part was extended to the west and a section of Gimbat pastoral lease was added in the south.

The team also recommended that the headwaters of Deaf Adder and Nourlangie Creeks in the Arnhem Land Aboriginal Reserve be designated a fauna and flora reserve and that consideration be given to the inclusion in the park of the crown land north of Mudginberri and Munmarlary.

Following presentation of the Planning Team's reports, two areas within the proposed park boundaries were reserved from mining in 1971. These were areas of 233 square kilometres in Deaf Adder Gorge and 100 square kilometres around Jim Jim Falls. In 1972 the proposed park area, except the sections of the Mudginberri and Gimbat leases, was declared a wildlife sanctuary.

The 1975 proposal for Kakadu National Park

On 4 December 1973 the then Prime Minister, Mr Whitlam, announced that Cabinet had agreed to establish a national park in the Region, to be given the name Kakadu, and on 13 May 1975 the proposed boundaries were notified in the *Commonwealth Gazette*. The boundaries are those proposed by the Planning Team just mentioned. No final proclamation of the park has yet been made. Since the announcement new legislation concerning national parks in the Northern Territory—the *Parks and Wildlife Conservation Ordinance* 1976—has been passed by the Territory's Legislative Assembly and is awaiting assent.

The fact that a national park has still not been established is clearly linked with the competing claims of other land uses, particularly mining. Prospects for uranium mining emerged in the early 1970s concurrently with proposals to reserve land from mining. A problem with proposals put forward earlier by the Northern Territory Reserves Board was that they conflicted with the responsibilities and interests of some branches of the Territory Administration or with the rights of holders of land already allocated for other purposes.

In part the failure can be attributed to the lack of a co-ordinated land use plan and an established plan of land use management for the Region, a situation by no means limited to this part of Australia. Allied to this is an apparent reluctance to give top priority to the reservation of large areas for national park or conservation purposes if there is a possibility of substantial economic returns from some other form of land use.

There was general agreement in evidence that the boundaries proposed in 1975 for the Kakadu National Park are unsatisfactory, if the park is intended to be representative of the Region. While the land types of the plateau, escarpment and upstream drainages are well represented, the flood plains are very poorly represented. Tidal land, which has an important ecological function, is not included. Most land types of the lowlands are represented, but the proposed park area does not include samples of the relic semi-deciduous forests of coastal areas.

The most distinctive features of the park proposed in 1975 are:

- The main escarpment with its scenic land forms, interesting vegetation and wildlife, and Aboriginal art.
- The plateau and its gorges, which have many of the qualities of the escarpment including waterfalls, rock pools and specialised vegetation. They also have value as a large, although hazardous, wilderness area.
- The plateau outliers, of which the Mt Brockman–Nourlangie Rock massif south of Jabiru, the Djawumbah massif close to Jabiluka, Cannon Hill and Obiri Rock are the most outstanding.
- The main drainage lines across the lowlands, and the associated water bodies, which have scenic and recreational value as well as interesting and sometimes beautiful vegetation and wildlife.
- The lowland areas with their less distinctive and more widespread land forms, vegetation types and wildlife. These areas have less impressive wilderness qualities than the plateau.
- Rocky hills such as Mt Basedow and Mt Cahill.

- The juxtaposition of areas of very different land types, particularly in the northern section.
- Sites of traditional significance to the Aboriginals, which are distributed throughout the area. Those associated with the sandstone areas are best known.
- Archaeological sites, containing evidence of Aboriginal occupation of the Region over tens of thousands of years.

The Planning Team proposed dividing the area into the following zones:

- Wilderness areas. Access to those areas, which would be remote from any settlements, would be by foot only. No development would be undertaken.
- Reference areas. Development and access would be allowed for scientific purposes. Otherwise the restrictions would be the same as for the wilderness areas.
- Natural areas. These would be left in a natural condition, except for minimal development for camping and picnicking.
- Hunting areas. Controlled hunting would be permitted in these areas.
- Development areas. These would be planned for visitor education and enjoyment, with appropriate structures and facilities.

Additional proposals placed before the Inquiry

A number of other boundaries for a national park in the Region were proposed in evidence. These were:

- The Kakadu National Park boundaries as proposed in 1975, but with the whole of Jabiluka and possibly part of the southern section excluded.
- The proposed Kakadu National Park boundaries, with various suggested additions including the rest of the Magela system and plateau country in the upper catchment of the East Alligator River from Tin Camp Creek southward.
- All catchments of the South Alligator River and its tributaries. It was suggested that the portions in the Arnhem Land and Woolwonga Aboriginal Reserves might become conservation reserves if they were not included in the national park (Map 13E). It was proposed in addition that the catchments of the West Alligator and Wildman Rivers might be included.
- The catchments of the South and East Alligator Rivers. As in the last-mentioned proposal, it was suggested that the portions in Aboriginal Reserves might become conservation reserves if they were not included in the national park (Map 13F). These boundaries were proposed by the Australian Conservation Foundation and the South Australia Conservation Council. Both organisations qualified the proposal by making the inclusion in the park of Aboriginal land conditional on the agreement of the Aboriginals. Both opposed mining in any part of the area. The South Australia Conservation Council argued, however, that if mining were to proceed it should be under the control of the park management in accordance with the National Parks and Wildlife Conservation Act.
- The entire catchments of the three Alligator Rivers and the Wildman (Map 13D).

The Australian Conservation Foundation argued that the best possible system of park and conservation reserves should be established in the Region, and stressed the importance of including total catchments from headwaters to the sea. The Alligator Rivers Region is one of five areas throughout Australia nominated by the Foundation as being worthy of becoming a part of the World Natural Heritage under the Convention for the Protection of the World Cultural and Natural Heritage.

The ACF claimed that mining was incompatible with national park concepts, that use of the land for a national park would be of greater long-term community value than mining and other possible uses, and that the Commission should recommend an area for a national park unfettered by consideration of these other uses.

Aboriginal proposals The wishes of Aboriginals with land rights in the areas are of prime importance in any consideration of the establishment of a national park. Our findings in relation to the land claims are given in Chapter 15.

The Northern Land Council has proposed that the areas within the Region claimed as Aboriginal land, together with the Woolwonga Aboriginal Reserve which is already Aboriginal land, should be a national park. A difficulty in establishing a park in the area arises from the fact that the *National Parks and Wildlife Conservation Act* 1975 provides that all the right, title and interest in land on which a national park is to be established must be vested in Australia (s. 7 (1)). The Aboriginals want the land to be vested in Land Trusts, as provided in the *Aboriginal Land Rights (N.T.) Act* 1976. Legislation would be necessary if it were desired that land in a national park be vested in Aboriginal Land Trusts, or vice versa. This matter is discussed in Chapter 14.

Both the *National Parks and Wildlife Conservation Act* 1975 and the *Territory Parks and Wildlife Conservation Ordinance* 1976 (which is not yet law) provide for the use by Aboriginals for traditional purposes of areas proclaimed as national parks or protected areas. Therefore the proclamation of an area as a national park under the Act or the ordinance would not exclude use of the land by Aboriginals for hunting or food gathering, or for ceremonial or religious purposes. Aboriginal people in the Region continue to include traditional foods in their diets and hunt in areas proposed for inclusion in the national park.

The Commission was told that the rock paintings of the Region form a rich cultural and historical source of identity to present generations of Aboriginals. Many used to be repainted as part of religious ritual, thus ensuring their preservation. However, the disruption of traditional life has largely brought an end to this practice, so the natural processes of destruction caused by climate, erosion and so on are no longer reversed by constant retouching.

There is an urgent need to adopt procedures for the conservation of this art in order that it might be preserved for future generations. Continued neglect would result in the loss of one of Australia's richest cultural resources. Many sites of archaeological importance are also in need of preservation.

The Commission was told that in other countries similar problems have been faced and solutions devised. For example, in the United States important sites have been incorporated into national parks. Trails and roads have been constructed to take visitors to rock art sites that are constantly under supervision. A regular program of recording and designation of sites as national landmarks is doing much to preserve an important part of American prehistory.

UNESCO has developed a series of guidelines designed to ensure the preservation of 'monuments, antiquities and sites'. These include recommendations that:

- any action for the preservation and protection of monuments, antiquities and sites of national importance be accompanied by scientific, historical and aesthetic research basic to a proper understanding and evaluation;
- there should be adequate provision for recruitment and training of qualified personnel, in particular laboratory specialists, archaeologists, architects, engineers and others whose responsibility it will be to plan conservation programs and supervise their execution;
- between local, regional and national agencies there should be continuing communication with the object of defining the interrelated aspects of the complex problems involved; and
- monuments, antiquities and sites be maintained in good repair at all times to ensure that they are properly preserved in perpetuity.

Aboriginal sites would be major features of a national park in the Region, and the park plan of management should provide for their preservation. Any program of preservation adopted should provide for the participation of the Aboriginal people themselves. It was suggested in evidence that, with more opportunity, Aboriginals would develop a sense of responsibility for the sites and would participate in their protection and preservation.

A national park would provide opportunities for the employment of Aboriginals as rangers and guides. We were told that the Aboriginal people would have an affinity for the type of work involved and that, with training, they could play a very positive role in the development and management of a national park.

The National Parks and Wildlife Conservation Act provides for the making of agreements with Aboriginal traditional owners of land respecting the protection and conservation of the land's natural features. Mr Justice Woodward, in the Second Report of the Aboriginal Land Rights Commission (para. 515), said that certain guidelines should be followed in planning the future of the Ayers Rock and Mt Olga National Park. The guidelines are as follows:

- Aboriginals, through the Land Council, should be consulted and their views taken into account before any schemes for the development or management of the area are adopted.
- Aboriginals should be well represented by people of their own choice on any board or committee finally made responsible for the area.
- Others appointed to such a board or committee should be persons who have some understanding of, and sympathy with, the relationship of Aboriginals to their land.
- The clear wishes of Aboriginals on any matter relating to the land should not be able to be overruled without reference to some independent authority who can determine the particular issue in an informed and impartial way.
- Development plans for the area should make allowance for any Aboriginals, and particularly those having traditional claims to that land, who wish to live there.

At the time that Mr Justice Woodward made those recommendations there was an Aboriginal claim to traditional land covering all the Ayers Rock and Mt Olga National Park area. The validity of the claim had not been determined by a Land Commissioner and it was not known whether any of the land would in fact become Aboriginal land. The recommendations were not made conditional on the outcome of the claim.

In Chapter 15 we consider the Aboriginal land claims in the Region. The evidence is clear that the Aboriginals themselves believe that they are entitled by tradition to the use and occupation of all the land in the Region. While there has been insufficient evidence presented to this Commission to allow us to determine whether or not there are traditional Aboriginal owners, as defined in the Aboriginal Land Rights (N.T.) Act, of all the vacant crown land in the Region, we have found that there are such owners of most of the vacant crown land east of the South Alligator River. In these circumstances, we are of the view that the guidelines developed by Mr Justice Woodward should be applied to the planning and management of the whole of any national park which is established in the Region, even though parts of it may not become Aboriginal land. This view is reinforced by the expert evidence put before us that the plan of management of a national park should be carefully integrated, so that development in one section is not incompatible with the functions of another. Achievement of such integration in a park in the Region, in a situation where Aboriginals were not fully involved in the development and administration of the plan of management, would be difficult indeed. The evidence before this Commission supports Mr Justice Woodward's view (para. 506 of his Second Report) that Aboriginal interests have much in common with those of conserving the environment.

Conclusions

The Commission agrees with the view that representative samples of all major ecosystems of the Region should be included in a national park and that they should be of adequate size to ensure their viability. The desirability of including in the one reserve areas which interact ecologically in an important manner is also recognised. Incorporation of a complete river catchment in a conservation reserve is desirable on this ground, and because it would protect water quality. We agree with the proposition that conservation, and the provision of national parks, is an important form of land use and that other land uses such as agriculture, the pastoral industry and mining should not automatically have priority. There are clear advantages to be gained in providing for conservation, scientific research, education and recreation in a compatible, carefully planned way within a single national park. The park should provide protection for all rare species of flora and fauna, rare habitats, and important Aboriginal art and archaeological sites and sites of significance. It should also include a variety of opportunities for park users, including wilderness and conservation areas, and accessible sites with scenic, education and recreation attractions representative of the Region. The mechanism of a formal plan of management, as provided for in the National Parks and Wildlife Conservation Act, provides flexibility, co-ordinated management and consequently efficient use of human and natural resources.

In order to assess, among other things, the relative merits of alternative boundaries for a national park in the Region, the Commission has divided the Region into thirteen major areas. The boundaries of these areas, which are listed in Chapter 16, have been selected mainly on natural geographical criteria, such as creek catchments, but where desirable for planning purposes man-made criteria have been used, such as the borders of existing pastoral leases. The values of each of the areas for conservation, recreation, scientific research, education and, consequently, for inclusion in a national park have been assessed. (The values for other uses have also been assessed. These other values are discussed in Chapter 16.)

We conclude from this assessment that each of the areas has particular value for national park purposes. Although there is similarity in characteristics between some of the areas, no two areas are so alike that one could be omitted from a national park without reducing the overall merit of the park. In our view a major national park should be established in the Region. The boundaries of the park should be arrived at as part of an overall land use plan. A plan for the Region is discussed in Chapter 16. In that chapter the merits of various parts of the Region for different land uses are examined.

Plate 22. Jim Jim Falls, in the Alligator Rivers Wildlife Sanctuary (photo: Australian Information Service).

11 TOURISM

Since the Arnhem Highway was completed to Jabiru in 1974 that part of the Region west of the Arnhem Land Aboriginal Reserve has become a prominent destination for tourists. Their impact is examined in this chapter.

Tourist attractions

No survey has been undertaken to determine which features of the Region hold the greatest appeal for tourists. Fishing for barramundi is a popular recreational activity; one of the areas most frequented by fishermen is the west bank of the East Alligator River, but dozens of other waterbodies in the Region can also be fished (see Map 14). Aboriginal art is another popular attraction. Nourlangie Rock, a point of call of tourist buses, and Obiri Rock are probably the most visited art sites. The spectacular scenery of the escarpment and its gorges, particularly at Jim Jim Falls and Deaf Adder Gorge, also attracts visitors. At present most of these areas are readily accessible only to people with four-wheel-drive vehicles. The bird life of the wetlands is another specific attraction. Tourist organisations which operate coach tours in the Region promote all the above attractions and emphasise the general remoteness and unspoiled state of the natural environment.

The dry season is the most popular time for visiting. Northern Pastoral Services estimates that 400–500 people camp, fish or shoot on the Mudginberri and Munmarlary pastoral leases during long weekends in the dry season, compared with perhaps 100 in the wet season.

Present and projected volume of tourism

Varying estimates and projections were presented to the Commission.

The Department of the Northern Territory estimated that the number of visitor days spent in the Alligator Rivers Region had increased from 19 000 in 1972 to 60 000 in 1976—largely as a consequence of increased accessibility from Darwin due to construction of the all-weather Arnhem Highway.

A detailed projection of growth in tourist numbers was given in *Alligator Rivers: Feasibility Study for a New Regional Centre*, prepared in 1972 for the Department of National Development. This projection was based on assumptions of energetic tourist promotion, creation of all appropriate facilities, and an increased mean length of stay of each visitor. It was concluded that, from the time a regional centre was established, the annual number of visitors would increase over twenty years from 65 000 to 708 000 and, likewise, visitor days would increase from 100 000 to 2 100 000 per year.

The current lack of accommodation and other facilities in the Region is a limiting factor to tourist expansion; overnight accommodation is available only at the Cooinda Hotel–Motel on Jim Jim Creek, towards the south of the Region. At present most visitors provide their own camping facilities. Many are people from Darwin who come mainly for weekends, but substantial numbers also come from other parts of Australia and overseas and stay for several days.

It was suggested by witnesses that the tourist industry alone would be unlikely to create adequate accommodation and facilities to achieve rapid growth in the number of tourists visiting the Region. Some held the view that a regional township which catered for tourism as well as housing people associated with uranium mining would provide a great stimulus to the industry.

They predicted that other investment associated with uranium development, on roads and water and electricity supply for example, would also benefit tourism.

On the assumption that such a township would meet requirements for tourism, the regional centre feasibility study estimated that permanent residents employed in the tourist industry and their dependants would number well over 2000 after fifteen years.

However, this estimate and the projection of growth in tourist numbers on which it is based were prepared in the early 1970s. They take no account of economic trends in Australia and overseas countries since that time, which have reduced spending ability and increased the cost of air travel. Also, in making the projections, little or no attention was paid to the important matter of the wishes and welfare of the Aboriginals.

Impact of mining on tourism

It was suggested in evidence that many visitors to the Region would regard uranium mines as an additional tourist attraction, and that this would increase the stimulus provided by the mining industry to tourism through the provision of facilities. Mining company spokesmen said that guided tours and viewing areas could be provided without interrupting mining and milling operations.

Other witnesses suggested that most visitors to the Region would be interested in the natural qualities of the environment and would find the mines intrusive and unpleasant.

Impact of *tourism*

The Commission received evidence that some environmental damage is already being caused in the Region by visitors. Piles of rubbish and dead fish have been left on the banks of the East Alligator River and at other popular fishing sites. Vegetation has been destroyed and the risk of soil erosion increased by four-wheel-drive vehicles smashing tracks through the bush. Other harmful acts ascribed to tourists include breaking fences, allowing fires to get out of control and disturbing cattle and buffaloes. Some Aboriginal sites of significance have been desecrated and there has been looting of archaeological sites. In one rock gallery ancient paintings have been damaged by recently applied acrylic paint; the origin of this vandalism is unknown. Northern Territory wildlife rangers and others who gave evidence believe strongly that visitors will cause irreparable harm to archaeological and art sites unless protection is provided without delay.

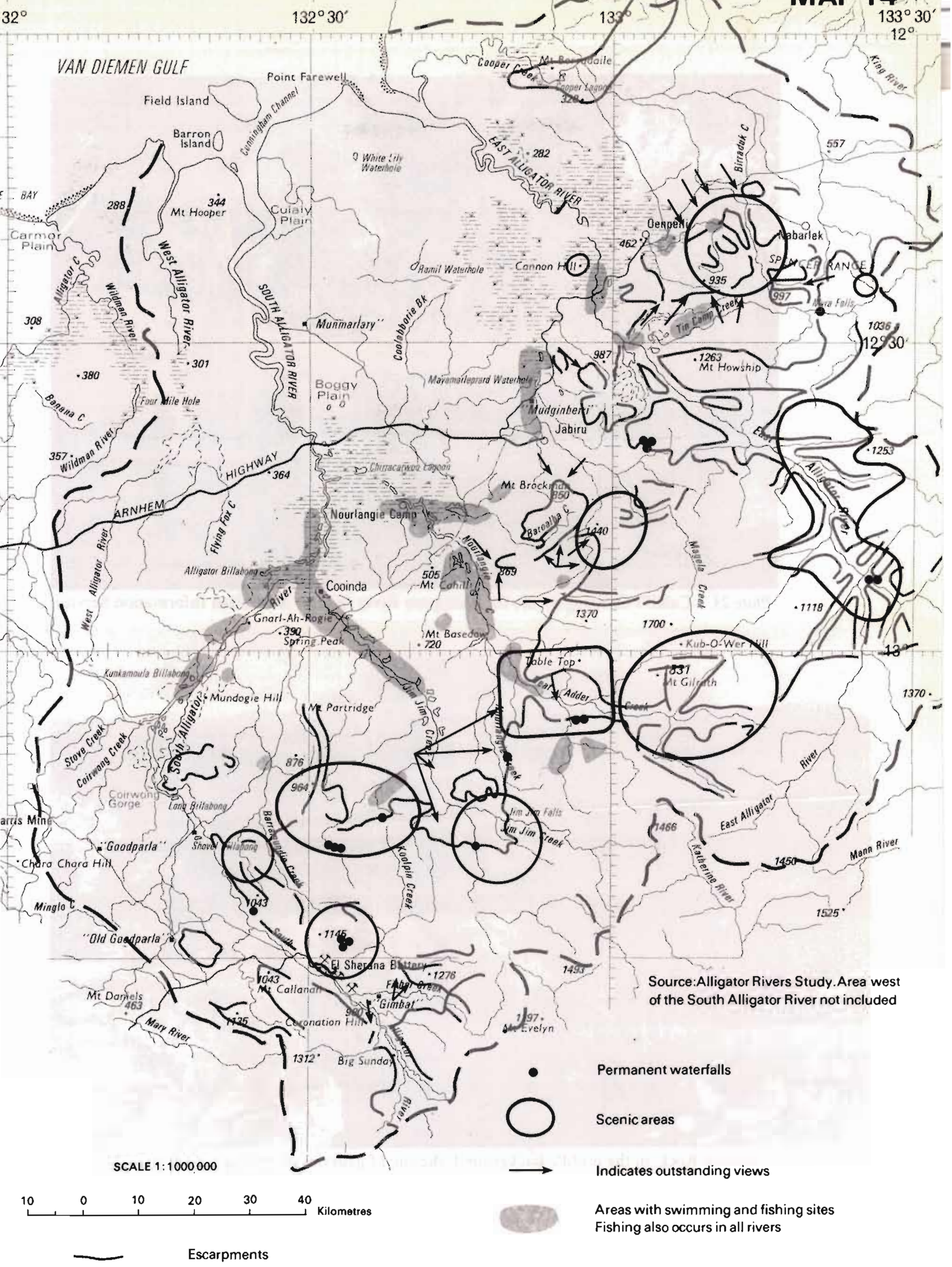
Aboriginal witnesses from the Region told the Commission that they were unhappy at the prospect of greatly increased numbers of tourists. The damage that visitors can cause was one of their most immediate and pressing concerns. They were also worried about the likely social effects of large-scale tourist development. Although the tourists would provide a market for handicrafts, this benefit would be outweighed by the social disruption caused by the more or less continuous presence in the area of several thousand transient strangers. The Aboriginals believed this influx could only exacerbate the effects caused by the presence of a resident mining population.

Control of tourist activities

It was generally agreed that the activities of tourists should be strictly controlled throughout the Region.

Some proponents of mining assumed that the area proposed in 1975 for the Kakadu National Park would be the major, indeed almost the only, destination of tourists and that control would primarily be exerted by park rangers in conformity with the park plan of management. The evidence indicates, however, that many people come to fish and hunt in other parts of the Region, and that these make up an important proportion of present visitors.

MAP 14



Scenic, Fishing and Swimming Areas

NMP 76/221.7

Plate 23. Cahill's Crossing on the East Alligator River (photo: Australian Information Service).

Plate 24. Nourlangie Rock, in the middle background, the site of galleries of Aboriginal art visited by tourist buses. The Koongarra uranium deposit is 4 kilometres from the Rock, in the right background. (photo: G. Chaloupka).

Other witnesses suggested that the existence of a regional township would make easier the task of control. This may prove correct, but any such gain would almost certainly be overshadowed by the impact of increased numbers of visitors.

It will be necessary for the activities of tourists to be closely controlled, and this can be done by the national park authority if a large national park is created, as we propose in Chapter 16. Essential components in a control program will include preservation of the sanctity of sacred sites and the erection of effective protective structures around vulnerable Aboriginal archaeological and art sites, combined, where indicated, with permanent supervision. The use of vehicles in the park, particularly four-wheel-drive vehicles, will have to be restricted to acceptable roads and tracks.

If, as we expect, much of the land constituting the national park will be Aboriginal land, special arrangements will have to be made to meet the legitimate requirements of the Aboriginals, one of which will be a desire for a substantial degree of isolation from tourists. We propose in Chapter 18 that a formal plan of management as a national park of that part of the Region west of the Arnhem Land Aboriginal Reserve should be developed, and that its approval by the Northern Land Council should be required. We further propose that there should be Aboriginal representation on the national park authority. We see it as one of the virtues of what we propose that those with the relevant knowledge and interest can between them decide upon what is to be done.

Conclusions

Changed economic conditions, and the fact that tourist facilities are not likely to be as extensive as projected, seem certain to result in the natural rate of growth in tourism being considerably less than that projected in the early 1970s. Nevertheless, the undoubted attractions of the Region are likely to lead to a substantial increase.

The Commission is of the view that a rapid increase in the number of tourists visiting the Region would cause severe social pressures on the Aboriginal people of the Region. The Aboriginals do not wish to see such an increase in tourism. It is quite vital that a large or sudden influx of tourists be prevented.

The regional centre should not for the present be seen as a place in which tourists can stay (see Chapter 12). Its population should be strictly limited to those people who must live there because of mining activities. Tourist accommodation should for the time being be found outside the park or at one or two carefully selected places within it; the choice should remain with the Aboriginals and the park authority.

To prevent environmental damage from the activities of tourists in the Region, strict controls will be necessary. The need for a comprehensive plan of management for the national park is discussed in Chapter 18. Time will be needed for the plan to be drawn up and for the provision of the staff and facilities necessary to make it work. For this reason alone the development of tourist activity in the Region will for the time being have to proceed slowly and cautiously. In the fullness of time we have no doubt that the tourist industry will have a prominent place in Northern Territory affairs, but it is in the ultimate interests of that industry that it be developed in the way mentioned, with due regard to all environmental considerations.

12 ACCOMMODATION OF MINE WORKERS AND THEIR FAMILIES

Proposals by mining companies

The proposal made by Ranger is that during the construction phase of at least three years it accommodate its mine workers in the Ranger Project Area, close to the mine works. Ranger estimates that, during this period, if it is preparing for production at the rate of 3000 tonnes of U_3O_8 a year, it or its contractors will employ up to 600 people, and if it is preparing for an immediate capacity of 6000 tonnes a year, up to 1000 people will be employed. Some of the construction, such as that relating to the tailings dam and retention dams, will only proceed during the dry seasons, with the result that the number of workers on site will fluctuate considerably. Once the mine is in production the company estimates its operating workforce at 250 for a production of 3000 tonnes a year, or 400 for the higher rate. A further seventy or more persons will be employed in connection with the mining operations by other employers. Ranger expects that after the construction phase all employees and their families will be accommodated in a regional centre some distance from the mine.

Very little evidence has been given concerning the nature of the accommodation at the construction camp or of the facilities which will be provided. It is obviously intended as temporary accommodation only. The question whether it would be possible to use the construction camp site on a more permanent basis has not been explored in the Inquiry.

It is obvious that, having in mind the interests of the workers themselves, and the sensitive nature of the environment, particularly the problems that can arise in relation to the welfare of the Aboriginal people, the presence of a large number of workers living in temporary accommodation in a remote area needs careful consideration and necessitates the making of adequate plans well in advance.

Depending upon whether the mine at Jabiluka is developed and, if so, when, the problems may be greatly exacerbated by the presence of a large number of construction workers for that mine. Pancontinental (with its co-venturer, Getty Oil Development Co. Ltd) proposes a main construction camp for 600 to 700 men, and a second construction camp in or adjacent to the regional centre for up to 250 persons, including married people. The main construction camp is planned to be immediately to the east of the mine works, close to a proposed extension of the Arnhem Highway. Pancontinental's plan for its permanent employees is to accommodate them in a regional centre with the Ranger employees. It estimates its permanent workforce at about 350 in the first year of operation, rising to about 700 in the fifth year, and then possibly continuing to rise slowly to a maximum of 800 to 900.

We make three recommendations in relation to accommodation during the construction phase. In the first place, Aboriginal title should be granted, the national park established, and the necessary control mechanisms be set up, before any substantial amount of construction work proceeds or substantial numbers of people are brought into the area. This need not result in any delay, having in mind all that has to be done before a mining lease or authority can lawfully be granted.

The second matter is that authority should not be given for both the Ranger proposal and the Pancontinental proposal to proceed at the same time. We have in our First Report tentatively suggested the desirability, on wider grounds, of a sequential development of mines within Australia, and we discuss the matter further in Chapters 8 and 16 of this Report. Apart from that consideration, it seems to us that, as between the two proposals, the Ranger mine should be allowed to develop first, at least to some extent. This again should not create any particular problem, because Ranger is in a more advanced stage of preparedness than Pancontinental. The latter yet has to present an environmental impact statement which will have to be examined and dealt with in accordance with existing legislation. Thereafter it has to reach the necessary agreement with the Northern Land Council. It would, we think, impose too great a strain on the whole scheme and involve too much risk to the environment and not least of all to the Aboriginal people if both mines were to embark upon full-scale development simultaneously. Apart from all other considerations, this would result in there being, during the greater part of three years, somewhere between 1000 and 1500 people in construction camps.

The Queensland Mines proposal at Nabarlek in the Arnhem Land Reserve is for a smaller mine with staff accommodated in Darwin spending intervals at a mine camp. Time of commencement of that mine will be dependent in part on Aboriginal attitudes.

The third recommendation is that steps be taken to keep the number of people in construction camps to a minimum. This will help to ensure that they enjoy reasonable amenities, while being subject to strict controls of the nature outlined, and will also reduce the risk of damage to the environment, and particularly to Aboriginal relations. Before a mining interest or authority is granted, the Northern Land Council will have an opportunity of reaching agreement with the mining operator about these matters. What we say about them does not, of course, prevent the parties coming to their own agreement, or in any way control or qualify what they may agree to. As mentioned previously we make this recommendation, and others also, in the hope that they may assist the parties in reaching agreement.

Regional centre studies

In 1972 and 1973 studies were done at the request of the Department of National Development respecting the establishment of a town, called in the studies a 'regional centre'. These separate studies were done by independent consultants, the earlier one by Cameron, McNamara & Partners and Heathwood, Willis & Partners, and the second by A. A. Heath & Partners Pty Ltd and Willis, Heathwood & Partners Pty Ltd. The second was a design study following on the feasibility study done earlier. It was the recommendation of the consultants that there be one regional centre and that it be situated in an area approximately 8 kilometres to the west of the Ranger site, on the south side of the Arnhem Highway. Other sites were considered, but the one mentioned was preferred.

No firm decision has been taken about the construction of a regional centre at any site. The studies mentioned were done carefully and are very helpful in a number of respects. However, they were related to a situation materially different from that which is now envisaged. The regional centre was planned for a population of up to 10 000 people, which it was projected would be achieved within twenty years of first occupation. At the time of the studies the extent of the Jabiluka deposits was not known and the proposals for the development of the mines there were very incomplete. The studies therefore took hardly any account of the needs from that direction. On the other hand, they proceeded on the basis that the Noranda mine at Koongarra would soon be developed and would make a substantial demand on the town. The estimates of requirements were based on the need to allow for a large tourist industry. A large and successful local pastoral industry was also envisaged. The details of the Ranger mining and milling proposals were not then known. In a number of other respects the information upon which the reports were based does not accord with that which has been placed before the Commission.

For these and other reasons the results of the studies are of limited use for present purposes. The choice of site was limited by the need to avoid the Woolwonga and Arnhem Land Aboriginal Reserves, the sandstone plateaux and escarpments, land which might be subject to flooding, known ore bodies and radiometric anomalies, and, if possible, land designated by the Bureau of Mineral Resources as being prospective for uranium. In finally choosing a site the feasibility study looked at the requirements for a regional centre largely in the light of what was best economically, and for the comfort and convenience of residents. Characteristics regarded as most important included proximity to the various known ore bodies, the avoidance of pollution from dust and radon, the avoidance of pollution of the Nourlangie and Magela catchments, suitability of the site for a town layout, attractive vistas, and drainage and sewerage considerations. Little, if any, consideration was given to other consequences which we see as very important, namely the impact of residents and tourists on the national park, on Aboriginal lands and on Aboriginal society itself.

Environmental impact

We are not concerned with the detailed planning of a town and, indeed, it may be thought appropriate to have a separate environmental investigation of the proposals for one when they have been prepared in sufficient detail. It is, however, necessary for us to form a conclusion as to probable sites for a town. We must also have an adequate concept of its size, the facilities which it will provide, and its organisation, in order that we might see sufficient of the environmental consequences, both physical and social.

We have already explained the interaction between the various land uses within the Region, its very highly sensitive environmental features, and the need for careful and thorough planning in order that environmental damage be minimised. In the Ranger Environmental Impact Statement (p. 7) it is asserted that 'the potential for disturbance of the natural environment will be greater from the activities of an increased population than from the proposed mining activity, which is more readily subject to control'. It is indeed the effect of the evidence that an increased population is likely to have seriously detrimental effects unless closely controlled, and as the passage quoted suggests, control is likely to be more difficult in that case than with mining operations. If place is to be found in this Region for mining activities and for a national park and if at the same time the welfare and well-being of the Aboriginal people are to be properly respected, constraints are inevitable.

It is necessary to strike a balance between on the one hand providing for the people whom the mining activities necessarily bring to the area, and ensuring that within reasonable limits their convenience and comfort are provided for, and, on the other, keeping damage to the environment, in all its aspects, to the barest minimum.

We refer in Chapter 5 to the possible impacts on the environment of a great increase in the European population living in the Region. There will be the need to occupy space, and to dispose of domestic waste water and solid wastes. Road traffic and associated hazards will be increased. Leisure time activities of residents of the town might include fishing, swimming, picnicking, sightseeing and shooting. Such activities could be accompanied by disturbance to mammal and bird habitats, fish and game poaching and uncontrolled collection of flora and fauna, accidental or deliberate lighting of fires, littering and dumping of rubbish, and vandalism. The use of off-road vehicles, such as trail bikes and four-wheel drive vehicles, could increase the number of access tracks, damage the bush and lead to soil erosion. No doubt residents in the Region would wish to keep pets, but the evidence is clear that domestic dogs and cats must without exception be excluded from the Region because of the destruction that they could cause to native wildlife, particularly if they go wild. We have previously explained that the virtual absence of feral cats is thought to be one reason for the large number and diversity of birds and small animals in the Region.

Irresponsible residents might damage archaeological sites and cave paintings. A matter of great seriousness is the risk of interference with sacred sites, of which there are several in the Region. Damage or interference can occur inadvertently, due to ignorance, or it may be deliberate, but the consequences are much the same. Another serious matter is the risk that white people living in or visiting the area will trespass upon Aboriginal lands. The existing Arnhem Land and Woolwonga Aboriginal Reserves have become Aboriginal land under the *Aboriginal Land Rights (Northern Territory) Act* 1976, and we recommend under that Act that other land in the immediate area also become Aboriginal land. If our further recommendations concerning the creation of a national park are accepted, the result should be to provide access to parts of that land for recreation purposes, at suitable points but subject to appropriate constraints.

Of equal concern is the possible social impact upon the Aboriginal people themselves. This is discussed more fully in Chapter 13. The common problems which have arisen in the past have been the selling of excessive amounts of alcohol to Aboriginal people, and the casual sexual association of white men with Aboriginal women. The problems mentioned are increased by the fact that numbers of Aboriginals, not necessarily those who have traditional affiliations with an area, are apt to congregate on the fringes of townships and to live in conditions and under circumstances which are less than desirable.

There are, of course, some advantages to the Aboriginal people in the presence of a European community. A town would provide some avenues of employment, both from work in the town and from the supply of goods and services to it. We do not expect that a large number of Aboriginals would find employment in this way, but some probably will. There are too some advantages to them from the provision of health, educational and shopping facilities and, possibly, from some social and sporting activities. There may be some Aboriginals who would wish to live in the town, but we believe they would be few.

Town size

We mentioned that at the time of the studies carried out by the consultants it was contemplated that substantial accommodation would be found in the regional centre for tourists and for people associated with tourism. It was also intended that it would become a substantial administrative centre, as indeed would be inevitable with a township of the size contemplated. We feel, however, that we are faced with the necessity of keeping numbers in the town to the barest minimum consistent with allowing the mine or mines to operate at the approved levels of production. We are therefore of the view that, for the time being at least, accommodation should not be provided in the town centre for tourists, or for anyone else who can reasonably be accommodated outside the Region. There will inevitably be some overnight accommodation for people visiting the area on business, but that is a different matter.

If our recommendation is accepted which provides for the town being within the national park, the plan of management will deal with the town, as it will with the rest of the national park. It may well be that the park authorities will think it appropriate to establish overnight accommodation for tourists in the park away from the regional centre. If so, its nature and extent will be determined in the plan of management. In order to minimise any risk of the problems arising which we have been discussing in connection with the town, it would seem to us to be advisable for tourist accommodation to be in the western part of the national park. The tourists will, of course, be subject to the constraints necessary for the proper maintenance of the national park.

It is relevant in this connection to draw attention again to s. 70 of the Aboriginal Land Rights (Northern Territory) Act which restricts entry on Aboriginal land. The exact ambit of the restriction is not yet plain, because complementary Northern Territory legislation is to be made (see Chapter 14). The point is, however, that if, as we expect to be the case, much of the Region, including the Ranger Project Area, will comprise Aboriginal land, rights of residents or visitors, and especially of tourists, to move freely over it will be restricted to some extent. The ultimate constraints will be those which, giving major weight to Aboriginal considerations, are nevertheless appropriate for the national park.

It is axiomatic that the more persons there are in the regional centre, the greater is the likelihood of some unwarranted damage to the environment. The feasibility study to which we have referred suggests that the town population directly depending on the mining industry will be about three times the number of mine workers. This, as we understand, is largely based on experience in localities in the Northern Territory but is dependent upon a number of factors, including the percentage of married people in the particular workforce. Other information put before this Commission suggested that the factor could be higher than this, if there were no limitations placed on town size. However, taking that factor of three, if the Ranger workforce is of the order of 250 to 400, a town to accommodate its workers and their families would have a population of about 800–1300 people. Pancontinental's permanent workforce is estimated to be about 350 in the first year of operation, rising to about 700 in the fifth year, and then possibly continuing to rise slowly to a maximum of 800 to 900. Applying the same factor, the town, in the fifth year of Pancontinental's operations (which might be seven or eight years from commencement of construction), could have a population of about 3500.

Our view is that the size of the town, in terms of population, should at the outset be strictly limited. The maximum ultimate population should for the present be set at 3500, the number considered essential to serve Ranger and Jabiluka mines. Advantage should be taken of experience during the earlier years to see whether the ultimate size should be less, or can be permitted to be greater. This means a gradual and orderly growth. It may mean that if the Pancontinental mine is allowed to proceed (after Ranger) it has to be told at some stage the town cannot accommodate all its projected labour force. It is difficult to be at all certain about what the position will be in, say, seven to eight years' time. There are many imponderables, including the state of the uranium market and the attitudes, at that time, of the Aboriginal people and the national park authority. In all aspects much will depend on experience over the intervening years. It may prove practicable to accommodate some of the mining community outside the Region.

What is important is that there be careful and prudent planning, with a full consciousness of the problems. The site suggested by the consultants as a regional centre is, they say, suitable for a town of 10 000 and more people. Our view, on present information, is that a town of 10 000 people would be quite disastrous for the area, and for Aboriginal relations. In any event, there is no present need for a town of anywhere near that size. We think it would be desirable to restrict its size as much as that can reasonably be done.

Site for a town

We have mentioned the site selected by the consultants as a town. The possibility of others was raised by witnesses during the hearings, but was not the subject of detailed evidence.

Alternative sites considered by the consultants include one on the Mudginberri lease, immediately north of that selected. This would place the town close to the Aboriginal settlement at Mudginberri, and for that reason alone must be rejected. Another site is on the eastern side of the Magela Creek, roughly due east from Jabiru. We are doubtful whether this would be suitable, because it is close to the Arnhem Land Aboriginal Reserve and would occupy land with valuable park qualities. Another possibility examined was a site north of Woolwonga, in Mudginberri–Munmarlary, adjacent to the Arnhem Highway. This site is about 4 kilometres further from Ranger than the proposed site, but, in the consultant's judgment, is otherwise little different. In our opinion its very close proximity to the Woolwonga Reserve is a major drawback.

We ourselves established criteria for the selection of a site and examined a number of other possibilities, including the three which were considered, but not accepted, by the consultants. Having in mind the absence of any firm suggestions about alternatives during the hearings, and the resultant dearth of information about them, we are not in a position to recommend a site different from that proposed by the consultants. It may well prove to be the most satisfactory.

On the basis of map information on topography, land type and geology, one other possible site, not among the four examined by the consultants, did suggest itself to us. We have not examined it on the ground. It is on Mudginberri lease, 10 kilometres north of the Arnhem Highway and 15 to 20 kilometres west-north-west of Mudginberri homestead. It is thus a good deal further away from the mine site than the regional centre proposed.

One matter which concerned us was whether airborne effluent from the Ranger mine, particularly radioactive dust, might, over a period, constitute a danger to the health of the inhabitants. This could not be dealt with satisfactorily in the report of the consultants. The query arose because the proposed regional centre is directly down the prevailing wind from the Ranger mine and mill site and would therefore be exposed to higher concentrations of airborne contaminants than a site the same distance from Ranger in any other direction. It was estimated in Chapter 6 that the additional radiation to which people living at the proposed regional centre site would be exposed was not more than 6 per cent of the recommended maximum exposure for members of the public, which is a small amount. Nevertheless, bearing in mind the ICRP recommendation mentioned in our First Report, that any unnecessary exposure to radiation be avoided and that all doses be kept as low as readily achievable, economic and social considerations being taken into account, we recommend that the possibility of choosing another site be examined. If an alternative site could be found which is no less satisfactory than the presently proposed site on all other grounds, then that alternative should be preferred on radiation protection grounds.

Because of its location, the proposed site would also be exposed to higher levels of sulphur dioxide pollution from the Ranger sulphuric acid plant than would a site the same distance from Ranger in any other direction. We note that the consultants in their feasibility study considered (p. 12) that sulphur dioxide pollution at the proposed site could be excessive if an acid plant were established adjacent to the Ranger mine, and they recommended that any such plant be located to the north of the Jabiru airstrip. In our view this is a marginal consideration. Our view (Chapter 6) is that sulphur dioxide is not likely to be a problem, even over a substantial period, but that, other things being equal, it would be better for the town to be further away or in a different direction.

The alternative site is far enough away from Ranger to be immune from exposure to worrying levels of airborne contaminants. In all other respects, save the distance to be travelled by mine staff, it appears to be at least the equal to and, in several respects, better than the proposed site. It has the advantages of being farther from the escarpment Aboriginal sites near Mt Brockman and farther from the Woolwonga Reserve. It is not in the prevailing wind path from the Ranger site and drainage from it does not flow to the main sections of Magela Creek. The suitability of both sites should be carefully examined before a decision is finally made.

Town services

Sewage from the proposed regional centre, according to the proposal put forward, will be treated to meet the U.S. Water Quality Criteria 1972 for discharge into freshwater rivers and lakes. It is estimated that during the dry season most of the treated effluent will be evaporated, but during the rainy season it will be discharged into the Magela Creek via Corndorl Creek. The volume discharged would be about 1.3 cubic metres per person per day. It is intended to separately treat and dispose of any toxic wastes that might be produced in the regional centre, so that the main burden entering Magela Creek will be phosphate, nitrate and other mineral nutrients occurring in treated domestic sewage. Since the population of the town wherever it is placed would be relatively small, the treated sewage is unlikely to create a significant environmental problem.

It is intended that water supply for the town should be drawn from wells in a groundwater field immediately west of the South Alligator River and north of the Arnhem Highway. This is about 40 kilometres from the proposed site. A buried pipeline from the wells would follow the Arnhem Highway for most of the distance. Water from this source meets World Health Organisation 'desirable' standards for potable water. The Commission was told that electricity for the town would be obtained from Darwin; the transmission line could also be used to supply electricity to the Ranger operations. Both sites discussed could be supplied with water and electricity from these sources with equal facility.

Policy and regulation

If Ranger and Pancontinental are both allowed to mine, they will be directly concerned with the planning and financing of the town. Ranger proposes to provide finance for the housing of its employees. Both companies have assured us of their desire to co-operate in the protection of the environment, at least in its physical aspects. We believe it should be expected of them that without attempting any unreasonable regulation or interference with the ordinary living arrangements of their employees, they will conscientiously endeavour to ensure compliance with the restrictions and limitations which will be necessary. We do not propose to list these, or to indicate in detail the way in which the purposes which we have mentioned are to be achieved. This is best done by people who are on the spot and who can give the matter close consideration after consultation with all interested groups.

In order to assist with park management and to minimise adverse consequences from the town development we suggest that adults becoming residents of the town be asked, as a condition of residence, to abide by the park plan of management. If this co-operation is sought at the outset, and they are made aware of the plan of management at that time, it is likely that problems will be considerably reduced. The Commission was told that all employees of Ranger now living at Jabiru are required to obey a comprehensive set of rules which are intended to prevent environmental damage. We were also told by the company that efforts are made to make all new employees aware of environmental values. At Jabiru, where the maximum population has been about 100, the company has the ultimate sanction of dismissing an employee who wilfully breaks the rules. It is difficult to see how such a sanction could be effective in the regional centre, since some of the residents would not be working for the mining companies. Many witnesses proposed that the regional centre should be a closed town in order to make it easier for control to be exerted over the residents by the companies concerned.

The possibility of having separate, smaller mining towns and not one regional town was considered by the consultants in their feasibility study, at pp. 105–22, and they concluded that one was preferable. Some of the considerations they took into account are not now appropriate, and, as previously mentioned, they did not give the emphasis we do to the environmental considerations. There are advantages and disadvantages in such a course. Put shortly, there is we think a greater chance of firm control in smaller mining towns, although that measure of control will have to be acceptable from the point of view of the employee-residents. We have not been able to examine appropriate sites adjacent to the proposed mines. A meeting of most but not all members of the Northern Land Council, specially summoned during the recent Darwin hearings, expressed to us, through counsel, the wish that there be only one town in the Region and that it should, if possible, be no bigger than Nhulunbuy. We believe the population of Nhulunbuy in 1976 to have been approximately 3550, nearly all white people.

It seems to us at present that the most satisfactory and generally acceptable course will be to have one town, but the possibility of having two separate mining towns should not be entirely neglected.

On the basis that the proposed site may be found to be the best available, we have recommended that it not become Aboriginal land. The same recommendation would be made regarding any other site. Having in mind the nature of its uses, there will be no real advantage to the Aboriginals in making it Aboriginal land. On the contrary, such a situation would be likely to prove unsatisfactory to both white and black people. The Northern Land Council accepts this situation.

If our recommendations are accepted regarding the creation of Aboriginal land and concerning the boundaries of a national park, there will be present the two relevant guardians of the environment. Policy for the administration of the town should be formulated in consultation with the Northern Land Council and the park authority.

Conclusions One of the consequences of the proposed mining will be the arrival in an undeveloped region, which has high national park values, of a relatively large resident population which will outnumber the Aboriginals at present living there. These new arrivals will have to be accommodated in a town or towns within a reasonable distance of the mine or mines. In the interests of the environment, and in particular of the Aboriginal people, it is important that these numbers be kept to a strict minimum necessary to allow mining to proceed at the approved rate. Tourists should not be accommodated there, at least for the foreseeable future. No decision has been reached about where the town will be, or even that there be only one. The solution most favoured is to have one town, and this seems to us on present information to be the best course. We recommend strongly that the number of people in the town not exceed 3500; but the smaller the better. This is a much larger number than will be necessary to accommodate people associated with the Ranger mine, but it allows for the possibility of the Pancontinental mine getting into production during the life of the Ranger mine. We recommend that there be a periodical review, in the light of experience, of the maximum number which the town should accommodate; this may lead to a lowering, or even a raising, of the figure of 3500.

It seems probable that the site which will be found most satisfactory is that which has already been selected, about 8 kilometres to the west of Jabiru. We have discussed alternatives and recommended that one in particular be investigated before a final decision is made.

It will be necessary for the town to be one of high amenity. It will also be necessary for firm environmental controls to be imposed. We have discussed these, and we recommend that they be made known to all new arrivals at the outset, and their co-operation, and the co-operation of Ranger and others in the Region, be sought to ensure that they are observed. The town will be in the national park and will be planned and managed in accordance with the park plan of management. The Northern Land Council should be consulted in connection with the scheme of controls and with regard to the planning and management of the town generally.

13 IMPACTS ON ABORIGINAL SOCIETY

We have already discussed in general terms, in Chapter 12, the consequences for Aboriginal people of the influx of a large white population to the Region. In this chapter we look at a number of specific aspects of their welfare and well-being which are likely to be affected directly or indirectly by the Ranger development. If mines are developed at Jabiluka and Nabarlek these also will have their impact. In relation to some aspects, such as employment opportunities, the effects of their development may be similar to those of the Ranger proposal; but these are matters which will have to be evaluated when consideration is being given to the question whether mining at those places should proceed. It is at present the intention of Queensland Mines Ltd that people employed in connection with the Nabarlek mine live in Darwin and work in rotation at the mine site, where they will have hut-type accommodation. It would be contrary to the recommendations we make in Chapter 12 for accommodation to be found in the regional centre for persons employed in connection with that mine.

Some witnesses expressed the view that any economic development within the Region, including mining, would benefit all people including Aboriginals. These witnesses predicted that Aboriginal employment would increase considerably if mining were to proceed. They forecast improved educational and health facilities, improved training opportunities, an increase in shopping facilities, the possibility of commercial enterprises for the Aboriginal people, and an improved communication service for people living within the area.

Others claimed that experience elsewhere in Australia indicated that wherever and whenever a mining enterprise had been established in close proximity to an Aboriginal community the latter had suffered from effects of the developments. They argued that regardless of the special efforts that might have been made by some companies and despite any efforts to implement special policies aimed at protecting the interests of Aboriginal people, history had demonstrated a disruption of communities to the detriment of the majority. It was considered that in the case of a community such as Oenpelli which was already experiencing social problems associated with widespread alcohol abuse, the disruption was likely to be more pronounced.

Employment

It was stated on behalf of Ranger that, if mining were to proceed, Aboriginals living in the Region would have a prior claim to employment with the company 'depending on their willingness and ability to acquire the requisite skills and their willingness to adapt to reasonably continuous employment'. The company stated that a wide variety of jobs would become available which Aboriginal people could take up when production began. These included the operation of plant such as bulldozers and front end loaders and the driving of trucks. Ore-processing operations would provide some jobs for people who receive suitable training, such as those of laboratory technician and process worker. With the growth of the town it was predicted that Aboriginals could be encouraged to develop local outlets for traditional craftwork and artefacts. It was also suggested that employment opportunities would arise if Aboriginals were motivated to supply local retailers with garden produce and poultry. There might be other employment from activities in, or associated with, the regional centre.

Ranger did not expect many Aboriginal people to be employed during the construction phase of the mining development because, in their view, there would be few Aboriginals with sufficient skills or trade qualifications to qualify for immediate employment.

We discuss in Chapter 4 the current employment situation. A number of witnesses, including representatives from two government departments, the Church Missionary Society and the Aboriginal communities, said that there was a wide variety of employment currently available to the Aboriginal people within the Region. Aboriginals at Oenpelli and Mudginberri could fill positions as stockmen, meat processors, plant operators, truck and bus drivers, mechanics' assistants, builders' labourers, shop assistants, clerks, gardeners, hygiene workers, teaching assistants and labourers. Only a small minority of employable adults seek regular work. Mr A. F. Wilson, of the Church Missionary Society, said that at Oenpelli 'between eighty and 100 would be employed, but this drops to below thirty in the dry season and most of those would average little more than half time'. It appears that at Mudginberri very few Aboriginals are employed either on the property or at the abattoirs.

Several reasons were given as to why the unemployment rate is high. The preoccupation of Aboriginals with acquiring and consuming alcohol was emphasised by many, but that state of affairs has to be related to their motivation to work. Motivation is a difficult matter to assess and about which to make generalisations. One thing is reasonably clear. Most Aboriginals have an approach to working for a living which differs considerably from that of most white people. We have elsewhere pointed to their very different traditional beliefs and lifestyle. We do not understand it to be the current view in the population at large that they should be expected to abandon, or modify, those beliefs or change their lifestyle. They may well do both, but in their own time and in their own way. So far as concerns employment, it has to be recognised that the performance of traditional ceremonies and the carrying out of customary duties may at times be given precedence. Also some may prefer to adhere closely to the traditional lifestyle, to which regular work as we understand it is quite alien.

It seems to us that these matters have to be taken into account when considering, in relation to Aboriginals, our conception of employment and the necessity or desirability of it. In our society it is generally accepted that those fit to work should do so, and we are geared to a necessity to work, if not for subsistence, at least for reasonable comfort. This is not the traditional Aboriginal way of looking at the matter. It is, of course, a fact that with social service payments, (mainly old age and invalid pensions and family allowances), many Aboriginals find no need at all to work in order to live according to standards they find acceptable. However, it would in our view be incorrect to view the unemployment situation as due simply to those payments.

In connection with the impact of mining on unemployment, the Commission's attention was drawn to the findings stated in the *First Report on the Present Conditions of the Yirrkala People* by the House of Representatives Standing Committee on Aboriginal Affairs (1974). That Committee found 'that although the establishment of the mining operation and the town of Nhulunbuy has introduced the western economic environment to the Gove area it is a mistake to believe that the employment opportunities thereby created are necessarily of value and benefit to the Aboriginal people'.

Other evidence provided information on employment levels of Aboriginals at the mining ventures on Groote Eylandt and Gove. At the time evidence was given in 1976, some forty-two Aboriginals were employed at Gemco, while none were employed directly by Nabalco. However there were twenty-six Aboriginals employed on work related to Nabalco activities.

One view submitted was that Ranger should be required to employ a certain number of Aboriginals. The Commission does not consider this a sound policy at this stage. There is too much difficulty at present in fixing numbers, or types of employment, and other special conditions, and too much uncertainty as to the extent to which a particular quota would be filled. Unfilled quotas would be likely to lead to a number of difficulties. Ranger does accept an obligation in relation to Aboriginal employment, and is prepared to take special measures with regard thereto, even at some cost to itself. We commend this approach, and the fullest advantage should be taken of it, but we do not believe that at this time it can be formalised.

It is clear that a wide variety of job opportunities are currently available to Aboriginal people living within the Region, and that only a small minority of potential workers actively seek to fill the available positions on a regular basis. It is therefore necessary to take a very conservative view of the numbers who will be employed in the proposed mining venture, or because of it. The Commission is not confident that the job opportunities which could be created if mining proceeds will attract more than a very few Aboriginal people during the early years of development. In the long term, much will depend upon the extent to which the Aboriginals themselves become motivated to participate in the mining program or in ancillary services. Certainly everything should be done to encourage those who show an interest in working. Provisions for employing them will probably have to include an option for a less than full-time working week. If their participation in the workforce is to be encouraged, it may be necessary, initially at least, to seek them out as employees, and not simply to leave the positions vacant. Ranger is prepared to co-operate fully in suitable training and employment programs, but these will have to be worked out carefully with the Aboriginals themselves, or their representatives.

It may be that there is scope for developing an Aboriginal contracting service, in relation to mining or the provision of town services. Such a scheme operates at Nhulunbuy. There will undoubtedly be some opportunity for the development of individual handicraft and artefact outlets in the town. Given experiences elsewhere is seems unlikely that the Aboriginals will become engaged in the sale of market garden produce to the town, except possibly in a very casual way. The total increase in the numbers of Aboriginals employed in gainful occupations of the nature so far discussed is not likely to be great.

Another possible opportunity for Aboriginal employment will arise from the establishment of a national park (see Chapter 10). We take the view that Aboriginals should, if they are willing, be employed freely as rangers in the park. This sort of work has an appeal to them, and it would seem a sound national investment to provide more such positions for them than might otherwise be thought necessary.

A final comment should be made. It is simply that we believe that, because of a number of special factors, and with energetic action, the morale of the Aboriginal people in the area can be lifted. It is at present at a low ebb. We discuss the matter later, under the heading of *Alcohol*. It is at least possible that, with revived self-respect, many more may seek employment than the conservative, though realistic, forecast we have given.

Education

It is likely that there will be a school, and possibly other educational facilities as well, in the proposed regional centre, and it was suggested that Aboriginal people could benefit from them. Ranger suggested that, if the scale of mining were increased sufficiently, the numbers might warrant the provision of at least the first two years of secondary schooling. We received no evidence on this matter from the education authorities in the Northern Territory.

As stated in Chapter 4, most Aboriginal children living in the Region are enrolled at the Oenpelli Primary School. The school at Mudginberri contains a small number of Aboriginal children, and very few, if any, are currently enrolled in the primary school at Jabiru. Of the 200 to 240 children enrolled at Oenpelli during 1975, only about 25 per cent attended school regularly. The reasons for this low attendance rate have been discussed in Chapter 4. It seems unlikely to the Commission that the establishment of a primary school in the town will draw many Aboriginal students.

Evidence was given that the education of Aboriginal children, especially those who belong to a tribalised group, is a specialist field involving programs which include bilingual education. The Commission was told that Aboriginals were no longer content to send their children to European schools in which only western values and culture are taught. The Chairman of the Northern Land Council, Mr Silas Roberts, stated: '. . . you must realise that our children are also learning our ways so they have to go to two schools. We think the white man's school should fit in better with our school'. There is now an expectation on the part of Aboriginal parents that their children should receive instruction in traditional culture, history and language, to reinforce values and beliefs held by the community in which the children live.

The Commission did not hear evidence about any likely advantages that a secondary school, such as that contemplated in the Ranger evidence, would provide for the Aboriginal community. The only secondary schools for children of the Region at present available are in Darwin, and it may well be that it would be an advantage to some children if they were given the opportunity to attend the first two years of secondary school closer to home. The evidence suggests, however, that parents of Aboriginal children would prefer to have such facilities established within their own communities so that their children do not have to leave home to further their education.

Vocational training was mentioned a number of times during the course of the evidence, but if something is to be done in this connection there will have to be a plan, with responsibility for its implementation clearly established. At present there is virtually no vocational training available to Aboriginal persons living within the Region. Dr Eedle, Director of the Department of Education in the Northern Territory, acknowledged that 'the number of training opportunities that are available to Aboriginal youngsters leaving school now are very, very limited . . . We have between 300 and 400 young Aboriginal people leaving our primary schools at the end of each year and there is to all intents and purposes no training available for them.'

It was the view of the Department of Education that, if mining were to proceed, the company or companies involved should assume a major responsibility for providing vocational training. The Director stated that mining companies should use 'the services and facilities of Government to the maximum extent practicable under the applicable policies and regulations for the training of Aborigines'. It seems to us doubtful whether at present the 'services and facilities of Government' are adequately developed for the particular situation.

Race relations With the influx of a large population of non-Aboriginal people into an area which is predominantly occupied by Aboriginals, tensions and conflicts will arise.

The difficulties may be greatest during the construction phase because it will be a time of initial contact and because those employed during this time will be a transient group who will, perhaps, have less social responsibility than those who come to live permanently in the Region.

It is probable that some Aboriginals will become resentful when they see the quick and efficient construction of a town with modern facilities, predominantly for the use of non-Aboriginals, near Aboriginal communities whose living standards and facilities are of a very much lower standard. The resentment may flow from, or be associated with, feelings of inferiority, or it may simply be that the Aboriginals in question will feel that they are being treated as inferior. Whatever the reason, and whatever white people may think of its logical basis, the evidence leads us to believe that this is likely to be the feeling of some of the Aboriginals of the Region.

The Department of Aboriginal Affairs suggested that consideration should be given to the employment of a suitably qualified liaison officer, who would undertake the task of informing non-Aboriginal people coming to the Region about Aboriginal customs and traditions through discussion, displays and visits. It was suggested that such a person would need to have a deep understanding of the local Aboriginal groups and would need to be known to them, and to have their confidence. This suggestion seems to us to have merit. Mutual understanding, particularly in the development stages, will be all important.

Health A representative of the Northern Territory Department of Health told the Commission that, if mining were to proceed, the Department would establish a health facility at the regional centre. The facility would take the form of a health centre geared to meet health requirements of the Region's population. Its services would cater for the rural population (which will be mostly Aboriginal) as well as the mining population. Special Aboriginal health programs along lines developed elsewhere in the Northern Territory would be made available. It was suggested in evidence that the establishment of such a centre within the Region would upgrade and render more accessible health services to all persons including the Aboriginal population. The Commission regards it as essential that Aboriginal health workers be trained to work among their own communities.

Some witnesses voiced fears that, with an increase in population, there existed the potential for an increased incidence of venereal disease amongst Aboriginals within the Region. Precedents for such an increase are well known to health authorities who attempt to minimise harmful effects by educational, preventive and therapeutic programs. It was pointed out also that malaria could be introduced into the Region. This risk necessitates setting up a program similar to that operating at Gove which involves searching for malarial parasites in people who come from malarious areas and maintaining mosquito control measures.

The Commission was told that, with increased contact between Aboriginals and non-Aboriginals, there was a likelihood that Aboriginals would be subject to increasing social pressures arising out of accelerated social change, which in turn would contribute to an increase in alcoholism and mental illness amongst the Aboriginal community.

Alcohol There is a serious risk that the influx of a European population into the Region will aggravate the sociological and psychological pressures which are regarded as causes of the excessive drinking of alcohol by the Aboriginal people. The evidence suggests that alcohol abuse is largely a symptom of stress and not the reflection of some inherent biological weakness which renders the Aboriginal people incapable of 'holding their liquor' (cf. House of Representatives Report, para. 27). Witnesses suggested that Aboriginals are led to consume excessive amounts of alcohol for a variety of reasons, including the desire to achieve equality with the white man, to avoid traditional responsibilities and inhibitions, to gain relief from the social pressures of cross-cultural contact, and to forget a low social and economic status. The Commission is in no position to draw conclusions on the relative contribution of these factors to the origins of alcohol abuse. We do note however that the Board of Inquiry into Liquor Laws of the Northern Territory 1973 (Adams Report) was given evidence very much to the same effect and concluded, in part, that alcohol abuse amongst Aboriginals was due to 'their being caught up in rapid social change and subsequent social disorganisation' (cf. House of Representatives Committee Report, paras 21–23).

In 1975 the Laverton Joint Study Group was set up by the Western Australian Government to investigate matters relating to the Aboriginals and non-Aboriginals living in the newly formed mining town of Laverton, Western Australia. In discussing the problems of alcohol abuse, the Joint Study Group wrote: 'The disintegration of tribal rules particularly amongst fringe dwellers and transient Aborigines, and their inability to pass into the European society, save only as unwanted intruders, produces an immense strain which affects all but the most resourceful and resilient. Frequent and extended escape from reality becomes to them not so much a desirable condition but a necessary state.' They concluded that alcohol was often used to achieve this 'necessary state'.

The proponents of mining pointed out that Aboriginal communities who had no association with mining enterprises were confronted with similar problems with alcohol. Further, they suggested that the problem of alcohol abuse within the Region was so bad that it could not in fact become any worse than it was at present. Consequently any increase in the supply of alcohol or an increase in the number of outlets at which alcohol could be purchased would have no real effect on the situation.

The Commission does not accept the view that the situation could not degenerate beyond the point already reached. The relevant question is how improvement can be achieved. As was pointed out, there are a number of Aboriginals currently attempting to establish outstations. Part of the motivation to do so is to escape problems associated with alcohol abuse. There are a significant number of Aboriginal people who strongly wish to have the situation improve. So long as that desire persists, the Commission believes it is imperative that every opportunity be taken to assist the people to overcome continuing disruption and decline. We believe improvement is possible, but only if appropriate conditions are created and persons residing in and visiting the

Region recognise the seriousness of the problem and are prepared to co-operate to improve it. To some extent this means regulations and restraints, to some of which they may not be accustomed.

It is also essential that positive measures be taken to restore the confidence and morale of Aboriginals living within the Region. This will only be done on the basis of an adequate understanding by all concerned of their hopes, fears, values and beliefs.

The Commission is of the view that there exists a unique opportunity to establish a program designed to reduce dependence on alcohol among the Aboriginal people in the Region. For the first time, if our recommendations are accepted, there will be an acknowledgment of Aboriginal title to land. This in itself should be a considerable boost to the morale of the Aboriginals directly concerned, as well as to others. There is also the prospect of a national park, which is a form of development reasonably consonant with their lifestyle and one which will provide suitable job opportunities. The national park will also provide a degree of protection from tourist intrusion, and will generally operate as a buffer between the Aboriginals, some of whom will live within it, and other people. If mining proceeds, the mining industry will also provide some job opportunities; more notably it will also in due course be the source of substantial sums of money, and Aboriginals will have a large degree of control over its application. The abattoirs at Mudginberri, where Aboriginals are employed, should be able to continue for some years at least, if our recommendations are followed. There will also be scope for their employment in connection with the intensive program for the eradication of buffalo on Mudginberri and Munmarlary which we recommend. Some degree of management participation by Aboriginals in relation to these activities might well be possible, at least after a few years. There is therefore scope for the improvement of Aboriginal morale in a number of ways. An opportunity presents itself which in our view should not be lost, but thoughtful and energetic planning and careful co-ordination will be necessary. We recognise that the program will directly affect only a small proportion of the Aboriginals in the Northern Territory, but this should not be an objection or a ground for diminished enthusiasm. It may well be that the program, if successful, can be adopted for other communities.

We believe that much might be gained by considering the Aboriginals in the Region as individuals (as well as members of families and clans) and not simply as a community. We suggest that an active program be established to ascertain the health, education, employment and accommodation needs of every individual, and to keep that information up to date. It may be possible for much of this work to be done by Aboriginal people, but in any event it should only be done if they agree, and their co-operation will be indispensable. The information should be of considerable assistance in enabling more satisfactory and more selective programs for their betterment to be developed.

There may be some Aboriginals who do not wish to work at all. If the circumstances are appropriate, it is probable that some of those who do not go to outstations, and perhaps some who do, will be prepared to work in suitable employment, and in that regard they may wish to indicate preferences. They may be prepared to furnish information relevant to their experience in, and aptitude for, particular jobs. In relation to accommodation, some will wish to go to outstations; others may wish to remain at Oenpelli (or Mudginberri), or to go to some other centre.

We have mentioned morale factors, including employment. Controls will also be necessary. What is necessary in this regard should be worked out with the Aboriginal people, through the Northern Land Council and, so far as appropriate, the Oenpelli Council. The Oenpelli people (including those who live in outstations based on Oenpelli) in fact constitute the great majority of the Aboriginal people we have in mind. As a guide, or a starting point, we set out hereunder an outline of a scheme which may prove both acceptable and satisfactory:

- Liquor to be on sale at Oenpelli, but only through a licensed club or clubs. Sales to be rationed on a suitable basis.
- The bringing of liquor on to Aboriginal land in bulk quantities (e.g. a dozen or more cans of beer) and the sale or supply in bulk quantities of liquor intended to be sent or brought on to Aboriginal land to be forbidden (except when being supplied to licensed premises). This prohibition should, for sake of completeness, also include Cooinda and the regional centre, and may be extended so as to relate to the whole national park.
- Bulk sales to be prohibited at Cooinda and in the regional centre.
- At the Border Store and Cooinda, and at any other licensed premises established on Aboriginal land (e.g. at Jabiru), no more than a very limited amount of liquor to be sold unopened. Facilities at these places to be such that consumption on the premises is encouraged.
- Liquor to be on sale in the regional centre, but principally in licensed clubs. Sales at clubs to be rationed on a suitable basis. At other licensed premises, sales to be governed by the same considerations as apply to the Border Store and Cooinda. An ordinary publican's licence should not be granted.
- A number of Aboriginal special constables to be appointed, whose primary duty will be to control excessive consumption of alcohol on Aboriginal land. They will have a duty to enforce the licensing laws and for this purpose will probably have to be given wide powers of inspection and, as incidental thereto, power to stop people and vehicles and to enter premises. Consideration should also be given to their having such additional power to deal with Aboriginals who are under the influence of liquor as is recommended by responsible Aboriginal bodies.
- A special magistrate should be appointed from Aboriginals who reside in the Region to deal according to law with people who commit breaches of the licensing laws on Aboriginal land, or who are found on Aboriginal land under the influence of liquor. He may be given special power to deal with Aboriginal offenders in some fashion not recognised under the general law, but recognised as appropriate by responsible Aboriginal bodies.
- Rangers in the national park should also be given authority to police the licensing laws within the park.

Conclusions

The arrival of large numbers of white people in the Region will potentially be very damaging to the welfare and interests of the Aboriginal people there. All the expert evidence on this matter was to the effect that, despite sometimes sincere and dedicated effort on the part of all concerned to avoid such results, the rapid development of a European community within, or adjacent to, an Aboriginal traditional society has in the past always caused the breakdown of the traditional culture and the generation of intense social and psychological stresses within the Aboriginals. There is no evidence which convincingly demonstrates that the result in the Region will be different, although the recognition of Aboriginal land rights is a uniquely favourable factor in this regard.

The outcome in the Region will depend very much on a number of factors, which we have discussed. Important among those will be the need to take firm measures to ensure that Aboriginal people can remain sufficiently isolated and sufficiently able to live according to their own lifestyle on their own land, without intrusion or interference from others. It will be important for white people coming to the Region to be well informed from the outset about possible problems and about ways to avoid them. Ranger, and other employers, can assist in this regard. A system of environmental controls will have to be instituted; we see this as taking place largely through the plan of management of the national park. There will be a particular need to regulate the sale of alcohol.

It is not likely that the mining venture will add appreciably to the number of Aboriginals employed. Nevertheless, all reasonable steps should be taken which will encourage those Aboriginals to work who are inclined to do so, and which will provide them with the necessary training and opportunities. The creation of a national park should offer further job opportunities. Health facilities are appreciated and welcomed by Aboriginals, and have the potential to be of considerable assistance to them. The arrival of a large white population is likely to increase a number of health hazards, with which health authorities will have to be prepared to deal. A primary school in the regional centre is, by reason of its location, unlikely to be much used by Aboriginal children, although some might do so. A secondary school might also find a few pupils among the Aboriginals. Consideration should be given to the suggestions which have been made concerning more suitable school curricula for Aboriginal children.

Finally, we have proposed a positive scheme for the welfare of the Aboriginal people in the Region which takes account of the consequences of mining, but which, on a modified scale, can operate whether or not mining proceeds. It invites the co-operation of all people in the Region. We believe it has some prospect of improving the situation of the Aboriginal people, particularly in relation to alcohol. Largely as a result, it offers a chance of ensuring a satisfactory relationship between white and black people, and of improving the general happiness and prosperity of all people in the Region.

14 THE EFFECT OF THE ABORIGINAL LAND RIGHTS (NORTHERN TERRITORY) ACT 1976

Reference has already been made in Chapter 1 to this Act and to its importance for the present Inquiry. It was passed after hearings of the Commission had been concluded and the First Report had been presented, and while this Report was in course of preparation. Because of the effects of the legislation, and having in mind the role given to this Commission under s. 11 (2) of the Act, it was necessary for the Commission to have further hearings, which have been referred to in Chapter 1.

From the outset of the Inquiry, the Commission has wanted to ascertain not only the impact of the proposals on the Aboriginal people in the area affected, but also the wishes of those Aboriginals who have a traditional association with the land on which it is proposed the mining take place and with the land on which the miners and their families would be living. Obtaining evidence from the Aboriginal people and an expression of their wishes at first presented difficulties of a nature which would be well known to those aware of the customs and practices of Aboriginal people; these are discussed in Chapter 4. In due course it became apparent to the Commission that there were a number of Aboriginals who were the tribal owners of the land upon which the mining was to take place and upon which the regional centre as then proposed would be built. At a late stage of the main hearings, with the very considerable assistance provided by the Northern Land Council, it was established to the satisfaction of the Commission that the Aboriginal people concerned were opposed to mining on their land. At that time there was no legislation giving Aboriginals rights in respect of any of the land in question. Before the passage of the recent Act, the body called the Northern Land Council had been incorporated (under Northern Territory legislation) with the name The Northern Aboriginal Land Committee Incorporated, following recommendations made by Mr Justice Woodward in the Aboriginal Land Rights Commission First and Second Reports (1973, 1974). Its attitude at that time flowed from the views of the traditional owners and was therefore also to the effect that mining should not take place on the Ranger site.

The area proposed to be mined is part of some 83 square kilometres, formerly the subject of an exploration licence (E.L. 219) granted under the *Mining Ordinance* 1939–1976 of the Northern Territory. An application for a special mineral lease (S.M.L. 63) in respect of an area of 2869 hectares, which includes the area to be mined, was lodged on 19 July 1974 but no lease has been granted. The question whether it will still be possible in certain events to grant a lease in accordance with that application is discussed later.

The Memorandum of Understanding entered into on 28 October 1975 between the co-venturers (the Commonwealth of Australia, Peko Mines Ltd and Electrolytic Zinc Co. of Australasia Ltd) provides that the Commonwealth will grant any necessary and appropriate authorities (which includes authorities to mine) under the *Atomic Energy Act* 1953 (see s. 41). No such authorities have yet been granted. Although invited by the Commission to do so on more than one occasion, the Commonwealth would not say whether it would definitely issue an authority under the Atomic Energy Act, or would adopt the alternative course of granting a lease under the *Northern Territory Mining Ordinance* 1939–1975.

Section 4 (1) of the *Aboriginal Land Rights (Northern Territory) Act* 1976 provides that the Minister (i.e. the Minister for Aboriginal Affairs) may establish Aboriginal Land Trusts 'to hold title to land in the Northern Territory for the benefit of groups of Aboriginals entitled by Aboriginal tradition to the use or occupation of the land concerned . . .' Certain areas of land which are to become subject to Land Trusts, such as existing Aboriginal Reserves, are described in Schedule 1 to the Act. For other land to become subject to Land Trusts it is necessary in the ordinary course for a claim to be made by or on behalf of the 'traditional Aboriginal owners', a term which is defined (s. 3 (1)). Those claims are normally to be dealt with by an Aboriginal Land Commissioner, who is appointed under the Act, and who must be a judge of the Supreme Court of the Northern Territory. If he finds that the claimants, or others, are the traditional Aboriginal owners, he reports his findings to the Minister and he may make a recommendation that a Land Trust be established (s. 50 (1)). The decision is one for the Minister (s. 11 (1)). As s. 4 (1) and s. 11 (1) show, a Land Trust is not in favour of particular individuals, but a group or groups of Aboriginals. Although it is necessary for there to be a claim by traditional owners, and for the Land Commissioner to find that there are such owners, the group in whose favour a Land Trust is established comprises 'Aboriginals entitled by Aboriginal tradition to the use or occupation of the land concerned'—usually a wider group than is made up by the traditional owners.

Section 11 (2) recognises the importance of the Act's operation to the recommendations of this Commission and also the fact that much, if not virtually all, that a Land Commission would have to inquire into falls naturally within the scope of our Inquiry. The sub-section provides, in substance, that if we make a finding that a group or groups of Aboriginals are entitled by Aboriginal tradition to the use or occupation of an area of land, the finding has the same effect as a recommendation by the Aboriginal Land Commissioner that a Land Trust be created and that the area be granted to the Trust for the benefit of that group or those groups of Aboriginals. Land subject to an Aboriginal Land Trust is referred to in the Act as 'Aboriginal land' (s. 3 (1)).

The members of an Aboriginal Land Trust must be Aboriginals who live in the area of the Land Council in which the land is or who are traditional owners of land in the area of the Land Council (s. 7 (6)). The functions of a Land Trust are to hold land, and to exercise its powers as owners of the land for the benefit of the Aboriginal groups concerned, but only in accordance with directions given by the Land Council (ss. 5, 19 and 20).

There are five main categories of land in the Region which are relevant when considering the impact of the Act.

1. *The Ranger Project Area*

This is referred to in s. 40 (6) and, although not surveyed, is described in Schedule 2 of the Act. It is the area of 83 square kilometres already referred to. It extends well to the north of Jabiru and takes in part of the area of the Mudginberri pastoral lease and a very small section of the area proposed in 1975 for the Kakadu National Park. The Ranger Project Area is identical with the area described in the Memorandum of Understanding which provides for the development of the ore bodies in this land, commencing with Ranger No. 1 ore body.

The Project Area includes land in the south-eastern corner which Ranger does not seek to have included in its mining lease, and its southern boundary goes very close to Aboriginal sacred sites. In this respect the Project Area as delineated in the Schedule to the Act goes too far, and in the interests of relations with the Aboriginal people it would be advisable for the Act to be amended appropriately.

Section 12 (2) of the *Aboriginal Land Rights (Northern Territory) Act* 1976 provides that a grant of land to a Land Trust is to contain a reservation of all minerals to the Crown. Independently of s. 12 (2), all uranium in the Northern Territory is vested in the Crown by virtue of s. 35 of the Atomic Energy Act. In the ordinary course, therefore, rights to mine (and rights appurtenant thereto, such as to erect buildings), can be granted over land although it has been alienated by the Crown, and even if it is in private ownership. The operation of the mining legislation is discussed later.

Section 40 (1) of the Land Rights Act requires in effect that, in respect of Aboriginal land, a 'mining interest' shall not be granted unless either both the Minister for Aboriginal Affairs and the Northern Land Council consent or the Governor-General declares that the national interest requires that the interest be granted. A 'mining interest' is widely defined to mean any lease or other interest in land (including an exploration licence) granted under a law of the Northern Territory relating to mining for minerals (s. 3 (1)). However, s.40 (6) provides that, if the Ranger Project Area or part thereof becomes Aboriginal land (and it may do so before the grant of the mining interest), s. 40 (1) does not apply to that land, or that part of the land. If it does not become Aboriginal land, the Act does not have any application. A 'mining interest' does not include a right or interest granted under the Atomic Energy Act. Section 41 deals with authorities under that Act. The prohibition in s. 41 (1) is similar to that in s. 40 (1). However, s. 41 (2) is similar in effect to s. 40 (6), so that the consent of the Land Council to the grant of authority to mine under the Atomic Energy Act will not be necessary in respect of the Ranger Project Area, even if it becomes Aboriginal land. It is important to note that the grant of a mining lease, and the grant of an authority under the Atomic Energy Act to mine crown land, do not involve the consequence that the land subject thereto becomes 'alienated' for the purposes of the Act. It remains unalienated crown land (s. 3 (1) and (2)) and an Aboriginal Land Trust can therefore be created over it after the mining lease or authority is granted.

Whether it would be possible for Ranger to establish a substantial mining town on the Ranger Project Area without Aboriginal consent would depend upon an examination of what is proposed in the light of the particular legislation (i.e. *Mining Ordinance* 1939–1976 (N.T.) or *Atomic Energy Act* 1953) and the relevant provisions of the Land Rights Act.

It is important to know whether the land in question is likely to become 'Aboriginal land' in the way mentioned. Although, by reason of s. 40 (6), it is possible for a mining interest to be granted without the consent of the Land Council and without a declaration that the national interest so requires, s. 43 (2) requires that the mining interest shall not be granted unless 'the applicant for the mining interest has entered into an agreement under seal with the Land Council containing such terms and conditions as are agreed on by the parties having regard to the effect of the grant of the mining interest on Aboriginals, which terms may include a requirement for the payment to the Land Council by the applicant of an amount or amounts specified in, or calculated in accordance with, the agreement'. The description in s. 43 (2) of the terms and conditions which are to be agreed upon is very wide. The terms of the agreement are distinct from those in the grant of the mining interest (which commonly will be a mineral lease or a special mineral lease); each will have its own terms, but they will have to be consistent (see s. 43 (3)).

Failing agreement, the Minister is to consult with the Land Council and the applicants for the grant, after which he may appoint an arbitrator who is to determine the terms and conditions that 'should be acceptable to the Land Council and to the applicants . . .' and those terms and conditions will then have effect as if agreed upon (s. 46).

What we have just said relates to the grant of a 'mining interest', but, as we have noted, that term, as defined, does not include an authority under the Atomic Energy Act. In relation to the matter now under discussion, namely the need for agreement on terms and conditions, or, failing agreement, arbitration, s. 44 (2) and s. 46 operate in relation to authorities under the Atomic Energy Act in a way similar to that in which s. 43 (2) and s. 46 operate in relation to 'mining interests'. Sub-section 44 (2) provides in effect that there is to be no entry on the land under the Atomic Energy Act unless there has been an agreement between the Commonwealth and the Land Council as to moneys to be paid, and as to 'other terms and conditions', these latter not being defined or described as in s. 43 (2) or in any other way. Agreements, whether under s. 43 (2) or s. 44 (2), may provide for the distribution of moneys received, to or for the benefit of specified groups of Aboriginals (s. 43 (4) and s. 44 (3)).

Having in mind these matters, it seems to the Commission to be important for it to make findings under s. 11 (2) so that the Minister can act on them, in his discretion, and at the same time for it to make recommendations as to the course to be followed by the Minister.

Although the Act says nothing of the need for a finding under s. 11 (2) to be based in turn on a finding that there are traditional Aboriginal owners of the land in question, this is the requirement when a Land Commissioner makes a finding under s. 50 (1) (a), and it is in our view desirable, if not necessary, that we follow the same course. Whether there are traditional Aboriginal owners is important to the scheme of the Act in a number of other respects. For example, a Land Council cannot give a direction for a dealing by a Land Trust with land vested in it unless the traditional owners, if any, understand the nature and purpose of the dealing and, as a group, consent to it (s. 19 (5)). Under s. 24 a Land Council is to keep a register of the persons who, in its opinion, are the traditional Aboriginal owners of land in its area; obviously this is an ongoing process.

2. *The area in which persons associated with the operaton of the mine and their families are to live, sometimes called the town site or regional centre*

It is conceivable that mine employees and their families could be permanently accommodated close to the mine or mines, on the land the subject of the mining grant or authority. In that event, consent from Aboriginals to their occupation is probably not necessary. Some employees will probably be accommodated close to the mine for some time; for example, during part or all of the construction phase. The plans are for more permanent housing to be outside the area of a mining grant or authority.

If the site chosen is one which Aboriginals have a traditional entitlement to use or occupy and it has become subject to a Land Trust, no estate or interest in that land can be disposed of except in accordance with s. 19. The relevant provisions are sub-sections (3) and (4):

> (3) At the direction, in writing, of the relevant Land Council, a Land Trust may, subject to sub-section (7), grant a lease or licence in respect of land vested

in it to the Commonwealth or an Authority for any public purpose or to a mission for any mission purpose.

(4) With the consent, in writing, of the Minister and at the direction, in writing, of the relevant Land Council, a Land Trust may—

(a) grant a lease or licence in respect of the whole, or any part of, the land vested in it to any person for any purpose; and

(b) transfer to another Land Trust, or surrender to the Crown, the whole of its estate or interest in the whole, or any part of, the land vested in it.

Subsection (5) provides that a Land Council shall not give a direction under s. 19 for the grant, transfer or surrender of an estate or interest in land unless certain conditions are satisfied, namely:

(a) the traditional Aboriginal owners (if any) of that land understand the nature and purpose of the proposed grant, transfer or surrender and, as a group, consent to it;

(b) any Aboriginal community or group that may be affected by the proposed grant, transfer or surrender has been consulted and has had adequate opportunity to express its view to the Land Council; and

(c) in the case of a proposed grant of a lease or licence—the terms and conditions of that lease or licence are reasonable.

The effect of these provisions is, in short, that if pursuant to a recommendation of the Aboriginal Land Commissioner or a finding of this Commission the Minister establishes a Land Trust in respect of land sought to be used as a town, the land, at least if outside the Ranger Project Area, cannot be used as a town unless the traditional Aboriginal owners consent and the Land Council gives an appropriate direction. As it is unlikely that the mining operations can be carried on without the establishment of a town, it becomes necessary for the Commission to consider where it is best for the town to be situated and then to make appropriate findings with regard to (a) traditional Aboriginal ownership of that land, and (b) traditional Aboriginal entitlement to its use or occupation and then (c) a recommendation as to whether the Minister should establish a Land Trust under s. 11 (1).

3. *The national park*

Notice of intention on the part of the Director of National Parks and Wildlife to submit a report recommending the declaration by the Governor-General of a national park (to be named Kakadu) under s. 7 (2) of the *National Parks and Wildlife Conservation Act* 1975 appeared in the *Government Gazette* on 13 May 1975. The Commission heard a strong body of evidence to the effect that boundaries containing a wider area would be preferable. Where the national park is to be located is of importance in a number of respects. It is of fundamental importance to the land use considerations which are discussed earlier in this Report. More specifically, the impact of the mining operations must be assessed by reference to the nature and use of adjoining land. The impact upon the Aboriginal people of the mining operations, of visitors to the area and of persons living or staying in the town, depends upon the juxtaposition of the mine, town, areas of Aboriginal occupation and ownership, and the national park.

The considerations affecting the establishment and functions of a national park and where it should be located are discussed elsewhere. The Gazette notification already referred to does not create any interest in the land and the land is not being 'occupied or used by the Crown' within the meaning of s. 14 of the Land Rights Act. Nearly all of the area the subject of the 1975 gazette notice has been proclaimed as a wildlife sanctuary under the *Wildlife Conservation and Control Ordinance* 1962, but that fact does not affect the operation of the Aboriginal Land Rights (Northern Territory) Act. It is unalienated crown land except for about 7600 hectares which is at present the subject of the Mudginberri pastoral lease. It is on part of this last-mentioned area that it is proposed to establish the Jabiluka mine.

The land rights claim made to the Commission by the Northern Land Council on behalf of Aboriginal persons includes all of the proposed park, except for the part thereof subject to the pastoral lease. The Commission has been asked by the Northern Land Council to recommend that Mudginberri and Munmarlary be resumed and become Aboriginal land. If these leases, or part of them, were surrendered or resumed, the land would, subject to any further disposition by the Crown, become 'unalienated crown land' and the proper subject of land rights claims, which could be heard by the Aboriginal Land Commissioner. Although the Act does not in terms limit our consideration of land rights claims to unalienated crown land, it is in our view inappropriate for us to make any formal finding under the Act about Aboriginal entitlement to the use or occupation of land the subject of the pastoral leases mentioned.

Nevertheless, because the clan areas which define Aboriginal entitlement are irregularly shaped and generally not coincident with any boundaries used by the white man except when the sea or a river form the boundary, and for other reasons associated with the evidence, it is inevitable that we should form a view as to whether, if made at the appropriate time, Aboriginal claims in respect of the pastoral leases would be likely to succeed. We therefore express views on these matters, and, under our general remit, make appropriate recommendations.

There are no special statutory considerations affecting the unalienated portion of the proposed national park. We therefore consider that part of the claim with the rest, and, so far as it is relevant to do so for the purposes of our main Inquiry, make findings with regard to it under s. 11 (2) of the Act.

4. *Other areas sought to be mined for uranium*

Although not directly the subject of the present Inquiry, the proposals to establish mines at Jabiluka and Koongarra are relevant. Section 40 (3), with similar effect to s. 40 (6), negates the prohibition of the grant of a mining interest in s. 40 (1), in a case where 'the holder of an exploration licence in respect of land applied, before 4 June 1976, for another mining interest in respect of that land . . .' The operation of the Act is then similar in effect to that mentioned in relation to the Ranger Project Area. However, Jabiluka is on Mudginberri and therefore cannot be the subject of a land claim or a finding under s. 11 (2) while the lease of Mudginberri subsists.

5. *Mudginberri and Munmarlary*

The Mudginberri pastoral lease comprises about 111 000 hectares and immediately adjoins the Munmarlary pastoral lease, which comprises about 101 000 hectares. The impact upon them of the land rights legislation has been sufficiently discussed under (2) and (3) above.

Royalties and other payments

A matter of importance arising under the *Aboriginal Land Rights (Northern Territory) Act* 1976 concerns monetary payments to or for the benefit of Aboriginals. We have already mentioned that the agreements required by ss. 43 and 44 may stipulate for the payment 'of an amount or amounts specified in, or calculated in accordance with,' the agreements. The nature of the payments or how they are to be calculated is nowhere dealt with. Presumably in an ordinary case they are intended to comprise, or encompass, compensation for disturbance of the land. Section 35(3) provides that they are to be applied by the Land Council in accordance with the agreement, or, if the agreement makes no relevant provision, are to be paid to Aboriginal Councils in the area, or Incorporated Aboriginal Communities or Groups (see the *Aboriginal Councils and Associations Act* 1976) the members of which are affected by the agreement, in such proportions as the Land Council determines. The moneys are not paid directly to individual Aboriginals.

The Crown may receive rent (or other prescribed payments) in respect of an interest, including a mining interest, granted by it in Aboriginal land (s. 16). Amounts equal to those receipts are to be paid by the Crown to the relevant Land Council (ss. 16, 17), and the Land Council is in turn required to pay an equivalent amount to or for the benefit of the traditional Aboriginal owners of the land (s. 35(4)).

The amount of royalties is currently fixed by the Northern Territory Mining Ordinance at a figure which, in respect of land not in Aboriginal reserves, is 1¼ per cent of an amount calculated in accordance with a formula which for present purposes can be described with sufficient accuracy as the gross proceeds of sale of the uranium less cost of transport to the place of delivery to the buyer. The rate in respect of land in Aboriginal Reserves is 2½ per cent, and it may be expected that the Mining Ordinance will be amended to make that the rate for minerals won on Aboriginal land. Royalties are normally payable to the Crown in respect of mining interests granted by it. They are not payable in respect of authorities under the Atomic Energy Act, because mining under those authorities must be on behalf of the Commonwealth (Atomic Energy Act, s. 41(1)). The Memorandum of Understanding, already referred to, in fact provides that no payments in the nature of royalties are to be made by the co-venturers (cl. 2(h)).

Section 63(2) of the Land Rights Act provides, subject to a qualification dealing with increases in the rate of royalty, that amounts equivalent to the royalties received by the Crown in respect of a mining interest in Aboriginal land are to be paid into the Aboriginals Benefit Trust Account. Section 63(4) provides that where mining operations are carried on under the Atomic Energy Act, amounts equivalent to the royalties which would have been received under a lease (subject to a qualification about increases) are to be paid by the Crown to the Trust Account. Section 64 deals with the disposition of moneys in the Trust Account. Sub-section (1) provides that from time to time 40 per cent of the moneys paid into the Trust Account under s. 63(2) or (4) are to be paid out for distribution among Land Councils in such proportions as the Minister determines, having regard to the numbers of Aboriginals in each Council area. If, as is presently the case, there are only two Land Councils, each is to receive 50 per cent of the distributed moneys (i.e. 20 per cent of the moneys paid into the Trust Account). After meeting administrative expenses, these moneys are to be distributed in the same way as mentioned before in connection with moneys received under agreements (s. 35(1)), that is to say, to Aboriginal Councils and Incorporated Aboriginal Communities. Additionally, 30 per cent of the moneys paid in is to be paid to each Land Council in the area of which the mining interest is or the mining operations are (s. 64(3)). Those moneys are to be paid by the Land Council to Aboriginal Councils or Incorporated Communities whose areas are affected by the operations, in such proportion as the Land Council determines (s. 35(2)). Section 64(4) provides that:

(4) There shall be paid out of the Trust Account such other amounts as the Minister directs to be paid or applied to or for the benefit of Aboriginals living in the Northern Territory.

A Trust Account Advisory Committee, comprising Aboriginals, is to advise the Minister concerning the payments (s. 65). Table 20 illustrates the way these provisions work, by reference to some assumed figures.

Entry on Aboriginal land

There are many provisions in the *Aboriginal Land Rights (Northern Territory) Act* 1976 which are relevant to our considerations. We will not discuss them all here. Section 70 will come into operation on a date yet to be fixed by proclamation. Sub-section (1) of that section provides that, except in the performance of functions under the Act or otherwise as the Act or a law of the Northern Territory permits, a person is not to enter or remain on Aboriginal land under penalty of a maximum fine of $1000. Aboriginals may nevertheless do so, if their occupation or use is in accordance with Aboriginal tradition, but not otherwise, and not if that use or occupation would interfere with someone

Table 20

Illustrative levels of royalty revenue from Ranger and Pancontinental operations

Annual rate of production (tonnes U)	*Total royalties*[1] *($ million)*		*20% of royalties*[3] *($ million)*		*30% of royalties*[4] *($ million)*	
	Low[2]	*High*[2]	*Low*[2]	*High*[2]	*Low*[2]	*High*[2]
2500 (Ranger only, initial capacity)	1.66	4.97	0.33	0.99	0.50	1.49
5100 (Ranger only, full capacity)	3.32	9.95	0.66	1.99	0.99	2.98
8900 (Ranger full capacity, Pancontinental initial capacity)	5.79	17.36	1.16	3.47	1.74	5.21
12 700 (Ranger full capacity, Pancontinental full capacity)	8.26	24.77	1.65	4.95	2.48	7.43

Notes: 1. Calculated on the basis of a royalty rate of 2½ per cent of the gross proceeds of sale of uranium (see note 2). Although it is not possible for the purposes of this table to estimate transport costs, it is expected that they will not exceed 1 per cent of the gross proceeds of sale. The total amount of royalties is to be paid to the Aboriginals Benefit Trust Account.

2. Low and high cases refer to the two prices of uranium used for illustrative purposes in the economic analysis described in Chapter 8 and Appendix V, viz. $26 000 per tonne U ($10 per pound U_3O_8) amd $78 000 per tonne U ($30 per pound U_3O_8).

3. To be paid out of the Aboriginals Benefit Trust Account to the Northern Land Council by virtue of the operation of s. 64 (1) and (2) of the Land Rights Act.

4. To be paid out of the Aboriginals Benefit Trust Account to the Northern Land Council by virtue of the operation of s. 64 (3) of the Land Rights Act.

else's use or enjoyment of an estate or interest in the land (s. 71). The terms of s. 70(1) point to complementary legislation being passed by the Legislative Assembly for the Northern Territory before s. 70 is proclaimed (see also s. 73). The scope of complementary legislation is affected by s. 70(2), which applies to a case, among others, where a mining lease or authority has been granted on Aboriginal land, and protects the right of entry to that land of certain classes of persons:

(2) Where a person, other than a Land Trust, has an estate or interest in Aboriginal land –

(a) A person is entitled to enter and remain on the land for any purpose that is

> necessary for the use or enjoyment of that estate or interest by the owner of the estate or interest; and
>
> (b) a law of the Northern Territory shall not authorise an entry or remaining on the land of a person if his presence on the land would interfere with the use or enjoyment of that estate or interest by the owner of the estate or interest.

A Bill, entitled the Aboriginal Lands and Sacred Sites Bill, was introduced into the Legislative Assembly in February 1977, but has not been taken to a further stage. Clause 4 of the Bill is as follows:

> 4. Subject to the laws in force in the Northern Territory, a person, including an Aboriginal, may enter and remain on an area of Aboriginal land only at the invitation of the authorised Aboriginal for that area.

This section (if enacted) would have to be read subject to ss. 70 (2), s. 71 of the Land Rights Act, to which we have referred above. An authorised Aboriginal is defined as a person who in accordance with Aboriginal tradition may control the entry of persons on Aboriginal land (cl. 3). We understand from the speech made by the Majority Leader and Chief Secretary when introducing the Bill that these persons are regarded as being, or including, the traditional owners. The power given to authorised Aboriginals may be delegated (s. 6). The Bill also gives qualified rights to the police and public officials and other designated persons to enter Aboriginal land. In general the effect of the Bill is to create restrictions upon entry additional to those imposed by the Act. The entry permit system currently existing under Part IV of the *Social Welfare Ordinance* 1964–1974 is to be abrogated by amendment to that Ordinance.

The terms of s. 70(2) are not unimportant. The phrase 'an estate or interest in Aboriginal land' is specially defined by s. 66 for Part VII of the Act, in which s. 70 appears (cf. s. 3(2)). That definition includes not only a 'mining interest' (as defined in s. 3(1)), and an interest arising under an authority granted under the Atomic Energy Act, but also, *inter alia*, 'an interest arising out of the taking possession, mining or occupation of land by virtue of a miners right'. The rights of entry and occupation given by miners rights are therefore preserved under s. 70(2), but, by s. 75, a miners right does not apply to Aboriginal land unless the land was being occupied or used by virtue of the miners right immediately before it became Aboriginal land. We do not have sufficient information to specify precisely the areas the occupation of which under miners rights can be continued by reason of s. 70(2), but this is a matter which should be explored further at the time it is intended to make any land in the Region Aboriginal land. A miners right is only in operation for one year (Mining Ordinance s. 19(d)), but may be renewed (s. 36).

Peko and E.Z. have jointly a number of mining leases relating to areas outside the Ranger Project Area, but within the area claimed by the Northern Land Council. These constitute an estate or interest in land for the purposes of Part VII, and entry and possession thereunder is therefore protected by s. 70(2). No separate point has been made that leases granted hereafter will have such protection, presumably because the grant of the lease, if the land has in the meantime become Aboriginal land, will need consent and the settling of terms and conditions.

Aboriginal Reserves

Section 72 deals with the position of existing Aboriginal Reserves. Under s. 4 (1) and (2) they become subject to Land Trusts, to be held for Aboriginal groups to be specified; s. 72 provides that the vesting of land in a Land Trust does not, except as provided by regulation, affect the status of the land as an Aboriginal Reserve.

Other considerations under s. 50

We have mentioned the desirability of our making, where appropriate, findings and recommendations concerning land claimed as Aboriginal land. Where the Aboriginal Land Commissioner deals with claims under the Act, he is required by s. 50 (3) to take into consideration certain matters in making his report. This sub-section is as follows:

> (3) In making a report in connexion with a traditional land claim the Commissioner shall have regard to the strength or otherwise of the traditional attachment by the claimants to the land claimed, and shall comment on each of the following matters–
>
> (a) the number of Aboriginals with traditional attachments to the land claimed who would be advantaged, and the nature and extent of the advantage that would accrue to those Aboriginals, if the claim were acceded to either in whole or in part;
>
> (b) the detriment to persons or communities including other Aboriginal groups that might result if the claim were acceded to either in whole or in part;
>
> (c) the effect which acceding to the claim either in whole or in part would have on the existing or proposed patterns of land usage in the region; and
>
> (d) where the claim relates to alienated Crown land–the cost of acquiring the interests of persons (other than the Crown) in the land concerned.

Section 50 (4) states two principles to which the Land Commission is to have regard. They are, in short, that occupancy should be made secure for Aboriginals living on the country of the 'tribe or linguistic group' to which they belong, and for those who do not live on that country but wish to do so. The concept of tribe is not of much assistance in the present case, but a linguistic grouping is. As a rule, many more persons share a common language than are members of one clan. It was put to us that s. 50 (4) provides the real criterion for deciding land rights entitlement, but we do not accept that view. Plainly the sub-section expresses a policy to which effect should be given if it is reasonably possible or practicable to do so, but its impact on other considerations will depend on the facts of each case. We are of the view that we should consider these provisions (s. 50 (3) and (4)) and act accordingly, as if we were the Land Commissioner.

Aboriginal self-determination

We have already pointed out that the legislation makes consent of the relevant Land Council necessary in some cases, before development can take place on Aboriginal land, and agreement with that Land Council on terms and conditions necessary before the proposed mining can take place, if the site becomes Aboriginal land. A question therefore arises as to what role, if any, this Commission has in considering and recommending particular courses designed to protect the Aboriginal people from adverse environmental consequences. Some discussion is desirable to meet the event of a recommendation concerning the creation of Land Trusts not being accepted, but where the land does become Aboriginal land, the position of the Aboriginal people can be protected to a very large extent by or through the Northern Land Council. We understand that the Council nevertheless wishes us to express views on material matters, and make relevant recommendations, and it seems to us that by so doing we may help the parties the more readily to make the necessary decisions and to reach the necessary agreements. Nevertheless, the power given by the legislation to the Aboriginal people to decide for themselves what is in their best interests so far as concerns the use and enjoyment of Aboriginal land, and, within limits, to enforce their wishes, should be fully recognised.

Control of Aboriginal use of land

The title to be granted to a Land Trust is an estate in fee simple (ss. 3 (1), 10 (1) and 11 (1) (e)). This is in accordance with the recommendation made by Mr Justice Woodward (Aboriginal Land Rights Commission's Second Report, para. 70) when he was dealing with land in Aboriginal Reserves and he gave reasons why leasehold title would be unsatisfactory. A practical consideration which would not arise if the grant were of a leasehold estate but does arise when the grant is of an estate in fee simple concerns the methods which can be employed to control the way the Aboriginals use the land. Doubtless it is intended that they should have considerable freedom to determine for themselves how they use the land, but considerations of the national interest, of protection of the environment and of the reasonable enjoyment of neighbouring lands may in particular cases require some external restrictions (see Second Report, paras 398, 492). In Chapters 9 and 16 we discuss the future of the Mudginberri and Munmarlary pastoral leases, and, associated therewith, the control of buffaloes and the desirability of being able to ensure, within about seven years, that tuberculosis in them is under control. If, because properties or part of them become subject to a Land Trust, Aboriginal people have control of the buffaloes on them, it will be necessary for an appropriate plan of management to be established, and for some course to be followed which ensures that it is carried out. Doubtless the best avenue to a solution of that and similar problems will be the reaching of agreement with the Northern Land Council which can be suitably enforced if occasion arises.

Mr Justice Woodward, at paras 492 to 509 of his Second Report, under the heading Reconciling Aboriginal Interests with Conservation, discusses the control of areas intended as national parks or wildlife reserves. If the land in question becomes Aboriginal land, but thereafter becomes part of a national park, the arrangements made in this connection will doubtless take care of problems such as we have mentioned.

Lack of survey

The Region in question, in common with most of the Northern Territory, has not been surveyed. The boundaries of leases, pastoral and otherwise, of reserves, parks and even of public roads can for the most part only be fixed by description of natural features and by metes and bounds in reference to them. This is evident from the description given to the lands dealt with in Schedule 1 to the Act. In the course of this Inquiry there has been difficulty in establishing quite a few locations and boundaries of importance, and some uncertainty and imprecision remain. There are two aspects in particular which should be mentioned. The first concerns the grants to Land Trusts. These are to be grants of estates in fee simple (s. 11 (1) (e)), and the Land Trusts are entitled to have them registered (s. 12 (5)). The boundaries are to be 'set out' (s. 4 (2) (c)). As previously mentioned, clan boundaries are apt to be irregular and curved—and a trifle uncertain as well. They plainly could not be fixed accurately, but in any event there is no survey. The problem was discussed with the Surveyor-General for the Territory, and the Registrar-General for the Territory, when they gave evidence. It seems to the Commission that at some stage a practical course will probably have to be followed, and where boundaries do not lie on reasonably well-defined natural features there will have to be straight lines defined as best this can be done by reference to those features, or existing boundaries. This must involve a degree of approximation in many cases. The Act does not permit us to follow such a course when making findings and recommendations, although, in the event, the resulting problems are not great. Adjustment, if possible at all, will have to be at a later stage.

The other aspect relates to the prohibition in s. 40 (1) which has already been discussed. It is a prohibition against the 'grant' of a mining interest. For a mining interest (e.g. a lease) to be 'granted' under the relevant legislation, the *Mining Ordinance* 1939–1976 (N.T.), it must be the subject of survey. The practice is not to grant leases except in rare cases, but to notify applicants of the Administrator's approval to the grant and of any conditions specially attached to the grant, and this is regarded as substantially the equivalent of a grant. The definition of 'lease' in the Ordinance, which is made to mean 'any lease granted or approved' (s. 7), seems to allow for such a course (see also ss. 71, 74). It nevertheless seems to us to be arguable that the approval or its notification does not infringe s. 40 (1), and we recommend that attention be given to the question whether that section should be amended to meet the situation.

Operation of mining legislation

Associated with the operation of s. 40(1) are questions of the operation of the mining legislation of the Northern Territory in relation to the applications which have been made thereunder by the respective mining companies. In discussing these applications, we assume their validity without investigation and without meaning to make any finding in respect thereof.

Ranger had an exploration licence in respect of the area proposed to be mined until December 1975, but not thereafter. During the currency of that licence, namely on 19 July 1974, a special mineral lease (S.M.L. 63) in respect of a large area was applied for by Peko Mines Ltd and Electrolytic Zinc Company of Australasia Ltd (two of the co-venturers). It was sufficient to encompass the mine, the mill and ancillary needs, such as an area for a construction camp. In the Environmental Impact Statement the S.M.L. is relied upon as the mining tenement which will enable the project to proceed.

Special mineral leases are granted under Division 2A of Part V of the Ordinance (ss. 54A–54K). They are normally regarded as appropriate for large-scale operations requiring a large parcel of land (see s. 54A(3)), and can only be applied for over crown land or land in an Aboriginal Reserve—a term which does not include Aboriginal land under the Land Rights Act (s. 54B(1); s. 7), although there is presumably the possibility of an amendment which will enable a special mineral lease to be granted over Aboriginal land. The subject land was and is crown land as defined in the Ordinance (s. 7). If it becomes Aboriginal land it will cease to be crown land. It will then, as the law at present stands, become 'private land' as defined in s. 106, except, perhaps, to the extent that it is 'held or occupied for mining purposes under the provisions of this Ordinance'. A question arises whether, if there is such a change in status of the land, the S.M.L. applied for can still be granted, even in part. If it can, it seems possible that the area granted may be confined to the much smaller portion of it which, because it is the subject of subsisting applications for mineral leases, is held or occupied for mining purposes and may not therefore be 'private land' (see s. 107, ss. 62, 63). Ranger made applications for ordinary mineral leases in 1970 in respect of a number of rectangular portions of up to 40 acres each (this is in general the maximum size, see s. 47). The leases applied for are in the area later made the subject of the S.M.L. application, but the area covered by the lease applications mentioned would not be enough to allow the Ranger proposal to proceed. Having in mind that the whole of the Ranger Project Area is exempted from the prohibition in s. 40(1), without any limit on the time in which applications for leases must be made, it is still open to Ranger to apply for the whole area it needs, but probably only by ordinary mineral lease applications.

There is an important consideration affecting ordinary mineral leases. The official view is that they cannot contain covenants and conditions of an 'environmental protection' nature. While, under s. 73(1)(g), they may contain 'such other covenants or conditions as are prescribed or as the Administrator considers to be necessary', legal opinion given to the Department concerned is that the powers mentioned only enable provisions to be inserted which are of the same nature as those specified in the preceding paragraphs of s. 73(1). The usual form of lease is indeed a relatively short document. As previously mentioned, leases are in fact seldom granted, so a 'lessee' is not in strictness bound by any covenants at all. The strict legal position would seem to be both uncertain and anomalous. What it is important to note for present purposes is that ordinary leases do not provide a medium for effectively binding Ranger in relation to the many controls and safeguards which are necessary.

Pancontinental and Noranda are only relieved from the need to get Aboriginal consent under s. 40(1) to the extent to which their intended operations can be supported by applications made before 4 June 1976 (s. 40(3)). As we read the legislation, it is necessary for them to have been the holders of exploration licences at the time of those applications. Pancontinental (with Getty Oil) is the holder of an exploration licence (E.L.12) granted on 17 March 1972, which embraced the Jabiluka mine area and much beyond, and part of which was refused renewal on 1 January 1974 as a matter of government policy because it fell in the area of the national park as then proposed. On 12 October 1973 it applied for a special mineral lease (S.M.L. 61) over a very wide area, including the proposed mine. The area claimed was (and is) part of Mudginberri, but as the lease of that property does not give the lessee a right of purchase, it is 'crown land' within the meaning of the Ordinance (s. 7), and therefore properly the subject of the grant of an S.M.L. If it is resumed and thereafter becomes Aboriginal land, a question will arise which is similar to that mentioned in relation to Ranger, namely whether an S.M.L. can then be granted and, if so, to what extent. The exploration licence still subsisted, in relation to a small part of the land, until 17 March 1977 when it was due to expire. Pancontinental (with Getty Oil) applied for a number of mineral leases in 1975 which cover part of the area of the S.M.L. application, and part of the area on which it is proposed the Jabiluka mine operations will be carried on, but they will be quite inadequate for those operations.

The situation in respect of Noranda is clearer; if the site of the Koongarra mining operations becomes Aboriginal land, Noranda will not be able to commence those operations without Aboriginal consent. The position, in short, is that nine mineral lease applications, made by Noranda in 1970, are protected against the application of s. 40(1), but, although they include the ore body, they would not cover a sufficient area to enable mining to proceed. An application for an S.M.L. was made in September 1976, but it was not supported by an exploration licence, and was in any event after the critical date—4 June 1976. Noranda draws attention to a letter dated 21 December 1973 from the then Minister for the Northern Territory explaining that its exploration licences, which included the Koongarra uranium deposit, were not being renewed in respect of areas within the proposed national park (where the deposit is). The letter gave an assurance that, if Territory legislation were passed dealing with national parks and providing for the grant of rights to prospect therein, Noranda would be given fresh licences in respect of the area within the park to which its renewal applications related. The operation of the assurance in the light of subsequent developments is uncertain, but probably its spirit is relied upon rather than its precise terms. Similar assurances were given to others, including Peko Mines and Electrolytic Zinc and Pancontinental. So far as Noranda is concerned, we are of the view that mining in or around the Koongarra area should not in any event be allowed to proceed for the time being (see Chapter 16).

Authorities under the Atomic Energy Act

An alternative for Ranger left open by the Land Rights Act is an authority to mine under the *Atomic Energy Act* 1953. We strongly recommend against the use of that Act for the grant of an authority to Ranger to mine uranium. There are a number of different reasons for our recommendation.

The relevant section is s. 41, which we set out in full:

> **41.** (1) Where it appears to the Minister that a prescribed substance, or minerals from which, in the opinion of the Minister, a prescribed substance can be obtained, is or are present on or under the whole or a part of an area of land, either in a natural state or in a deposit of waste material obtained from an underground or surface working, the Minister may, by writing under his hand, authorise a person to carry on, on behalf of the Commonwealth, operations in accordance with this section on that land.
>
> (2) Subject to any conditions or restrictions specified in the authority, the person so authorised in relation to any land may—
>
> (a) enter upon that land, with such workmen and other persons as he thinks fit, and bring on to that land such machinery, vehicles and other things as he thinks fit;
>
> (b) take possession of the whole or a part of that land;
>
> (c) carry on, upon or under that land, operations for discovering prescribed substances, and for mining, recovering, treating and processing prescribed substances and such other minerals as it is necessary or convenient to mine or recover in order to obtain prescribed substances;
>
> (d) for the purposes of the operations referred to in the last preceding paragraph—
>
> (i) erect or install buildings (including residential buildings), structures and machinery on that land;
>
> (ii) cut and construct water races, drains, dams, tramways and roads on that land;
>
> (iii) bore or sink for water, and pump, raise or use water, on that land; and
>
> (iv) do other work on that land;
>
> (e) demolish or remove buildings, structures and machinery erected or installed on that land;
>
> (f) pass over, or authorise persons and things to pass or be carried over, land giving access to that land; and
>
> (g) do all such other things as are necessary or convenient for the effectual exercise of the powers specified in the preceding paragraphs of this sub-section.
>
> (3) All prescribed substances and minerals mined or otherwise recovered in pursuance of an authority under this section that are not otherwise the property of the Commonwealth are, by force of this section, vested in the Commonwealth.

It will be seen (sub-section (1)) that the section gives power to carry on operations only if they are 'on behalf of the Commonwealth'. It must be doubtful, to say the least, whether the proposed operations could fairly be said to be carried on on behalf of the Commonwealth. Although the Commonwealth is a participant, the project is to be, as we understand, an ordinary commercial one. The Memorandum of Understanding describes the undertaking as 'a joint venture'. The Commonwealth is to find 72½ per cent of the working capital, with Peko Mines Ltd and Electrolytic Zinc Company of Australasia Ltd providing the rest. The project assets are to be held in 'like undivided percentages'. What are to be divided are the 'net annual proceeds of sale of the uranium concentrate' and of those the Commonwealth is to receive only 50 per cent. Management of the enterprise is to be by a private company (Ranger) not owned or controlled by the Commonwealth, although it will appoint two of the four directors.

In any event, the section is inappropriate for a venture such as is planned, and which has to be subject to strong environmental controls, determined upon and maintained independently of the co-venturers. It is a re-enactment of s. 13A of the *Atomic Energy (Control of Materials) Act* 1946. Section 13A was enacted in 1952, by way of amendment to the principal Act. Under s. 6 of the principal Act, all uranium in the Territories became, and it still is, the property of the Commonwealth. The preamble to the Act describes it as:

> an Act to make provision, in the interests of the Defence of the Commonwealth, for the Control of Materials which are or may be used in producing Atomic Energy, and for other purposes.

Section 13A was enacted in order to make more clear and certain the powers already existing under the 1946 Act (see House of Representatives *Hansard* for 21 May 1952, 614, 950).

It seems to us that s. 41 is a special power which was enacted at a time when the need to secure Australian uranium for use by Great Britain and the United States of America in nuclear weapons was uppermost in the minds of those concerned. If its use is to be continued in a situation where peaceful uses only are in mind and commercial profit is intended, the changed rationale should be recognised. The power, if it can be applied in the circumstances, should not be used simply because it exists and may appear convenient.

In our First Report we explained the very special nature of uranium, and described it as being a highly strategic material. It is therefore necessary for there to be close government controls. This does not mean that the actual mining operations must be conducted by or on behalf of the Government, still less that the local environmental controls be determined or supervised under the Atomic Energy Act.

The purpose of s. 41 is to put aside the ordinary law of the land respecting mining. This law has a long and special history in this country, and is designed to secure a balance between the public interest and the interest of the individual, while ensuring public procedures and allowing public scrutiny.

A strong body of evidence demonstrates a widespread lack of confidence in the Atomic Energy Commission as the final arbiter of standards for the proposed mining operations, and as monitor of them. This is in part because it is proposed that the Commission be actively engaged as entrepreneur, and in part because one of its ordinary roles is the promotion of uranium mining and nuclear development generally.

The purposes of the Commission were stated by the Commission in the foreword to its First Annual Report (1953):

> The functions committed to the Commission by the Atomic Energy Act fall broadly into two divisions. On the one hand there are those directed towards the development of the uranium resources of Australia, to ensure the supply of this metal for the production of atomic energy. On the other, there are those which have as their objective the employment of atomic energy for practical purposes in the service of the nation. The latter are to be pursued through the advancement of atomic energy technology, and the establishment in Australia of plant and equipment for the conversion of atomic energy into other forms of power.

It seemed to many witnesses, as it seems to us, that ordinary principles should lead it to decline a role in deciding what is best to be done as between the mining operations and the environment. This involves no imputation against any Commissioner or officer of the Commission. We see no reason why the scientific and technical expertise of the Commission should not be used in helping to fix standards and establishing monitoring procedures, and no reason why particular scientists and technicians should not be engaged in those activities. We make no criticism of the scientific objectivity of officers of the Commission who have given evidence to us. In many respects they have given us invaluable assistance. The central difficulty for present purposes is that they belong to an organisation whose function is not simply one of research; it is also an active commercial and political force in the promotion of nuclear development and the mining of uranium.

It is inevitable, we feel, that the Minister's use of s. 41 will attract doubt and suspicion simply because he is the Minister responsible for the Commission, and would normally be expected to turn to it for advice in relation to the operation of that section. This particular reason could have less force if the recommendation in our First Report, that a Uranium Advisory Council be created, were adopted. A main reason for that recommendation was to give the Government the opportunity of obtaining competent advice from a source which would be, and would be recognised as being, independent of the principal proponents of uranium mining.

Uranium mining in Australia received its original impetus from military needs, and the Commission's first activities were related to satisfying those needs. It was responsible for the control of the Rum Jungle operations, which helped to supply the needs for nuclear weapon production overseas. Quite apart from whether the Atomic Energy Commission was in any way at fault in not ensuring greater protection for the physical environment at and near Rum Jungle, the fact is that it now represents to many people, not least of all the Aboriginal people, an awful example of what should not be allowed to happen.

The security provisions of Part IV of the Atomic Energy Act, some of which seem extreme in the current context, were doubtless enacted with defence considerations in mind. While they remain, public access to information is seriously curtailed.

Other manifestations of the early role of uranium mining are to be found in the Northern Territory Mining Ordinance, already discussed. Section 87A(2) of that Ordinance (inserted in 1953) forbids the forfeiture of a uranium mining lease by the Administrator without, *inter alia*, a recommendation from the

Atomic Energy Commission. This provision should in our view be repealed, or at least appropriately amended. By s. 68 (3) (also inserted in 1953) uranium mining is in effect given a preference over alluvial mining which other forms of land mining do not enjoy. There are a number of other provisions in the Ordinance specially dealing with uranium, some of which it may be desirable to retain.

Estuarine and inland waters and fishing

The area claimed by Aboriginals under the Land Rights Act includes a number of rivers and a number of billabongs, lagoons and lakes. Most of these latter connect to the sea at the time of the wet, through one of the principal rivers. A question was raised as to the rights, if any, the Aboriginals will have in respect of these rivers and inland waters in the event that the land on which they are situated becomes Aboriginal land. A grant to a Land Trust of land does not include 'water' (s. 12 (2), s. 3 (1)). This remains the property of the Crown.

The ownership, use and control of waters in the Northern Territory are governed by the *Control of Waters Ordinance* 1938–1971. There are so many exceptions, qualifications and special cases provided for in the Ordinance that the particular position of each parcel of land and each river, billabong and lagoon has to be looked at separately before precise answers can be given, but a general position can be stated. The Ordinance does not make any special provision concerning Aboriginals or their use of water. (Part III of the Aboriginal Lands and Sacred Sites Bill (N.T.) does, however, contain proposals concerning coastal waters). The ownership of the water in a river, creek, lake, lagoon or billabong belongs to the Crown, save in so far as it is granted to others, or others are given rights thereto under the Ordinance or other legislation (s. 3 (1)). Where a watercourse or lake forms the boundary of land which has been or is alienated by the Crown, its beds and banks remain the property of the Crown. Extensive rights are given to owners or occupiers of land to use water within their land for various natural purposes, but obstruction and diversion, and the erection of some earthworks, are prohibited or regulated. Pollution is prohibited, unless authorised under a law in force in the Northern Territory. In general, it would seem that the position of a Land Trust in relation to water on or bordering its land will be much the same as that of any other owner of land. We do not understand the Northern Land Council to contest this view.

Aboriginal people will be free to use waters within their own lands for fishing, subject only to any general provisions of the law respecting fishing as, for example, those under the *Fisheries Ordinance* 1965–1974. The only interference to their fishing by others will be such as they agree to accept. This is one of a number of reasons why their agreement to the plan of management of the national park should be regarded as necessary, and why they should have a say in its administration.

The Chairman of the Northern Territory Commercial Fishermen's Association submitted on behalf of his Association that Aboriginals did not have any legal right to claim rivers and inland waters under the Act. This aspect has been dealt with in the foregoing paragraphs. He also expressed concern at excessive fishing in the upstream areas, but in relation to fishing generally, whether done by white man or black. This is a question which doubtless is receiving the attention of the Chief Inspector of Fisheries appointed under the Ordinance, and will receive attention from the national park authority.

Commercial fishing is not at present allowed in the Mary, Wildman, West Alligator and South Alligator Rivers upstream of an east–west line or in the East Alligator River upstream of a north–south line prescribed under the Fisheries Ordinance. We understand the position to be that Aboriginal and non-Aboriginal people will have equal opportunities to fish in the waters, whether for commercial of non-commercial purposes. Aboriginals will not, however, be able to engage in commercial fishing where it is forbidden to the white man.

15 LAND CLAIM MADE UNDER THE ABORIGINAL LAND RIGHTS (NORTHERN TERRITORY) ACT 1976

The scope of the claim

The land that is claimed by the Northern Land Council on behalf of the traditional Aboriginal owners of the Region includes all the unalienated crown land within an area which is bounded by a line commencing at the north-east boundary of Carmor Plain (formerly part of Point Stuart) pastoral lease and proceeding generally south-west along the eastern boundary of Carmor Plain, then generally south along the eastern boundaries of Point Stuart, Wildman River and Annaburroo pastoral leases, thence east along the northern boundary of Mt Bundey and Goodparla pastoral leases, then generally south along the eastern boundary of Goodparla pastoral lease, then east along the northern boundary of Gimbat pastoral lease (excluding the part thereof recently resumed), then north along the western boundary of Arnhem Land Aboriginal Reserve, then generally north-west along the East Alligator River to the coast, then generally west along the coastline to the commencing point on the boundary of Carmor Plain pastoral lease. The area thus delineated, which comprises much of the area defined in Chapter 2 as the Region, is bounded by straight lines, except for a small section of the Wildman River where it forms the east boundary of Carmor Plain pastoral lease, the East Alligator River, and the coastline. Within it, but not included in the claim, are the Mudginberri and Munmarlary pastoral leases. It surrounds the Woolwonga Aboriginal Reserve, which (together with a small portion of land in the centre of that Reserve but which was not part of it) is to become Aboriginal land under the specific terms of the *Aboriginal Land Rights (Northern Territory) Act* 1976 and which is not therefore the subject of the present claim. The claim extends to Field and Barron Islands, which are in Van Diemen Gulf, immediately to the north of the land claimed. It also includes nearly the whole of the area proposed in 1975 as the Kakadu National Park.

Both Mudginberri and Munmarlary pastoral leases constitute alienated crown land. It was conceded by counsel representing the Northern Land Council that alienated crown land cannot be granted to a Land Trust under the provisions of the Aboriginal Land Rights (N.T.) Act, and it did not seek any formal finding by this Commission under s. 11 (2) in respect of that land. It did seek a recommendation from this Commission that the two properties be resumed at an early date by the Crown. In that event the land would become unalienated crown land and as such the proper subject of a land claim, and the Northern Land Council invited us to indicate in our Report what in our view would be the position concerning the likely success of a claim made then. In this respect we would be acting in much the same way as a Land Commissioner is intended to do under ss. 50 (1) (b) and (3) (d) of the Act.

The Ranger Project Area, as described in Schedule 2 of the *Aboriginal Land Rights (N.T.) Act* 1976, is included in the land claimed. The Jabiluka mine site is located within the boundary of the Mudginberri pastoral lease and hence cannot be the subject of a finding under s. 11 (2). The Koongarra mine site is part of the land claimed.

Basis of land claim

The formal finding to be made under s. 11 (2) is 'that a group or groups of Aboriginals are entitled by Aboriginal tradition to the use or occupation of an area of land . . .' When a claim is made to an Aboriginal Land Commissioner, what has first to be shown is that there are 'traditional Aboriginal owners', a term which is defined in s. 3 (1) as follows:

> "traditional Aboriginal owners", in relation to land, means a local descent group of Aboriginals who–
> (a) have common spiritual affiliations to a site on the land, being affiliations that place the group under a primary spiritual responsibility for that site and for the land; and
> (b) are entitled by Aboriginal tradition to forage as of right over that land.

The view we have taken, and with which the parties have agreed, is that this Commission should as far as possible follow the course which the Statute prescribes for the Land Commissioner. This includes consideration of the matters referred to in ss. 50 (3) and (4). We do not supplant the Land Commissioner. The same or similar claims can be pursued before him at any time before the Minister makes a decision, favourable to the claim, or the relevant part of it, under s. 11 (1) (b).

Effect is given by the Land Rights Act to findings of this Commission in so far as they are findings made by it 'for the purposes of its inquiry', that is to say, its principal inquiry under the *Environment Protection (Impact of Proposals) Act* 1974. Having in mind the nature and scope of the evidence relating to the land claim we did not attempt to predetermine what findings we needed to make or would make for the purposes of the Inquiry, but heard the claim as presented, intimating at the same time that we might not need to make findings in respect of all the area claimed.

Although the claim is submitted as one whole, the evidence relates to a number of separate clan areas, for each of which there are said to be traditional owners, and a larger class of persons entitled by Aboriginal tradition to use or occupy it. The clan areas are irregularly shaped; their boundaries, as shown on a plan in evidence, are necessarily approximate. It is not suggested that they can be defined accurately. Their boundaries are not coincident with any artificial boundaries and indeed in many cases they cross natural features, such as rivers. In the west and south-west there are gaps between the boundaries of the clan areas and the boundaries of the pastoral leases in those areas. We are nevertheless asked to make a finding in respect of the areas in the gaps.

Although Pancontinental is not faced with a claim under the Act, we permitted counsel for it to make submissions generally in relation to the claim. He submitted that the power under s. 11 (2) was limited to findings in respect of the Ranger Project Area, but we see no justification in the legislation for such an unnatural limitation on the scope of the Inquiry. If correct, the submission would entail the postponement of our Report until such time as the position concerning title to and rights over other land in the Region became known. As it is, we are able, in this Report, to make recommendations under the *Environment Protection (Impact of Proposals) Act* 1974 which are based on findings under s. 11 (2) and recommendations related thereto.

A further submission by counsel for Pancontinental concerned evidence given to us to the effect that certain clans had succeeded to the estates of others which had died out. This evidence postulated a situation in which primary rights in land passed to the members of another clan who previously had only had secondary rights in respect of it. Pancontinental is not ever likely to have to meet claims made on that basis, because there are primary traditional owners of the land it wishes to mine who are still living. We nevertheless found counsel's submission of considerable value, and importance, having in mind, in particular, that we are considering the first claim made under the Act. We shall return to a discussion of the matter when we have dealt with the claim of the Northern Land Council so far as it relates to areas in respect of which it is submitted there are primary owners still living.

The definition of 'traditional Aboriginal owners' has already been set out. There are a number of key concepts, which have to be understood by reference to Aboriginal customs and traditions. These have already been dealt with to a large extent in Chapter 4. We understand the term 'local descent group', which is used in the definition, to refer, in the Region with which we are concerned, to a group of persons who share with each other a common ancestry in the male line (see First Report of Mr Justice Woodward, para. 37). The group is commonly larger than a single family. The membership of the group is usually well known not only to members of the group themselves, but also to members of other groups. Land ownership in Aboriginal society is manifested in and determined primarily through members of local descent groups, which in Western Arnhem Land are called *gunmugugur*.

The spiritual beliefs held by Aboriginal people in relation to land and their integration with it have been discussed in Chapter 4. They believe that the pattern of entitlement of local descent groups to particular territories or estates arises from the dictates of the dreamtime spirit beings. Each member of a gunmugugur is related to the locality jointly with every other member of the group, without distinction of sex, age, status or any other criterion. It is in this sense that members have a 'common spiritual affiliation' to the land.

The definition speaks of 'spiritual affiliations' and 'spiritual responsibility' in relation to *sites* on land. 'Sites' are physical sites, but they are not always as closely circumscribed and as well defined as our use of the term suggests. They can constitute a natural feature or a cultural feature, such as a stone arrangement, ceremonial ground, burial ground or well. The general locality of particular waterholes, rocks, trees, small patches of ground, arrangements of stones, burial grounds and many other places besides can be 'sites' in the relevant sense. These have religious significance for Aboriginal people because of their association with Aboriginal mythology, in particular the Aboriginal belief in the dreamtime spirits.

There is 'spiritual responsibility' for sites such as we have mentioned because of the Aboriginal belief in their origin and their traditional acceptance of a duty to safeguard them from intrusion, damage and interference. There is usually the associated aspect that they are the places for the performance of certain rituals, ceremonies and songs which are connected with them. These are matters of the spirit. We discuss later the question of how far the Aboriginal claimants do in fact adhere to these beliefs and engage in traditional ceremonies.

The 'land' refers to the stretch of country upon which the various sites belonging to a group are located. The evidence shows 'that the territory belonging to a gunmugugur can be seen as the sum of the sites owned by people of that gunmugugur. In toto, they constitute a stretch of country which integrates with or blurs into that of contiguous gunmugugur ... while the "edges" are not sharply defined, the main bulk of the territory is and its sites are precisely defined.'

Paragraph (b) of the definition of traditional Aboriginal owners (see above) requires that the group have traditional entitlement to 'forage as of right over that land'.

It is clear from anthropological evidence and evidence of the Aboriginals themselves that ownership of land carries with it the unrestricted right to the use of the natural resources found within the boundaries of one's own 'estate'. This is not to say that persons from other land-owning groups will be denied access to the resources of the estate, but it is the one area the resources of which can be exploited by the landowners themselves, without their being required to seek the permission of other land-owning groups.

As distinct from 'traditional ownership' the Act speaks of 'traditional use or occupation' of land, but this concept is not defined and requires further clarification.

We have mentioned in Chapter 4 that the Aboriginals traditionally form flexible domestic units, as distinct from land-owning units, in order to exploit the land. These groups, described by us as hordes or bands, have a varying membership and comprise persons from a number of land-owning groups, or gunmugugur. The members of a horde hunt, forage, camp, take part in ceremonies and participate in other activities within an area of land which extends beyond the boundaries of one estate. The total area over which this domestic unit travels in order to satisfy both its economic and social needs is called its 'range'.

The horde or band has an entitlement of access to areas adjoining the estates of its members, and areas further afield, which depends upon mytho-ritual linkages, kinship ties and clan affiliations of the members to other land-owning groups. There is some obligation upon the members of a horde to make known their presence to the traditional owners of the land over which they travel, but the lengths to which the senior members of the horde will go to gain either express or tacit permission from the landowners will depend largely upon the strength of mutual kinship ties, clan affiliations, totemic relationships and the current state of political relationships. In this way an Aboriginal person, as a member of a group, has a traditional, though qualified, entitlement to use and occupy an area of land which is much larger than the area of land to which he or she claims traditional ownership.

The evidence

Mr G. Chaloupka and Mr I. Keen submitted in evidence a report entitled 'Report on Aboriginal traditional land ownership of the Alligator Rivers Region' which was prepared in 1975 for the Northern Land Council. The report is in two parts:

Part One: The land-owning groups (clans) and their membership by I. Keen.

Part Two: The land-owning groups (clans) and their traditional territories by G. Chaloupka.

Mr I. Keen, a postgraduate research student in anthropology in the Australian National University, provided detailed genealogies of the Aboriginal persons claiming primary rights of ownership through patrilineal descent to gunmugugur estates identified within the Region. He travelled to a number of centres both within and outside the Region including Oenpelli, Mudginberri, Jim Jim, Nourlangie, Katherine, Humpty Doo and Pine Creek, during which time he gathered genealogical data on more than 120 Aboriginal people.

The evidence presented by Mr Keen was not challenged in any substantive way by Ranger or by any of the other parties represented, except to the extent to which he relied upon the process of succession, and then the only challenge was that made by Pancontinental, to which we have already referred, and to which we will return.

Mr G. Chaloupka, author of the second part of the report, has, for the past three years, been employed as a Sites Survey Officer with the Northern Territory Museums and Art Galleries Board. This task involved the location, mapping and documentation of Aboriginal sites of religious significance (sacred sites) in various regions of the Northern Territory. Although possessing no formal academic qualifications Mr Chaloupka has interested himself in Aboriginal art and culture in the Northern Territory, and elsewhere, over many years. He has travelled extensively throughout the Region for the past twenty years and consequently has come to know well both the Region and many of the Aboriginal people living within it. Mr Chaloupka travelled with several of the traditional owners through their territories, and mapped and described sacred sites within their estates. His report is detailed; it obviously was prepared with care, and, we believe, with objectivity. Information as to the location and significance of sites within twenty-two gunmugugur estates was recorded and has been presented to us.

A number of maps were presented upon which had been depicted by Mr Chaloupka the approximate boundaries of the various gunmugugur estates located within the Region. He stated that some of the boundaries were more accurately depicted than others, as some were located as a result of 'on the ground' checking, whilst others were determined some distance from the actual locality, 'from the description of the country, from the description of the adjoining territories and from people's knowledge of existing European names for the rivers'. Clan areas within the area of the land claim made by the Northern Land Council are shown in Map 16.

Mr Chaloupka stated that the boundaries of the following estates were in his view shown more accurately than others: MIRARR GUNDJEIBMI, GARNDITJBAL, JURKMANJ, MURRUMBURR, WILIRGU, WARDJAG, WARRAMAL, DJAMGOLOR, ROL, BARDMARDI, MIRARR ERRE.

Mr Chaloupka also submitted a map upon which were depicted the routes taken by certain mythological creator beings through the Region. The information upon which this map was drawn came from a number of Aboriginal informants who claimed traditional ownership of certain estates within the area. In many respects, however, Mr Chaloupka had been able to cross-check what he was told. The significance of this evidence was said to be that it demonstrated a socio-ritual link between the gunmugugur over whose land the totemic heroes passed. This linkage gives rise to important secondary rights, which are in turn an important factor in deciding traditional succession to land.

Mr J. Hunter, a field officer, employed by the Northern Land Council, later interviewed a number of Aboriginal persons located both inside and outside the Region. He referred the people whom he interviewed to the report by Mr Chaloupka and Mr Keen and found a general consensus as to the validity of the information contained within that report.

The evidence shows that it would be highly unusual for an Aboriginal person to lie about traditional ownership of clan areas and matters connected therewith. On the contrary, Aboriginals usually acknowledge frankly the limits of their own clan areas and the ownership of neighbouring ones. What we have learned supports the following statement in the First Report of Mr Justice Woodward (para. 65):

> I have no doubt that, even today, the necessary information is available to divide much, if not all, of the Northern Territory into dialect group or clan regions. If the right people could be taken out to the right places, to

demonstrate the position on the ground, I believe that there would be little disagreement. I have so far come across no case in which ownership of land has been disputed among full-blooded Aborigines. But the task of obtaining the necessary information from different informants, having different degrees of knowledge, and then converting it into clear terms for record purposes, could undoubtedly be a very long and difficult one. Since detailed surveying would be necessary, the job would certainly take a number of years and the expense would be very great.

The Commission took the initiative of inviting submissions in relation to Aboriginal matters from Professor R. M. and Dr C. H. Berndt of Western Australia. Both Professor and Dr Berndt are highly respected anthropologists who have jointly published what is generally held to be the most authoritative and comprehensive work on the Aboriginal peoples of Western Arnhem Land. Their book *Man, Land and Myth in North Australia: The Gunwinggu People* was based largely on their own field work. It was often referred to during the course of our Inquiry and was taken into evidence as an exhibit. The Commission asked Professor and Dr Berndt to check evidence in relation to anthropological matters raised during the course of the Inquiry, and to give evidence with regard to it. This they did and we wish to express our indebtedness to both of them for the time and effort they gave to the task.

In essence the evidence given by Professor and Dr Berndt at the principal hearings supported the evidence given by Messrs Chaloupka and Keen in the report we have mentioned. Professor and Dr Berndt expressed the view that the boundary of the MIRARR GUNDJEIBMI gunmugugur estate was correctly depicted by Mr Chaloupka, and included the area of the proposed Ranger mine, and they supported the methodology used by Mr Chaloupka in plotting it. They both confirmed the substance of the evidence given by Mr Keen in his report in relation to Aboriginal land ownership and land use.

Succession

It was argued on behalf of the Northern Land Council that when a gunmugugur dies out, members of another gunmugugur may, in accordance with recognised customs and traditions, assume ownership of the estate. Those persons are members of a local descent group who have had secondary responsibility for the sites and the land but who assume primary spiritual responsibility for them on the extinction of those who previously had the primary responsibility. The succeeding group have rights to forage and hunt over the land being taken over. Expert testimony was given to support claims made on this basis.

The only challenge to this view came from counsel for Pancontinental. As we understood his argument, it did not deny the possibility of succession (to use our term) in some circumstances, but contended that the transfer, or succession, did not take place at the time of the death of the last member of a clan, but after a much longer interval, when a different clan could have developed a relationship to the sites being taken over by a process of gradual adaptation of its own particular beliefs and traditions. In the meantime, the last-mentioned group might assume a trusteeship or guardianship over the land of the extinct clan. Counsel did not call oral evidence in support of his argument but relied mainly upon two passages in a book by Professor Lloyd Warner entitled *A Black Civilization* (1937), and upon cross-examination of Dr Peterson, an anthropologist, and of Mr Keen.

The argument, it should be appreciated, was an academic one. It postulated a rather formal doctrine, and said that it was of wide, if not universal, application among Aboriginals, and precluded immediate succession. It was therefore said that the instances of succession relied on could not have happened.

The question of succession was first raised at earlier hearings in Sydney in December 1976, when the Commission received submissions on the subject from Mr Chaloupka and from Mr P. Carroll, the latter being a linguist employed by the Church Missionary Society at Oenpelli. The evidence given at these hearings identified the actual estates in the Region which had been the subject of succession and gave details as to how the succession had arisen, and was recognised.

The Commission was at that time uncertain about the processes of succession and its effects. Mr Justice Woodward only mentions the matter briefly, but what he does say seems to support an argument against immediate succession (First Report, para. 46):

> 46. One further point remains to be made. It is apparent that a clan, being of only moderate size, can die out. This must have happened on occasions even in the days before white contact. With the coming of the white man, such instances must have occurred more frequently even in the Northern Territory. Since the produce of all land is important and, in Aboriginal belief, good seasons depend upon ritual observances, it was normal for the sacred objects and ceremonies of that clan to be taken over or cared for by another closely related clan. Since, as I have said, the connection of Aborigines with their land is timeless, commencing before birth and continuing after death, *this taking over should be seen as a form of trusteeship rather than a transfer of rights.*

Mr Justice Woodward was talking of the position in North-eastern Arnhem Land, which is the area about which Professor Warner wrote, and it is acknowledged that customs and practices often differ as between different regions and over a period of time in the one region (see, for example, paras. 31, 58 of Mr Justice Woodward's First Report). In fact it is known that in one relevant respect the position in West Arnhem Land (with which we are concerned) is different from that in East Arnhem Land. That difference is that in the former region certain social groupings (moieties) are matrilineal, whereas they are patrilineal in East Arnhem Land.

The Commission made it known at the hearings referred to that it wished to have anthropological evidence on the subject and it itself referred the evidence it had received to Professor and Dr Berndt. Their comments, in the form of a statutory declaration, were received in evidence when, in February, we sat in Darwin. The Berndts made some helpful observations concerning the evidence on the topic given by Messrs Chaloupka and Carroll in December, and they disagreed with some parts of it. In general, they supported the existence of a process of succession along the lines of that for which the Northern Land Council contended, although they did not favour the use of the term 'succession'.

At the Darwin hearings a paper entitled 'Succession to land: Primary and secondary rights to Aboriginal estates' by Dr N. Peterson, Dr B. Sansom and Mr I. Keen was presented on behalf of the Northern Land Council. The three authors of the paper were experienced anthropologists, all of whom had had field experience in the Top End of the Northern Territory (Dr Peterson and Mr Keen had both given evidence to the Commission earlier). They supported the view that succession did exist in West Arnhem Land and could be of immediate rather than postponed or suspended operation. Dr Peterson was closely cross-examined by counsel for Pancontinental, as well as by members of the Commission.

On the particular aspect raised in argument—that of delayed succession—Dr Peterson was of the view that the ownership of land by a succeeding clan would not in fact depend upon the creation for itself of a new set of myths rationalising its new ownership, nor would the mythology and ceremonies associated with the extinct clan be forgotten easily. He said: 'The spiritual connections and the spiritual history of particular tracts of land are widely known beyond a single clan, because the religious life of clans is interconnected . . . it is not a matter of the traditions changing before people feel they are the new owners of an area . . .'

After careful consideration we have come to the conclusion that succession of the nature relied upon by the Northern Land Council is recognised in the Region with which we are concerned. It means that primary spiritual responsibility for sites on the land of a clan which becomes extinct will pass to members of another clan which has had kinship and religious ties with the extinct clan. In this way, clan areas can become enlarged. The nature and degree of the association is not precisely fixed and not always the same. In relation to the particular clan areas with which we are concerned, the principal elements are those of kinship and ritual, but recognition of the succession by all interested parties is crucial. Aboriginal persons of one gunmugugur or another, and usually more than one, know who is to succeed. What happens is that recognised secondary rights held by an extant land-owning group are translated into primary rights. As there may be more than one group with secondary rights, the question of which is to succeed may be to a greater or less extent a matter of mutual agreement or understanding between those groups.

At a special hearing of the Commission held in Sydney on 22 March 1977 Dr Letts, Majority Leader and Chief Secretary of the Northern Territory, made a submission in relation to succession which is of a different nature. He argued that 'succession' was not in the contemplation of the Federal Parliament when the land rights legislation was passed, and that its acceptance could have disastrous consequences for law and order in the Northern Territory. It is not possible to know what was in the contemplation of Parliament in relation to the matter in question; doubtless members held a variety of views as to the operation of the legislation. But to refer to succession as if it were a supplement to the Act is apt to be misleading, and is wrong. The Act contains a single definition of 'traditional Aboriginal owners' and it is a question of fact in each case whether it is satisfied. The central question is whether there is a local descent group which has '*common spiritual affiliations* to a *site* on the land, being affiliations that place the group under a *primary spiritual responsibility for that site* and for the land'. An examination of the notion of succession (as we have called it) is an element in determining, as a matter of fact, whether the requirements of the definition are satisfied. One imagines that the possibility of succession to clan areas was present to the mind of any person who has considered the matter. The evidence shows quite conclusively that succession has long been accepted as part of the Aboriginal socio-cultural pattern, and numbers of persons have written concerning it. The particular question for us was whether it could occur immediately, or over a short interval of time, and, if so, whether it had done so.

It is convenient to mention here that Dr Letts invited us to construe and apply the Act as if it had prescribed a policy more in keeping with *The Report of the Committee to Review the Situation of Aborigines on Pastoral Properties in the Northern Territory* of December 1971 (the Gibb Report) than that of the Woodward Report. In particular, he asked us to confine any recommendations we made favouring Aboriginal ownership to land of which they stood 'in need', in a material sense. He explained to us that such an approach would be fair, and more generally acceptable, than a wider or more generous one. He added to his submission the contention that the Woodward Report had not been adequately debated in any parliamentary forum, and inferred that if it had the ensuing legislation would have been less in favour of Aboriginal people. While we appreciate that these considerations were pressed upon us in good faith by the political leader of the Territory Government, we feel, with respect, that we cannot give effect to them. It seems to us that we are obliged, when acting under the Act, to accept it as it is, and to apply faithfully the policies it manifests. In relation to the land claim presented to us by the Northern Land Council, Dr Letts said that some people in the Northern Territory had not been sufficiently aware of all its implications at the time of the Darwin hearings in late February, and he inferred that if they had they might have been more active in opposing it, wholly or to some extent. We do not wish to take time in an already over-long report to set out all the many steps which were taken to make known the existence of the claim, to invite comment upon, or opposition to it, and to make known the days on which we would sit. Those matters are all covered by formal evidence given to us by the Secretary of the Commission. Newspaper publicity given to the claim, and to the hearings, is also in evidence before us. Interested people were given every opportunity to find out the nature and extent of the claim, and to appear at the hearings. Many did. The Commonwealth, through appropriate departments, made known to us at the hearings, all the interests, whether its own or otherwise, which it considered relevant. Dr Letts was present for some time at the hearings, but, because he wrote to us subsequently (the letter and our reply are also in evidence) we invited him to offer any further evidence he thought we should receive. When on 22 March he appeared before us, we again gave him an opportunity to produce any specific evidence he thought relevant, but he did not suggest any. While we think it important to make all these matters clear, we should at the same time say that Dr Letts, both on an earlier occasion and on 22 March, gave us much valuable evidence. We certainly do not wish to be critical of his appearance on the later occasion.

The present Northern Land Council was created on 26 January 1977. In anticipation of its establishment the old Northern Land Council arranged a large meeting of Aboriginal people at Batchelor on 23, 24 and 25 January 1977 for the purpose of getting instructions for the new Council concerning the land rights claims due to be heard by this Commission in Darwin, commencing 22 February 1977. More than one hundred people came together, including fifty-three people whom it was thought had interests in the lands in the Region. Thirty of them were listed by Mr Chaloupka as traditional owners of land the subject of the claim. Linguists were present. An audio and video tape record was taken of what was said and it is in evidence. Mr A. Bishaw, Acting Manager of the Northern Land Council, and Mr Chaloupka were present and they gave us an account of the proceedings. Among other things which took place, the clan areas as depicted on Mr Chaloupka's map, to which we have referred, were suitably explained to those present and the owners of those areas, as understood by Mr Chaloupka (and Mr Bishaw), were named. After deliberations, from some of which white men were excluded, there was unanimous agreement with Mr Chaloupka's information, subject to the addition of the names of two further owners. Although this meeting was arranged at what, for Aboriginal people at least, was relatively short notice, and although the time taken at the meeting was much less than Aboriginal people normally require to consider matters of importance, we believe that the meeting did provide useful confirmation of the evidence of Messrs Keen and Chaloupka. Many of those present had of course already been spoken to on the topic of land ownership by one or both of these people. In relation to a number of clan areas, the Aboriginals agreed upon as owners were those entitled by succession.

Before dealing in detail with the evidence, we should point out that it is not strictly necessary under the Act to identify particular traditional owners. All that is necessary is that there are 'Aboriginals who are the traditional Aboriginal owners of the land' (s. 50 (1) (a) (ii)) whether or not they are the claimants (cf. s. 50 (1) (a) (i)). We understand the scheme of the legislation to allow for Land Councils determining for themselves who are the traditional owners from time to time (see s. 24).

Clan areas, ownership and use

MIRARR GUNDJEIBMI

We now discuss each clan area in turn. The evidence shows that the Ranger mining area, the Jabiru settlement and the proposed regional centre (all of which are unalienated crown land) fall within the boundaries of the estate belonging to the MIRARR GUNDJEIBMI gunmugugur. There are some twenty-four persons identified as being the traditional owners of this estate and their claim is based on primary rights of ownership through patrilineal descent.

The evidence presented by both Mr Keen and Mr Chaloupka identified the members of the gunmugugur and the major sites within the MIRARR GUNDJEIBMI estate. The boundary of the estate was shown upon Mr Chaloupka's map and was claimed to be as accurately plotted as the nature of estate boundaries would allow. A map was also produced which indicated the extent to which Mr Chaloupka and his informants travelled throughout the area of the estate and the sites which they visited. There were some thirteen sites of significance (i.e. sites of religious significance or historical or scientific value) which were identified as being located within the estate.

Ranger questioned the effectiveness of the methodology employed by Mr Chaloupka in determining the boundary of the estate, but it did not challenge the conclusion that the Ranger area was in MIRARR GUNDJEIBMI gunmugugur territory and could become the subject of a Land Trust.

The evidence shows that the Jabiluka mine sites are also located within the boundary of the MIRARR GUNDJEIBMI gunmugugur estate. This evidence was not challenged or contradicted by Pancontinental. However, we cannot make any formal finding on the matter under s. 11 (2) of the Land Rights Act because this land is alienated crown land, being on the Mudginberri pastoral lease area.

MURRUMBURR

The MURRUMBURR gunmugugur estate includes Special Purpose Leases Nos 146 and 147 upon which the Cooinda (Jim Jim) Motel and ancillary services are established. This part is also alienated crown land, and not properly the subject of a finding under s. 11 (2) of the Act. Other parts of this estate are unalienated crown land.

The evidence indicates that there are twenty living members of the MURRUMBURR gunmugugur who claim primary ownership through patrilineal descent. The evidence of Mr Chaloupka identifies four major sites of significance within the area. The boundaries of the estate are also identified. Much of the information regarding the area was given to Mr Chaloupka by Mr Toby Ganggali, an Aboriginal man who, we understand, has spent most of his life living and working in the area. Mr Ganggali was not a member of the MURRUMBURR gunmugugur. The information he gave was cross-checked with other informants, including members of the MURRUMBURR group.

The proprietor of the Coöinda Motel, Opitz 'Cooinda' Enterprises Pty Ltd, did not oppose the claim beyond submitting that the land leased to it was alienated crown land, a submission which we accept. Apart from this submission there was no evidence which opposed or contradicted the claim made on behalf of the MURRUMBURR gunmugugur.

MIRARR ERRE

The estate of the MIRARR ERRE gunmugugur has located within its boundaries the site of the Border Store, at Cahill's Crossing. The evidence shows that there is only one survivor of this gunmugugur, Magdalene Jorawadj, and consequently the group is on the verge of extinction. The Commission was told that the MIRARR GUNDJEIBMI gunmugugur would take over the area on the basis of traditional succession.

The evidence given by Mr Chaloupka was that 'there are two hundred or more individual sites in this clan's territory. They include important archaeological sites which give us the earliest date for the edge ground stone axe, and remains of a Tasmanian Devil. Others are equally important rock painting sites . . .' Details of five sites of significance in the clan area were given in evidence.

The proprietors of the Border Store, Mr and Mrs K. Hill, hold a miners right which allows them to occupy certain portions of crown land for the purposes of residence, market gardening or business, if those purposes are connected with mining (Mining Ordinance s. 23 (1) (f)). We were not told of any mining purpose they are furthering, but they nevertheless hold, by virtue of the miners right, mining tenements known as Business Area 7A and Garden Area 39A (see Mining Regn 81) on one or both of which the Border Store is erected, and which are within the MIRARR ERRE gunmugugur. It was conceded that the occupation of crown land by way of a mining tenement did not result in it being alienated within the meaning of the Aboriginal Land Rights (N.T.) Act. The area was therefore the proper subject of a land claim. The validity of the claim itself was not questioned by the proprietors of the Border Store nor was there any evidence presented which contradicted the claim as presented on behalf of the surviving member of the MIRARR ERRE gunmugugur. They did, however, oppose the granting of land rights in respect of the land occupied by the Border Store. The grounds of objection are dealt with later in this chapter under the heading *Detriment to others.*

ROL

The ROL estate as described in the evidence by Mr Chaloupka encompasses the areas in which Noranda Australia Limited have established certain mining interests, already referred to.

The evidence indicates that there are seventeen members of the ROL gunmugugur who claim primary ownership of the estate through patrilineal descent.

Noranda Australia Limited did not oppose the claim but submitted that its nine mineral lease applications lodged before 4 June 1976 were 'protected' under s. 40 (3) (see Chapter 14), and that otherwise its established interests should be given due consideration by this Commission in accordance with s. 50 (3) (b) of the Aboriginal Land Rights Act.

Counsel for Noranda questioned Mr Chaloupka concerning the location of the respective boundaries of the ROL estate and those of the WARRAMAL and WARDJAG estates, as there seemed some doubt as to the estate in which the Koongarra site was located. Mr Chaloupka was firm in his view that the Koongarra site fell within the ROL estate. He said: 'The ROL territory extends from the road leading to Koongarra'. No opposing or contradictory evidence was presented by Noranda Australia Limited. In view of Mr Chaloupka's oral evidence, and his acknowledgement that the boundary as shown on the map tendered was only approximate, we are of the view, on the balance of evidence, that the Koongarra mine site is located in the ROL estate.

BARDMARDI

The BARDMARDI gunmugugur estate contains within it some thirteen sites of significance which were identified and described in evidence. The Commission was told that another 100 sites or more containing occupational deposits and rock paintings as well as numerous traditional quartzite quarries and worksites had been located. There are eleven members identified as being the primary owners of the estate.

BUNITJ

The BUNITJ gunmugugur has five living members claiming primary ownership of that estate. The estate consists mainly of subcoastal flood plains and the evidence describes three sites of significance located within it.

DADJBAGU

The DADJBAGU gunmugugur estate as depicted in the evidence is relatively small. Information about the size of the estate and its boundaries derived solely from members of neighbouring gunmugugur. The two living survivors of the DADJBAGU gunmugugur reside outside the Region, at Humpty Doo. No sites of significance were referred to in the evidence.

GARNDITJBAL

The GARNDITJBAL gunmugugur membership is limited to three people, whose territory includes the catchments of Coirwong, Goodparla and Gerowie Creeks and the South Alligator River from above the U.D.P. Falls to 7 kilometres north of Long Billabong. The area includes the Goodparla homestead. Nine sites of significance were named and described in the evidence.

JURKMANJ

The JURKMANJ gunmugugur has two female survivors. The evidence describes five sites of major significance within the estate.

KODJKARNDI

Maudie (Hunter) Gundjalk is the only surviving member of the KODJKARNDI gunmugugur. The Commission was told that the estate would pass to the MIRARR GUNDJEIBMI on the extinction of the KODJKARNDI gunmugugur. One site of significance in the estate was described, and this was an 'Ubar' ceremonial ground located at Bandjibandji hill.

MANILAGARR

A small portion of the MANILAGARR gunmugugur estate protrudes into the area the subject of the land claim. There were ten members identified as being primary owners of the estate. No evidence was given in relation to sites of significance within the estate, but the boundaries are depicted upon the map produced by Mr Chaloupka.

WURNJGOMGU

The WURNJGOMGU gunmugugur estate lies in the south-east portion of the land claim. There are six members claiming primary ownership of the estate. One major site of significance has been identified and described in the evidence.

WILIRGU
MARRERMU

Although the two gunmugugur WILIRGU and MARRERMU are, according to the evidence presented, without primary heirs, a large proportion of both their estates are in fact covered by the Woolwonga Aboriginal Reserve. Under the provisions of the Land Rights Act, the area within the reserve is now Aboriginal land (see Schedule 1 to the Act).

The remainder of the area claimed comprises the whole, or in some cases part, of the DJINDIBI, DJAMGOLOR, DJONED, MADALG, WARRAMAL and WARDJAG estates. They are without members of gunmugugur claiming long-standing ownership by their clan through patrilineal descent. These areas are now claimed by other gunmugugur on the basis of traditional succession.

Claims based on succession

Mr Chaloupka gave evidence concerning the individual gunmugugur who claimed ownership of estates originally belonging to now extinct gunmugugur. We now deal in turn with each set of clan territories.

DJAMGOLOR DJAMGOLOR gunmugugur territory, succeeded to by the WORGOL gunmugugur. Mr Chaloupka's evidence that there were no longer any living members of the DJAMGOLOR gunmugugur came from three major informants–Jimmy Namandjalawogwog, Nipper Gabarrigi and Elijah Namarabundja, all old men from neighbouring gunmugugur. That WORGOL had succeeded to DJAMGOLOR territory came from information given by five Aboriginal informants–Nipper Gabarrigi, Jimmy Madjandi, Toby Ganggali, Maudie Hunter and George Namingurr. Although questioned independently, they agreed that WORGOL succeeded to DJAMGOLOR territory. The evidence given indicates that the secondary rights held by the WORGOL gunmugugur arose from mytho-totemic links between the two groups manifested in the sharing of a common Ubar ceremonial ground.

WARDJAG The WARDJAG gunmugugur territory, succeeded to by the ROL gunmugugur. Mr Chaloupka identified the last two members of the extinct clan as Nym Djinarggar and Fred Namandjalawogwog, and they died in 1967 and 1974 respectively.

Mr Chaloupka's informants as to succession in this case were Nipper Gabarrigi, George Namingurr, Jimmy Madjandi, Toby Ganggali and Frank Nalowed. These men were said to have a good knowledge of the Region as they had lived within it for most of their lives. All were senior members of their respective gunmugugur. The secondary rights held by the ROL gunmugugur arose from the fact that the ROL members had entitlement to use and occupy the WARDJAG estate and in addition had mytho-ritual connections with the extinct group.

WARRAMAL MADALG The WARRAMAL and MADALG estates, succeeded to by the BARDMARDI gunmugugur. The evidence as to the extinction of the WARRAMAL gunmugugur is based primarily on an absence of knowledge amongst persons interviewed of any living members of the clan. The consensus was that there were none. Mr Chaloupka said that a man who was reported to be the last surviving member had died in the late 1950s. A number of informants confirmed that the MADALG gunmugugur was extinct.

The secondary rights held by the BARDMARDI gunmugugur in respect of both estates derived principally from socio-ritual connections. A map in evidence shows the social range of a BARDMARDI man and his family which it was claimed demonstrated the close connections which existed between the BARDMARDI group and the members of both the MADALG and WARRAMAL gunmugugur.

MARRERMU WILIRGU The MARRERMU and WILIRGU estates are largely within the Woolwonga Aboriginal Reserve. The evidence indicates that the MURRUMBURR gunmugugur has succeeded to their estates on the basis of having close socio-ritual ties with the extinct clans. Mr Chaloupka said that his informants told him of a close social and spiritual relation between the three groups, based on a common usage of two large ceremonial grounds located within the MARRERMU estate. The members of the three gunmugugur also shared responsibilities in relation to a site connected with Waramurungundji, an important creator being.

The evidence given by both Mr Bishaw and Mr Chaloupka in relation to the Batchelor meeting previously mentioned indicated that the traditional owners of other gunmugugur estates within the Region confirmed that the clans identified by Mr Chaloupka had succeeded to the particular areas mentioned by him. It is clear that they were prepared to accept that position, and that in itself is significant.

DJINDIBI The DJINDIBI gunmugugur is extinct. The last surviving member was said to be Ruby Gayden, and she is now dead. In respect of this area succession has not been proved. While it may be inferred that there are now some traditional owners, whoever they may be, we prefer not to make a finding on the subject without more specific evidence.

The Northern Land Council was told by the traditional owners of land in the Region who attended the Batchelor conference that the area of land west of the South Alligator River through to the western boundary of the land claimed should transfer to the MURRUMBURR gunmugugur. This area is outside of and geographically distinct from the larger area of the claim in which Aboriginal ownership has been established. The evidence presented to this Commission in support of the claims of ownership over this particular area is in our view insufficient for us to make any findings in respect of it. While it may be possible for inferences to be drawn that, whoever the owners might be, it is land with traditional owners, and land which Aboriginal people are entitled by tradition to use or occupy, we are of the view that we should not draw such inferences in the absence of more specific and detailed information.

We have so far dealt principally with the question of traditional ownership. For reasons which have already been made clear, it is plain that there are groups of Aboriginals entitled by Aboriginal tradition to the use or occupation of the land in respect of which we find there are traditional owners.

Further considerations —traditional attachment

We have set out the terms of sub-sections (3) and (4) of s. 50 in Chapter 14. In short, they require the Commission to have regard to certain matters. The first of these considerations (dealt with in the opening words of the sub-section) is the strength or otherwise of the traditional attachment by the claimants to the land they respectively claim. The Commission was concerned to establish the degree to which traditional spiritual affiliation to various sites was still meaningful to the Aboriginal people and to what extent the indigenous religion of the people was still considered important by them. This is a difficult enough matter to determine with white people. With Aboriginal people problems of communication make it much more difficult. We did not attempt to examine most of the claimants ourselves in relation to such matters. Aboriginal people did however give evidence before us, some with the assistance of an interpreter or linguist. A number dealt with traditional beliefs, and especially with the meaning land had for them. Mr Silas Roberts, who understands and speaks English well, gave evidence to us twice. He was the President of the old Northern Land Council, and is the President of the new Northern Land Council. He dealt specifically, and in some detail, with traditional Aboriginal beliefs, and, by implication, with the degree to which Aboriginals in the Region still adhere to and practise those beliefs. His evidence was to the effect that traditional customs and beliefs are still meaningful to Aboriginal people in the Region. Ceremonials are still held and sites are still respected. There is in general a strong identity with and concern for the land. No one seriously challenged his evidence on those matters, or the evidence of any other Aboriginal who gave evidence to similar effect.

The Commission thought the evidence of white people who have close association with the Aboriginals to be of considerable value in this connection. For example, Mr Peter Carroll, a Christian missionary who has worked at Oenpelli for a number of years, expressed the view that the Christian religion had had 'very little effect' upon the traditional beliefs and mythology of the Aboriginal people. Ceremonials were still held quite often, not always at traditional sites. Mr E. C. Evans, at the time he gave evidence in 1976 an officer employed by the Department of Aboriginal Affairs with some thirty years' experience in the field, believed that 'Oenpelli people still, a large majority of them, more than 50 per cent I'd say, have still got a strong belief in the traditional religion, side by side with whatever influence the mission has had'. The evidence to which we have referred was not challenged nor was it contradicted by any other evidence brought before the Commission.

It is a fact that to some Aboriginals, particularly some younger ones, traditional beliefs have less meaning, and gain but slight adherence. In one way or another this is of course a direct result of the advent of the white man and his disruptive influence on the traditional socio-cultural pattern of Aboriginal life. It is possible that the numbers and proportion of the people thus affected will increase; we do not know. It should not, however, be accepted that Aboriginal traditions and customs are immutable or that Aboriginal people, given the opportunity, will necessarily wish to return to the ways of their parents and grandparents. Nor should it be accepted that the attitudes of all Aboriginal people in a region are necessarily uniform. The changes, and the differences in attitude, provide another reason why self-determination is important. Mr Justice Woodward made what we believe to be a very pertinent observation (Second Report, para. 60);

> Aborigines should be free to choose their own manner of living. In saying this it is necessary to remind some non-Aboriginal enthusiasts that this involves a freedom to change traditional ways as well as a freedom to retain them.

The evidence shows that most of the claimants, for one reason or another, do not live permanently or even for long periods of time upon their own traditional estates. Some do, but they are few. It is possible that some have never been on their own estates, although it is still quite common for numbers of Aboriginals to return for ceremonies to land for which they have spiritual responsibility. Of the total number of persons identified as traditional owners in the present case, it was estimated that only a small fraction would have lived on their own clan areas for any length of time.

It is not suggested that attachments to land can or should be judged on the basis of actual and substantial occupation. Clearly this was not a traditional requirement, and it is not contemplated by the legislation. It has been pointed out that Aboriginal occupation of land was always sparse, even in the northern coastal regions. It has been estimated that there were only 300 000 Aboriginals living on the whole Australian continent in 1788. The anthropological evidence points to the fact that members of a gunmugugur often spent extended periods of time away from their own estates, but this in no way lessened their attachment or entitlement to them. With the intrusion of white men and their conflicting land uses, with the pressing of assimilation and integration policies by governments in relation to Aboriginals, and with the establishment of towns, missions and pastoral properties, opportunities to utilise and to occupy traditional estates were lessened. There is evidence that some Aboriginal groups are now returning to traditional estates in the Arnhem Land Aboriginal Reserve and establishing decentralised communities, or outstations (see Chapter 4). Given time and the opportunity, some of the claimants may well attempt to develop similar communities within their own estates, if their title thereto is recognised.

Having carefully considered the evidence, we have formed the opinion that in general traditional spiritual affiliation with the land in the Region continues. It tends to be stronger with the middle-aged and elderly, but can fairly be said to be present with all the claimants, in some degree.

Although it has so far been necessary to consider each clan area separately, para. (a) of s. 50 (3) requires consideration to be given not simply to the Aboriginals who are *claimants* for a particular area of land, but to 'the number of Aboriginals with traditional attachments to the land claimed'. This makes for a more sensible and practical approach to the question the paragraph poses: the number who will be advantaged, and the nature and extent of the advantage, if the claim is acceded to.

The number of people we have identified as traditional owners of the clan areas (including the alienated parts thereof) is 107. The number of Aboriginals who are entitled to the use or occupation of that land is much greater, but cannot be stated with accuracy. We discuss later the question whether each clan has an entitlement to the use or occupation of all the clan areas with which we are concerned, and conclude that they do. There are others besides who will have such an entitlement to at least one of those clan areas. Their numbers may be as few as fifty or a hundred or as many as several hundreds. We doubt if there are more. They will come from a wide area. Mr Chaloupka identified the places where the fifty-three people mentioned earlier, including the thirty listed as owners, were then living:

Place where now living	*No. of persons*
Black Point–Cobourg Peninsula	1
Murgenella	2
Mudginberri	9
Woolwonga	1
Spring Peak	1
Jim Jim	2
Oenpelli	18
Annaburroo	1
Humpty Doo	3
Pine Creek	12
Katherine	1
Bamyili	1
Darwin	1
Total	53

The advantages which would accrue if title were recognised to the traditional land are mainly of three kinds: (a) use or occupation, (b) mining royalties, rent and agreed payments, (c) spiritual and psychological consequences.

(a) Use or occupation

The extent and nature of Aboriginal use or occupation will depend on whether mining proceeds, and whether a national park is created, and, if so, where. If, and to the extent that, mining leases are granted, Aboriginal use or occupation will probably be minimal. Nevertheless, the Northern Land Council will have a greater say in protecting their lands than otherwise would be the case; terms and conditions have to be agreed with it. The Northern Land Council will have an important say in reserving a right to use land which becomes part of a national park for traditional purposes, including if desired a right to forage.

We see it as being a likely consequence of the recognition of Aboriginal title that some of the larger settlements, for example those at Oenpelli and

Mudginberri, will become smaller, with some of their present occupants moving out into outstations, or at least into less developed territory. We also believe that if, through recognition of Aboriginal title, a spirit of traditionalism is allowed to return, some will become more nomadic than they have been in recent years. In other words, we see some return, which may not be very great, to the natural customs and practices which developments generated by the white man have stultified for some time. To the extent to which the subject land becomes Aboriginal land, and remains so, without also becoming a mining area or national park, we believe that there will be some limited use and occupation of it by Aboriginal people, including, in particular, those with a traditional attachment to it. In white man's terms, the degree of use and occupation, in relation to the size of the areas in question, will be very small indeed. Even so, it is to be borne in mind that Aboriginals are at present by far the larger part of the population, and are likely to be so again once mining ceases, an event which will probably be in the lifetime of many Aboriginals now living. Aboriginals at present constitute over 60 per cent of the rural population of the Territory.

(b) Agreed payments, rent and mining royalties

Monetary benefits flowing from the giving to Aboriginals of title to areas proposed to be mined are discussed in Chapter 14. Briefly, they are three:

(i) *Payments* agreed between the Northern Land Council and the miners under ss. 43 or 44. These moneys are to be applied by the Land Council in accordance with the agreement, or, if the agreement makes no relevant provisions, they are to be paid to Aboriginal Councils or incorporated Communities in the Region (s. 35 (3)). Their scale, and the beneficiaries, will be regulated by the agreement.

(ii) *Rent.* Whether the Crown will receive rent, or pay an amount equivalent to what it might have received were it not itself involved in the operation, remains to be determined. The amount thereof, if paid, is to be received by the Northern Land Council, and paid by it to, or applied by it for the benefit of, the traditional owners of the land to which it relates. The amount of the rent payable under a mineral lease is normally small. Currently the amount payable under the Mining Ordinance (s. 50 (1)) is 50 cents per acre per annum. It is the same for a special mineral lease (s. 54F (2)).

(iii) *Royalties.* The amount and disposition of royalties are dealt with in Chapter 14. The sums involved in the case of the Ranger and Jabiluka mines are likely to be very big. No Aboriginal is given a right to receive any sum himself, but substantial amounts are likely to be paid to local councils and communities for the benefit of Aboriginals in the Region, and these will undoubtedly include Aboriginals with traditional attachments to the subject land.

(c) Spiritual and psychological consequences

This is the most important aspect. It is related to (a), but is largely a separate consideration. While royalties and the other payments referred to in (b) are not unimportant to the Aboriginal people, they see this aspect as incidental, as a material recognition of their rights. The material benefits they visualise as likely to become available to them by reason of their collective receipt of these amounts are things like motor vehicles, hunting rifles, fishing gear and the like. Our impression is that they would happily forgo the lot in exchange for an assurance that mining would not proceed. We had an illustration of this attitude in February 1977 when the traditional owners, through two mature and informed spokesmen who had available to them the advice of counsel and solicitor, asked us while we were at the site to fix the southern boundary of the mine area on a line which ran through the centre of the Ranger No. 1 ore body—a line which they knew would make the mining proposal impossible.

The Aboriginal people with traditional attachment to the land we are discussing are for the most part, in common with others of their race in the Region, in a depressed and debased condition. The condition of most, and the behaviour of some, particularly in relation to drink, is the despair of their own elders and of many white people. The great need, constantly explained in the evidence before us, is to provide them with the means of making their lives meaningful in their own terms, and of thus restoring their own dignity and self-assurance. It is thought that a recognition of their association with the land and the grant to them of title to it, albeit in white man's terms, are basic means to that end. In our view it is an egregious error to regard this simply in material terms. We do not accept, any more than did Mr Justice Woodward, or the Federal Parliament when it enacted the land rights legislation, that the answer lies in giving to the Aboriginals only such land as they 'need' for material purposes. It is probably sufficient answer to that argument to point out, again, that their relationship to the land, that is the whole land, is essentially religious in nature. It is possible if part of their land is to become subject to mining operations, and most or all of the rest is to become a national park, that some of the spiritual satisfaction and psychological benefit will be lost. This is not an argument for rejecting their claim; what it does point to is the desirability of recognising their title as fully as that can reasonably be done, consistently with other compelling purposes. In fact, while they are opposed to mining, they are not opposed to the creation of a national park over their land.

Detriment to others

Paragraph (b) of s. 50 (3) asks for comment upon 'the detriment to persons or communities including other Aboriginal groups that might result if the claim were acceded to either in whole or in part'. This is best done by reference to those with known interests or claims in the area, each in turn.

(i) Ranger. The Ranger proponents do not oppose the Aboriginal claim. Whether their proposal will be affected at all depends, of course, on whether it is allowed to proceed, and to some extent on the terms on which it is allowed to do so. If approval is given by the Government, the major disadvantages to Ranger will be the need to agree on terms and conditions with the Northern Land Council before it can secure the grant of a mining interest or authority, and compliance with those terms and conditions. This may include making continuing payments of money to the Northern Land Council. The conditions will doubtless also include one respecting the location of the southern boundary of the mine area—that which is nearest Mt Brockman and the sacred sites in its vicinity. We were invited by the Northern Land Council to express a view about this matter, and we do so (at the conclusion of this chapter) in the hope that further debate might thus be obviated, or at least minimised. Although we were asked at one stage by Ranger not to make a finding under the Land Rights Act in respect of the site which has been proposed for the regional centre, it did not oppose the claim so far as it extended to that area. The site is in fact within the same clan area as the Ranger mine, but it is outside the Ranger Project Area. If the whole clan area (excluding that part which is within Mudginberri and therefore already alienated) becomes Aboriginal land, the Northern Land Council will have the right to refuse consent to the regional centre, as proposed. They could in this way stop the mining project unless it proved possible to house the miners and their families on some part of the Ranger Project Area. We believe that if mining at Ranger were approved, consent to the establishment of the regional centre, where currently proposed, would not be withheld. In fact, we think it will be a solution which is acceptable to the Aboriginal people for the land which constitutes the town to remain crown land and become part of the national park, and we so recommend.

There will be other, relatively minor, disadvantages to Ranger if the Aboriginal claim is acceded to. There is the matter of restricted entry to the mine area, which we have discussed in Chapter 14, and restrictions will exist in relation to other, neighbouring lands which might not exist, or be so strict, if the land remained crown land. We were not addressed on these matters, and conclude that they are not seen as a major consideration.

It is possible for the Ranger lease or authority to be granted first and for an Aboriginal Land Trust in respect of the same area to be constituted later. This was not suggested to us. It would, inter alia, deprive the Aboriginal people of the right to settle with Ranger terms and conditions acceptable to them as the basis for mining to proceed. We do not think this would be a wise course.

(ii) The Border Store. The grant of Aboriginal title is consistent with the title and possession of the proprietors of the Border Store, since the land on which it is situated is unalienated crown land for the purposes of the Land Rights Act (see Chapter 14). Although the validity of the claim so far as it related to the Border Store was not disputed, the proprietors of the store were opposed to the land becoming Aboriginal land. They also denied the jurisdiction of the Commission to make a finding in relation to it under s. 11 (2) of the Act—for the reason that it was outside the Ranger Project Area. We have already said that the operation of s. 11 (2) is not confined to the Ranger Project Area. The reasons advanced in support of the submission that we should not recommend that the land become Aboriginal land were related to the volume and nature of the business the store transacts. It was said that it provides an important, if not necessary, facility for the few white men resident in the vicinity, and for the many tourists, as well as for Aboriginal people living in or passing through the area. There is we think much to be said for the importance of the store for tourists, and for some people living in the immediate area. Accounts submitted to us showed that in the period 1 July 1976 to 22 February 1977 gross sales were \$117 000, the trading profit was \$54 900, and net profit \$48 919. The figures for the year ending 30 June 1976 (during the whole of which the store was under different owner/managership) were: gross sales \$152 698, trading profit \$44 874 and net profit \$32 313. We were told that liquor sales (nearly all beer) comprised in value about half the total sales.

We discuss in Chapter 13, when dealing with proposals concerning alcoholism, the problem posed for the welfare of the Aboriginal people by the sale of beer at the Border Store, and we make recommendations in this connection. On the present question we think that there is a need for the operations of the store to be fitted into the plans for the area. It has grown up in an unregulated way, and its liquor sales have in the past contributed greatly to the degradation of the Aboriginal people, particularly those at Oenpelli. It seems to us that if it is of importance as a provisions store it is entirely incongruous that the authority for its presence rests on annually renewable mining authorities. In our view the store should not become an isolated enclave, but should, with the neighbouring land, become Aboriginal land and part of the national park, and should be subject to the control mechanisms that those steps involve.

(iii) Noranda. The principle detriment to Noranda, and a serious one, is that if the land on which its mining operations at Koongarra are to be carried on becomes Aboriginal land before the grant of the necessary leases or authorities to them, they will not be able to carry on those operations without prior Aboriginal consent. We have discussed the matter in Chapter 14. We were invited in this connection to take into account a letter dated 1 September 1976 from the Minister for Aboriginal Affairs to Noranda, and we have done so.

Our view is that, if the Noranda operations were carried out in accordance with present plans, they would of themselves constitute a serious danger to the environment. The presence of more than two operating mines in the Region, west of the Arnhem Land Aboriginal Reserve, would, in our view, be quite unacceptable, for reasons stated in Chapter 8. As discussed in Chapter 12, the population of resident Europeans in the Region should be strictly limited. The operation of the Noranda mine concurrently with the Ranger and Pancontinental mines would involve bringing into the Region an excessive number of Europeans. Noranda should not therefore be allowed to proceed. The company is in fact a long way from being able to do so, and its situation offers no sufficient reason for refusing to grant Aboriginal title over the land on which its proposed mine is situated. We doubt whether, as planned, the operation would be acceptable at any time in the future, simply because of its location at the headwaters of the Nourlangie Creek system, but the position can be examined again at a later time.

Alienated crown land

This includes Munmarlary, Mudginberri, the Cooinda Motel–Hotel and the Roper Bar Trading Co.'s premises on the Arnhem Highway just west of the South Alligator River. In accordance with the suggestion of Northern Pastoral Services (the owners of the two pastoral leases), and the request of the Northern Land Council, we recommend that their properties be resumed. It is likely that Aboriginal land claims will then be made in respect of those areas of land and, if they are made, it seems to us likely from the evidence we have received that it will be found that there is traditional ownership and traditional use and occupation which will support a recommendation under s. 11 (1) that they become Aboriginal land. Because of the number of Aboriginals living at the Mudginberri settlement, the provisions of s. 50 (4), referred to in Chapter 14, would become important.

Although we would prefer not to have to express any view about what should happen in relation to these properties, it seems to us to be unsatisfactory not to do so. In our view they should as soon as possible become Aboriginal land, and then part of the national park. The present lessees have not objected to such a course, because their interest as lessees will cease with resumption.

The lessee of Cooinda and the lessee of the Roper Bar premises at the South Alligator River, both of whom were represented before us, did not raise any objection to the land claim, beyond submitting that their respective interests as lessees should not be prejudiced. The Cooinda leases were granted in 1964 for a term of thirty years and the Roper Bar lease was granted in 1975 for a term of fifty years. Those leases are not a proper subject of the land claim, and we do not make any recommendation for their termination.

Mining tenements and interests

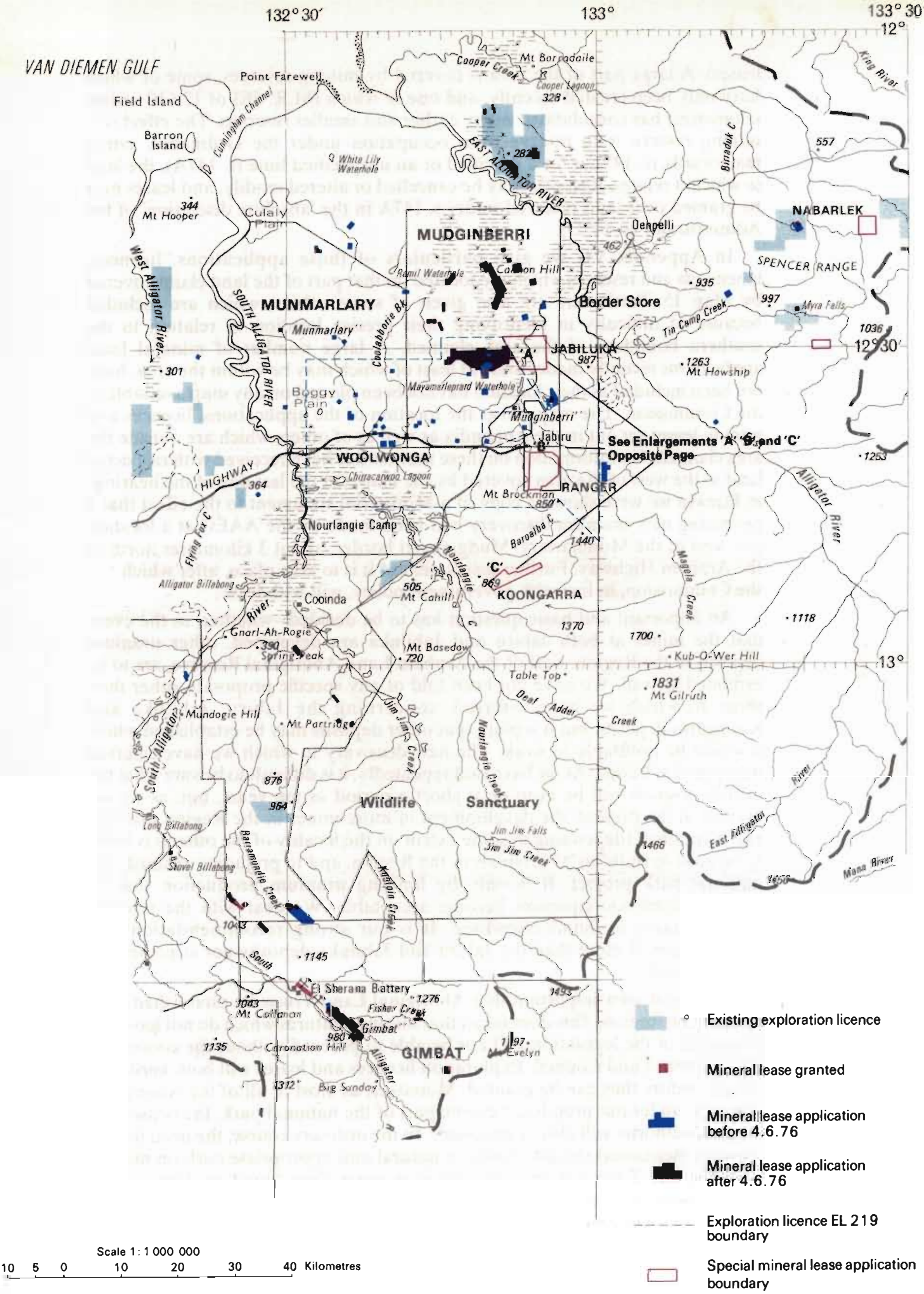
We have already discussed the lease applications of Ranger, Pancontinental and Noranda relevant to their proposed mining operations. In the total area claimed there are a number of exploration licences, a number of applications for exploration licences and many applications for mining tenements (e.g. mining leases). A large part of the area is covered by mining reserves, some of which have only been created recently, and one of which (M.R. 563 of 12 610 square kilometres) has consolidated many earlier and smaller reserves. The effect of a mining reserve is to reserve from occupation under the Ordinance, either temporarily (s. 147) or for a specified or an unspecified time (s. 147A), the land to which it relates. Reserves may be cancelled or altered readily, and leases may be granted over land reserved under s. 147A in the 'absolute discretion' of the Administrator (s. 147D).

In Appendix VII we give particulars of those applications, licences, tenements and reserves which are located on that part of the land claim covered by Map 15. Particulars are also given of some others, which are included because of difficulty in identifying their precise location in relation to the southern boundary of the area claimed. A large number of mineral lease applications recently made, some at least of which may be within the area, have not been included as their location has not been plotted on any map available to the Commission. The map shows the location of the applications, licences and mining leases set out in the Appendix as well as of others which are outside the area claimed. No information on these matters has been received with respect to land to the west of the area covered by the map. On the last day of the hearings in Darwin we were shown a copy of a Ministerial statement to the effect that a promising new uranium discovery had been made by the AAEC at a location just west of the Munmarlary–Mudginberri border, about 3 kilometres north of the Arnhem Highway. Further assessment of it is to take place, after which '. . . the Commission, in line with government policy, will withdraw'.

An important and basic question has to be decided—whether, in the event that the mines at both Jabiru and Jabiluka are developed, other uranium deposits in the Region, west of the Arnhem Land Aboriginal Reserve, are to be exploited as well. We have not been told of any specific proposals, other than those to which we have referred, concerning the Jabiru, Jabiluka and Koongarra deposits, but it is plain that other deposits may be established which it would be profitable to work. The new discovery to which we have referred may prove to be one. As we have said repeatedly, it is difficult to be sure what the overall position will be even in as short a period as ten years, but, as we see matters at the present, the development of more mines in the Region than the two mentioned (depending to some extent on the locality of the others) is likely to be most harmful to Aboriginals in the Region, and to prejudice seriously the national park project. It is only by limiting uranium production that its environmental consequences become acceptable. We deal with the relevant considerations in detail elsewhere. It is our strong recommendation that development of more than the Jabiru and Jabiluka deposits not at present be contemplated.

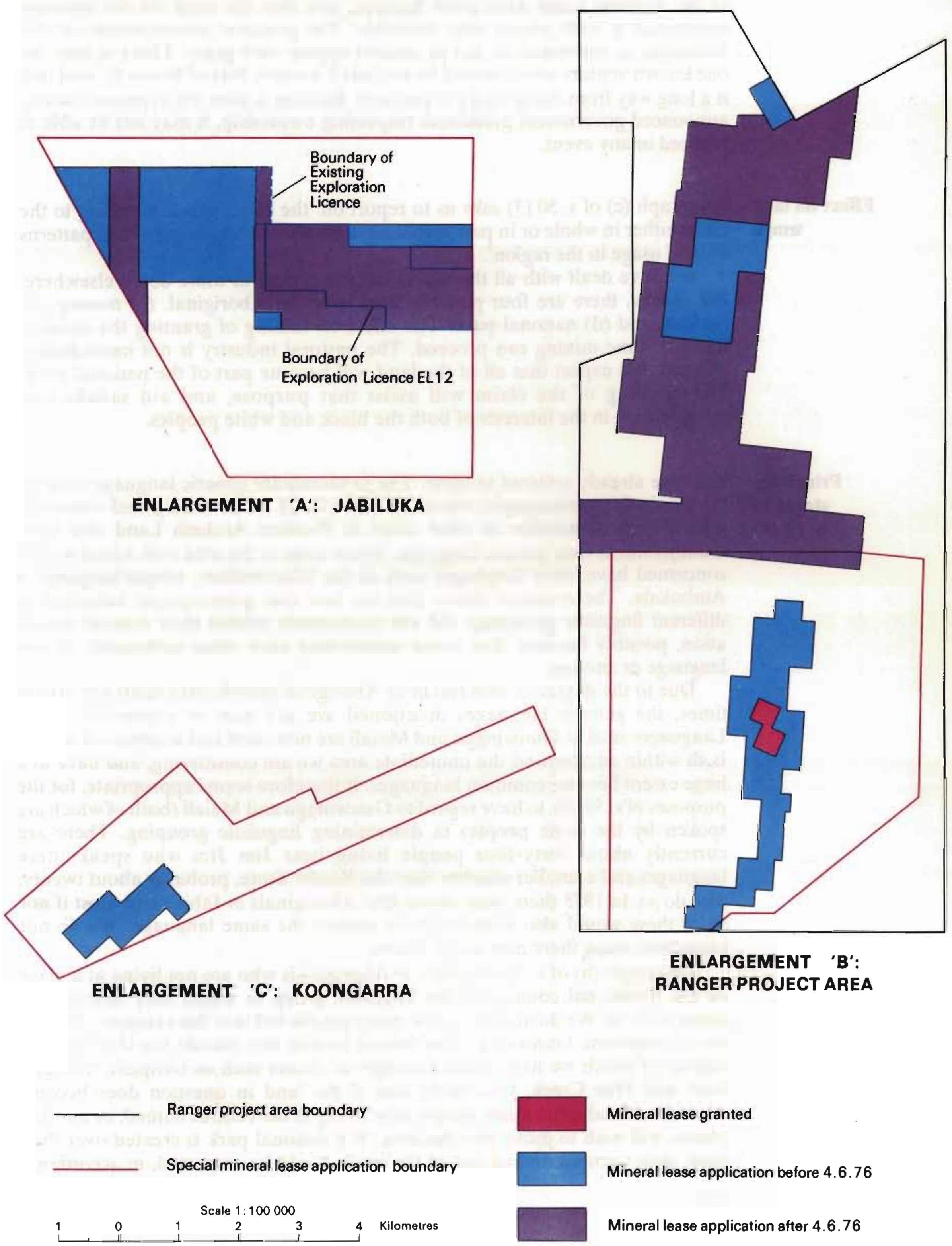
It is in our view important that Aboriginal Land Trusts be established over much of the Region. This does mean that mining ventures which do not have the protection of the legislation will not be able to proceed without the consent of the Northern Land Council. Exploration licences and leases will both need that consent before they can be granted. Moreover, as most or all of the Aboriginal land will, under our proposal, become part of the national park, the consent of the park authority will also be necessary. In the ordinary course, the need for the consents mentioned should provide a natural and appropriate curb on mining ventures, but if the national interest is at some time found to demand the development of a mine or mines notwithstanding the absence of a necessary consent, this can and should be attended to by legislation. At present it is our

MAP 15



Mining Tenures

NMP 76/221.12


Boundary of Existing Exploration Licence
Boundary of Exploration Licence EL12
ENLARGEMENT 'A': JABILUKA
ENLARGEMENT 'B': RANGER PROJECT AREA
ENLARGEMENT 'C': KOONGARRA
Ranger project area boundary
Special mineral lease application boundary
Scale 1:100 000
1 0 1 2 3 4 Kilometres
Mineral lease granted
Mineral lease application before 4.6.76
Mineral lease application after 4.6.76

view, based on considerations discussed in our First Report, as well as in this Report, that two mines in the Region are the most that should be permitted west of the Arnhem Land Aboriginal Reserve, and that the need for the consents mentioned is both proper and desirable. The practical consequences of this limitation or restriction do not at present appear very great. There is only the one known venture which would be excluded, namely that of Noranda, and that is a long way from being ready to proceed. Because it does not at present satisfy announced government guidelines respecting ownership, it may not be able to proceed in any event.

Effect on land usage

Paragraph (c) of s. 50 (3) asks us to report on 'the effect which acceding to the claim either in whole or in part would have on the existing or proposed patterns of land usage in the region'.

We have dealt with all the aspects of this matter in more detail elsewhere. Put shortly, there are four possible land uses: (a) Aboriginal, (b) mining, (c) pastoral and (d) national park. The effect on mining of granting the claim is limited; some mining can proceed. The pastoral industry is not immediately affected. We expect that all of the land will become part of the national park. The granting of the claim will assist that purpose, and aid satisfactory management in the interests of both the black and white peoples.

Principles stated in s. 50 (4)

We have already referred to these. The predominant generic language used by the particular gunmugugur whom we have listed as the traditional owners is Gundjeibmi. A number of other clans in Western Arnhem Land also have Gundjeibmi as their generic language. Some clans in the area with which we are concerned have other languages such as the Murrumburr, whose language is Ambukala. The evidence shows that the fact that gunmugugur belonged to different linguistic groupings did not particularly inhibit their mutual association, possibly because they could understand each other sufficiently in one language or another.

Due to the degree of movement of Aboriginal people over relatively recent times, the generic languages mentioned are not now so commonly used. Languages such as Gunwinggu and Maiali are now used and understood widely both within and beyond the immediate area we are considering, and have to a large extent become common languages. It therefore seems appropriate, for the purposes of s. 50 (4), to have regard to Gunwinggu and Maiali (both of which are spoken by the same people) in determining linguistic grouping. There are currently about forty-four people living near Jim Jim who speak these languages and a smaller number near the Border Store, probably about twenty, who do so. In 1975 there were about fifty Aboriginals at Jabiru and most if not all of these would also probably have spoken the same language. We do not know how many there now are at Jabiru.

Paragraph (b) of s. 50 (4) refers to Aboriginals who are not living at a place on the traditional country of the linguistic group to which they belong, but desire to do so. We do not know how many people fall into this category. Most of the Gundjeibmi, Gunwinggu and Maiali people live outside the clan areas in respect of which we have made findings—at places such as Oenpelli, Mudginberri and Pine Creek. It is likely that if the land in question does become Aboriginal land quite a few people now living at the centres named, or at other places, will wish to move into the area. If a national park is created over their land, their occupation and use of the land should be respected, in accordance with the principles of s. 50 (4). The occupancy of those living at Jabiru will doubtless be suitably protected by the Northern Land Council under the agreement which ss. 43 (2) and 44 (2) require.

Formal findings It seems to us that the scheme established by ss. 4, 11 and 50 of the Act requires that findings and recommendations be made in relation to identified finite areas of land, of which there are traditional Aboriginal owners, and which Aboriginal persons are entitled by Aboriginal tradition to use or occupy. In relation to both requirements, what are to be looked for are groups of Aboriginals. These may be gunmugugur, as in the present case, or tribal or linguistic groups. We do not doubt that a sole surviving member of a clan can be regarded as a group for relevant purposes.

In establishing a Land Trust the Minister must identify the groups for whose benefit the land is to be held in trust (s. 4 (2) (b)). Section 4 (1) makes it plain that the 'beneficiaries' are to be groups having traditional entitlement to the use or occupation of the land the subject of the trust. This may require that the entitlement of each group be in relation to the whole of that land, particularly in a case to which ss. 11 and 50 apply. It may not be sufficient for entitlement by a group or groups to extend to part only of the land the subject of a Land Trust. If so, it would not be possible to group together under one Land Trust a number of areas in respect of each of which there are different groups entitled to use or occupation of part but not the whole of the land. In the present case the difficulty does not arise, because the evidence shows that each clan is entitled by tradition to the use or occupation of the whole area. This is said to be largely the result of the size and number of the areas, and their 'compactness'. We shall briefly review the evidence on this aspect.

Extent of use or occupation Professor and Dr Berndt stated that amongst the peoples of Western Arnhem Land contiguous gunmugugur often were considered as a community, the members of which 'did interact more frequently with one another than with those outside'. They pointed out however that the communities did not confine themselves to the territory of their 'community'. Dr Peterson stated that 'there is a very close network of kinship relations between adjacent clans . . .' and he elaborated further: 'Gunmugugur are very small; they are in a very tight network related to each other. They all participate in each other's ceremonies' and 'groups of neighbouring gunmugugur in the West Alligator area have a common interest in the economic resources. They use each others resources; they have rights through kinship to use those resources'.

The physical relationship of the clan areas to each other is as follows:

MURRUMBURR — MURRUMBURR estate is contiguous with the JURKMANJ, WARRAMAL, WILIRGU and MARRERMU estates.

MARRERMU — MARRERMU is contiguous with the DJINDIBI, BUNITJ, WILIRGU, MURRUMBURR and MIRARR GUNDJEIBMI estates.

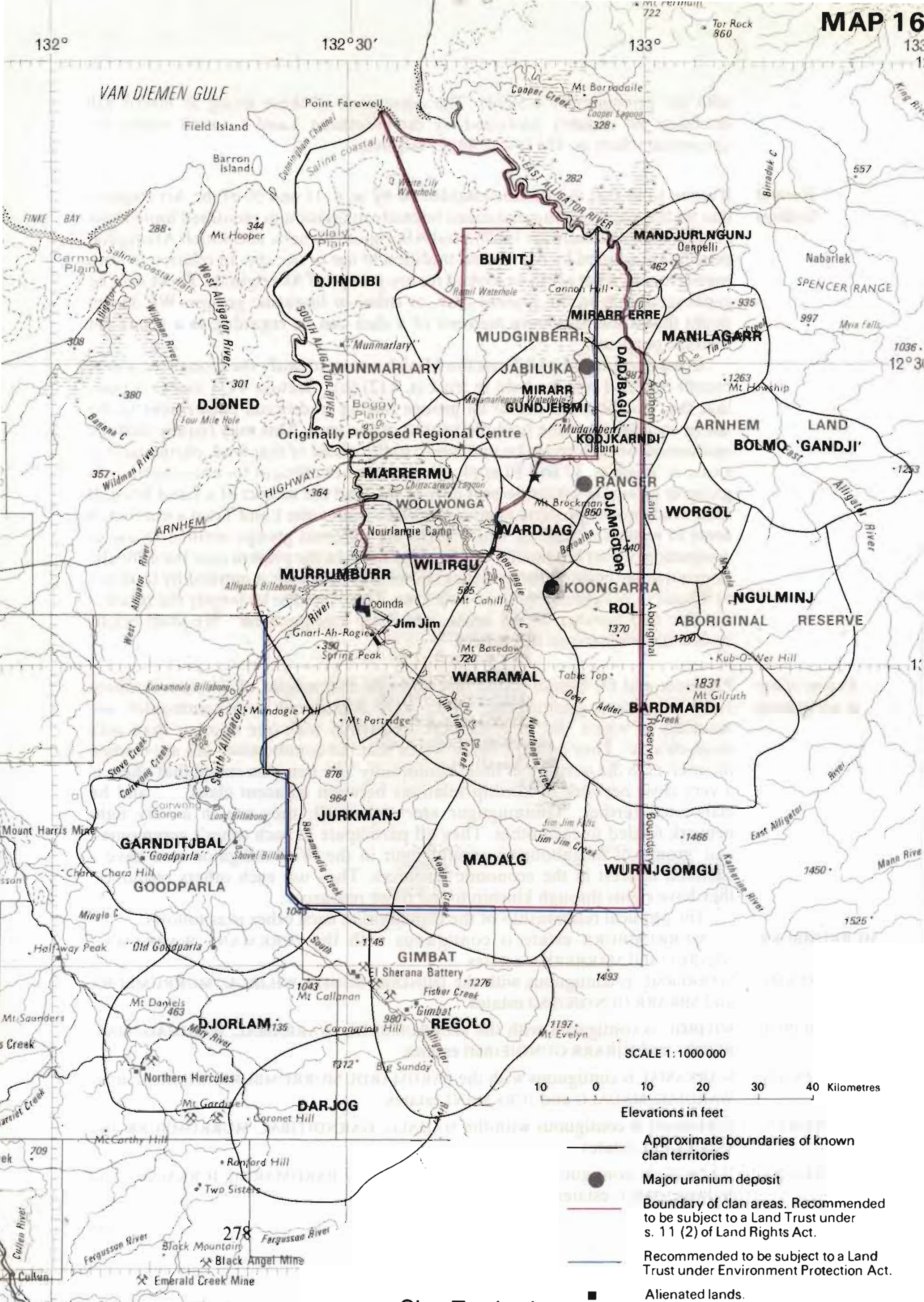
WILIRGU — WILIRGU is contiguous with the MURRUMBURR, WARRAMAL, WARDJAG, MARRERMU and MIRARR GUNDJEIBMI estates.

WARRAMAL — WARRAMAL is contiguous with the BARDMARDI, MURRUMBURR, WILIRGU, ROL, WARDJAG, MADALG and JURKMANJ estates.

JURKMANJ — JURKMANJ is contiguous with the MADALG, GARNDITJBAL, MURRUMBURR and WARRAMAL estates.

MADALG — MADALG is contiguous with the WARRAMAL, BARDMARDI, JURKMANJ and WURNJGOMGU estates.

MAP 16



Clan Territories

NMP 76/221.16

BARDMARDI — BARDMARDI is contiguous with the ROL, WARRAMAL, MADALG and WURNJGOMGU estates.

ROL — ROL is contiguous with the BARDMARDI, WARRAMAL, WARDJAG, DJAMGOLOR and WORGOL estates.

DJAMGOLOR — DJAMGOLOR is contiguous with the KODJKARNDI, MIRARR GUNDJEIBMI, WARDJAG and ROL estates.

KODJKARNDI — KODJKARNDI is contiguous with the WORGOL, MANILAGARR, DADJBAGU, MIRARR GUNDJEIBMI, DJAMGOLOR and ROL estates.

DADJBAGU — DADJBAGU is contiguous with the MANILAGARR, MIRARR ERRE, MIRARR GUNDJEIBMI and KODJKARNDI estates.

MANILAGARR — MANILAGARR is contiguous with the MIRARR ERRE, DADJBAGU, KODJKARNDI and WORGOL estates.

MIRARR ERRE — MIRARR ERRE is contiguous with the MANILAGARR, DADJBAGU, MIRARR GUNDJEIBMI and BUNITJ estates.

MIRARR GUNDJEIBMI — MIRARR GUNDJEIBMI is contiguous with the BUNITJ, MARRERMU, WILIRGU, WARDJAG, DJAMGOLOR, KODJKARNDI, DADJBAGU and MIRARR ERRE estates.

BUNITJ — BUNITJ is contiguous with the MIRARR ERRE, MIRARR GUNDJEIBMI, MARRERMU and DJINDIBI estates.

GARNDITJBAL — GARNDITJBAL is contiguous with the JURKMANJ estate.

WURNJGOMGU — WURNJGOMGU is contiguous with the MADALG and BARDMARDI estates.

WARDJAG — WARDJAG is contiguous with the MIRARR GUNDJEIBMI, DJAMGOLOR, WILIRGU, WARRAMAL and ROL estates.

Mr Chaloupka submitted a map depicting the route taken by a particular 'horde' or domestic group through what was described as its 'social range'. The map illustrates the area of land and the number of neighbouring estates (sixteen) visited and used by the group. The evidence does not suggest that the use of the land in this way or to this degree was in any way exceptional.

Specific evidence was given to the effect that members of gunmugugur within the Region were dependent upon one another for the performing of ceremonies and the carrying out of other ritual observances. A map produced in evidence depicted the routes believed to have been taken by certain mythological heroes during the dreamtime. Close ceremonial and totemic links are established between the gunmugugur over whose estates the totemic heroes travelled. It was shown that in this way the BARDMARDI, ROL, DJAMGOLOR, MIRARR GUNDJEIBMI, DADJBAGU and MIRARR ERRE gunmugugur were linked; the MURRUMBURR, MARRERMU, MIRARR GUNDJEIBMI and MIRARR ERRE gunmugugur were linked; and the WILIRGU, MIRARR GUNDJEIBMI, DADJBAGU and MANILAGARR gunmugugur were linked.

The evidence which we have outlined was not challenged or contradicted. In the circumstances it is a reasonable inference that each of the Aboriginal groups or clans in the area has a traditional though qualified entitlement to the use and occupation of the lands of each of the others, and we have come to that conclusion.

Definition of area

The Northern Land Council presented one claim for a large area of land, extending to recognisable or established boundaries. The evidence showed that one claim for all that land could not be maintained. The claim has to be considered by reference to particular clan areas. We have mentioned earlier a problem arising from the irregular boundaries of those areas, and the fact that survey data are not available. In view of our findings, the aggregate of the clan areas can be taken as one, and it is only necessary to look to the external boundaries. We can, however, see no justification, when carrying out our function under the Land Rights Act, for adding to or subtracting from those areas by drawing straight lines, segmentally or tangentially. Whether the Minister will be justified in doing so is a different matter, about which we do not comment.

We find for the purposes of our Inquiry under the *Environment Protection (Impact of Proposals) Act* 1974 and in accordance with s. 11 (2) of the *Aboriginal Land Rights (Northern Territory) Act* 1976 that:

(a) the land shown on Map 16 within the line edged red thereon, but excluding therefrom the areas comprised in the special purpose leases held by Opitz 'Cooinda' Enterprises Pty Ltd at or near Jim Jim, is unalienated crown land;

(b) the unalienated crown land referred to in (a) comprises a number of clan areas, the boundaries and names of which are shown on Map 16.

(c) there are Aboriginals who are the traditional Aboriginal owners of each of the clan areas referred to in (b), being the persons whose names are set out hereunder opposite the names of the areas of which they are respectively the traditional Aboriginal owners.

Clan area	*Traditional Aboriginal owners*
BARDMARDI MADALG WARRAMAL	Nadalanbak Nipper Gabirrigi Aldalmanj George Namingun Marjorie Mundalmi Paul Nawarrai Dolly Margaret Elsie Gumaienggirrk Rosie Ngalmanjdjurlmak Bugowanj Peter McLevi David Canari
BUNITJ	Big Bill Najidji Magdalene Ngalamin Samuel Gardabarda Jonathan Djardamarna Lizabeth Marabarli
DADJBAGU	Elizabeth Michael
GARNDITJBAL	Mick McGuiness Henry McGuiness Rose McGuiness
JURKMANJ	Lorrie Djanjborrang Ngaldjalamarnmuru
KODJKARNDI	Maudie (Hunter) Gundjalk (will transfer to MIRARR GUNDJEIBMI)

Clan area	Traditional Aboriginal owners
MANILAGARR	Jacob Nayinggul Alfred Djirigard Walter Walamada Anita Wardjin Martin Lionel Harold Samuel Connie Katie
MIRARR ERRE	Magdalene Jorawadj (will transfer to MIRARR GUNDJEIBMI)
MIRARR GUNDJEIBMI	Elijah Namarabunjdja Jimmy Madjandi Toby Ganggali Frank Djanjdjul Enid Manganbalad George Gamarawu James Rodney Simon Rose Yvonne Margurula Nida Ngalbanggawulmi Toby Nalirrk Melaine Ngalguritjbarl Annie Ngalmirama Jayson Valerie Mina Girdjarrawarr Luke Raelene Stephanie Julie Tony Sandra
MURRUMBURR MARRERMU WILIRGU	William Alderson (Yorky Billy) Robin Gayden Kevin Gayden Mary Namandkrag (Butcher Knight) and four children Michael Alderson Jessie Alderson Violet McGregor Elizabeth Alderson Judy Alderson Nelly Alderson Kenny Alderson

Clan area	*Traditional Aboriginal owners*
Murrumburr, Marrermu, Wilirgu (cont.)	Yorky Alderson Sarah Gayden Stephen Gayden Daphne Gayden
ROL WARDJAG	Ruby Djurrugu Maudie Namamalaia Laura Ngaldalmain Fred Nagauli Henry Ford Nagawuli Fred Matjarrang Billy Moor George Hunt Jacob Pauline Buyumina Curtis Nagidjawu Patrick Muralwalma Marie Anne Cumil Carrol Anne Colin Andrew
WURNJGOMGU	Maudie Alwonggu Sarah Marritjarratj Peter Sullivan Jimmy Ahtoy Dennis Peter
DJAMGOLOR	Jimmy Namandjalawogwog Charles Nicholson Whittaker Rankin Frank Gananggu Nelly Andjarngerg
Total 18	107

(d) that the groups of Aboriginals the names of whose clan groups are set out hereunder are entitled by Aboriginal tradition to the use or occupation of the area of unalienated crown land referred to in (a) and (b):

BARDMARDI; BUNITJ; DADJBAGU;
GARNDITJBAL; JURKMANJ; KODJKARNDI;
MANILAGARR; MIRARR ERRE; MIRARR
GUNDJEIBMI; MURRUMBURR; ROL;
WORGOL; WURNJGOMGU.

(e) that the Aboriginals who are at present the members of the groups referred to in (d) are, or include, the persons whose names are set out in (c).

We recommend that the unalienated crown land referred to in (a) and (b) above but excluding the area selected as the regional centre be granted to a Land Trust for the benefit of the groups of Aboriginals who are entitled by

Aboriginal tradition to the use or occupation of that land, being the clan groups mentioned in (d) above.

There are obvious difficulties in giving to a Land Trust a registrable title in respect of the land thus delineated (see Chapter 14). Because in our view some legislation is necessary to deal with the special circumstances of the Region, we suggest that a proper and sensible boundary would be as shown by blue edging on Map 16 and we recommend, as part of our function under the Environment Protection (Impact of Proposals) Act, that Aboriginal title be given in respect of the land within that boundary (excluding alienated parts thereof and the area selected as the regional centre). The opportunity might also be taken to clarify the course a Land Commissioner should follow in delineating land recommended under s. 11 (1) to become the subject of a Land Trust, and the course the Registrar of Titles should follow on receiving a request under s. 12 (5).

Boundary of the Ranger mining area

We mentioned earlier the matter of the southern boundary of the Ranger mining area, and said we would deal with it here. The way in which the Ranger company came to establish this boundary was the subject of considerable discussion during the Inquiry. The history of the matter can be summarised as follows:

1. An Aboriginal man, Mr Peter Balminidbal, had been asked by the dying leader of the local descent group who had responsibility for Djidbidjidbi and Dadbe to act as guardian for the two sites.
2. Mr Balminidbal in 1970 approached the then Manager of Mudginberri station, Mr G. Cross, to ask Ranger personnel not to enter the sandstone country at Mt Brockman in the vicinity of Djidbidjidbi.
3. In 1972, when the extent of the Ranger deposit became known, the Ranger company sought advice from the then Welfare Branch of the Northern Territory Administration with regard to establishing a boundary beyond which Ranger personnel would not go.
4. Between 6 and 9 May 1972 Mr E. J. Brandl, then Senior Research Officer with the Welfare Branch, on the advice of Mr Balminidbal and Mr Frank Namiyilk established a boundary approximately 700 metres from Djidbidjidbi. This line was subsequently surveyed.
5. On 1 August 1972 Mr Alan McIntosh, of the Ranger company, sought and received Mr Balminidbal's concurrence to modify the surveyed boundary. This modification took the boundary about 70 metres closer to Djidbidjidbi.
6. On 17 February 1973 Mr McIntosh sought the agreement of Mr Balminidbal to once again modify the boundary, moving it to a position some 200 metres closer to Djidbidjidbi than the original line established by Mr Brandl. Mr Balminidbal agreed to this further modification, and the new line was used as the boundary of the proposed Special Mineral Lease and was subsequently marked and surveyed. A marker fence was established for a length of 100 metres along the section of the boundary closest to Djidbidjidbi.

The Commission was told by the Ranger company that the changes to the boundary had been sought because the company was keen to ensure that any boundary established would incorporate the area described as Anomaly 2.

Professor R. M. and Dr C. H. Berndt gave us evidence relevant to the problem. They said:

> A particular site does not consist simply of the actual place associated with a mythic event or where a particular mythic being or djang was metamorphosed, but extends all around that site. Any alien activity within its vicinity should be regarded with the utmost concern.

Later they said, in relation to the particular problem:

> The inviolable area should most certainly be extended to at least 1000 to 1500 yards, and should on no account be allowed to be reduced.

All members of the Commission have visited the relevant area three or more times, both in the wet and the dry. In the presence of the interested parties, we re-examined the position as recently as February 1977. It is, of course, impossible for us to see the situation in the same way as the Aboriginal owners. After considering all the relevant evidence, which comes from a number of sources, Aboriginal and non-Aboriginal, and taking into account the history of the matter, we are of the view that it is unreasonable for the boundary to be fixed where the Northern Land Council has asked that it be fixed—through No. 1 ore body. We are satisfied that a reasonable location, which should give to the Aboriginal people a comfortable satisfaction that Mt Brockman and the sacred sites on or near it are safe and secure, is a line running east–west and passing through or close to the turn in the road (A.M.G. ref. approximately 8593920N, 0273290E) to which an arrow points on Exhibit 189 which has against it the notation 'Chained road which J. Madjandi and T. Gangele were told on 12.5.76 was P. Balmanidbal's first line'. This boundary will mean that it will not be possible to explore or develop Anomaly 2 any further. This is in our view an unfortunate but necessary result of its location close to Mt Brockman.

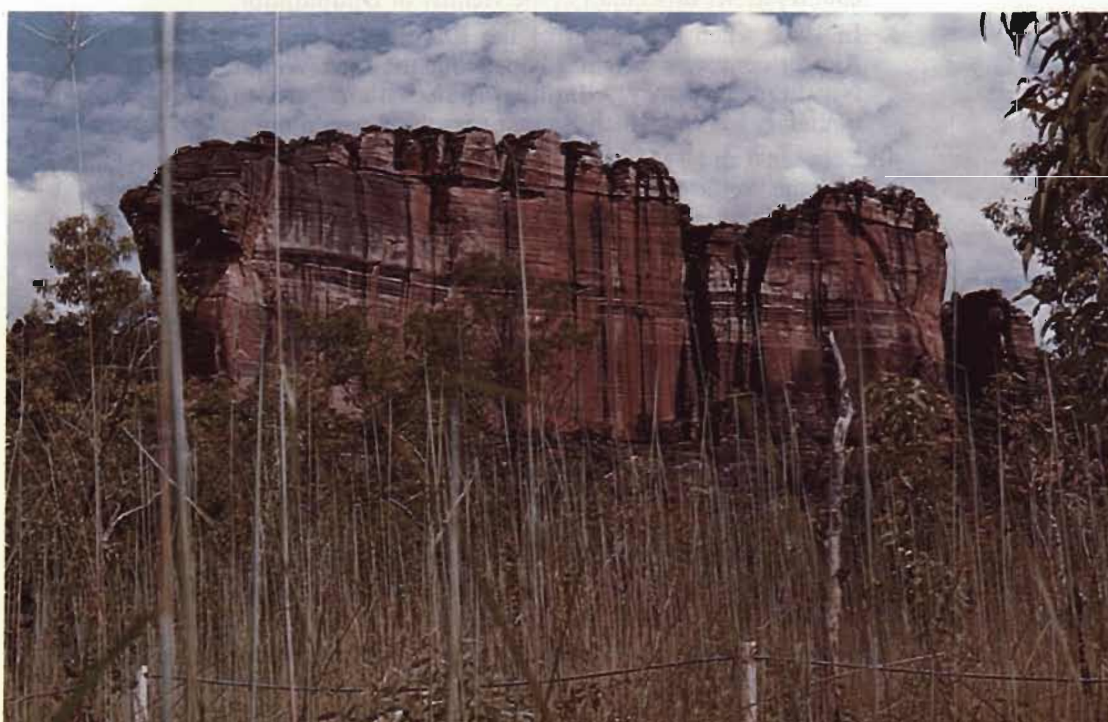
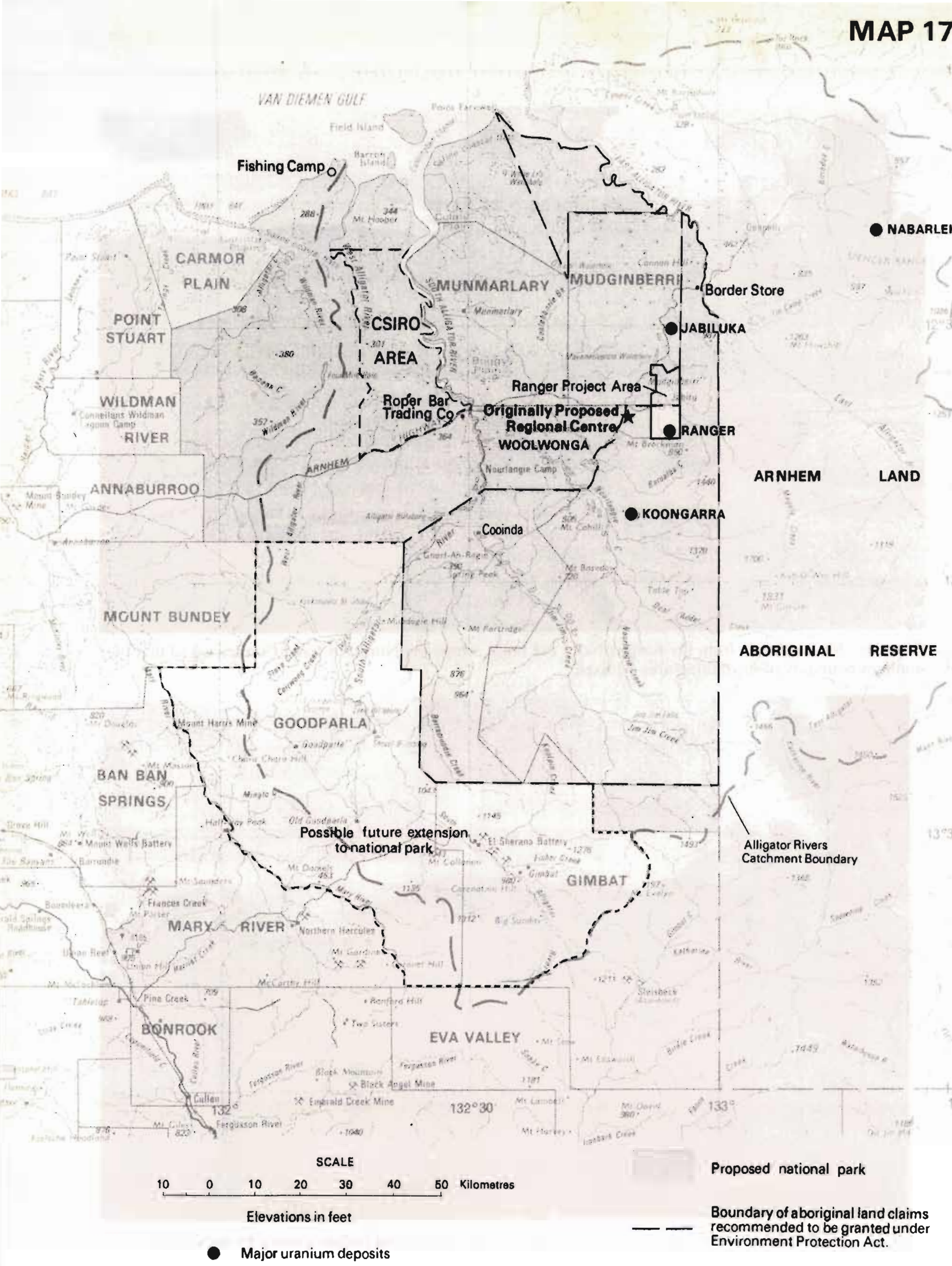


Plate 25. Mt Brockman from the southern boundary of the Ranger S.M.L. application area.

Plate 26. Mt Brockman from the Ranger No. 1 ore body, where the Northern Land Council asked that the southern boundary of the mining area be fixed.

Plate 27. Mt Brockman from the southern boundary of the mining area recommended by the Commission.



Proposed National Park
NMP76/221.14

16 FUTURE DEVELOPMENT OF THE REGION

Possibly no other part of Australia is faced with as many strong and concurrent competing claims for the use of the land as this Region. We agree with the suggestion of a number of witnesses that the regional environmental effects likely to arise from the development of a uranium industry can be evaluated adequately only in relation to a particular pattern of land use. We have examined potential land uses and propose a broad strategy for the use of the Region's land resources in which we seek to provide as far as possible for the various values and interests which it contains.

Land use planning

We see the primary objective of a land use plan in the Region as being to ensure that the land is used so as to maximise its long-term value to the people of Australia.

In earlier chapters we have described the existing characteristics of the Region, the major potential land uses and their probable effects on one another and on the natural environment.

Briefly the land use interests of major importance in the Region are:

- the use and occupation of land by Aboriginals (see Chapters 14 and 15);
- proposals for a national park and conservation of the natural features of the Region (see Chapter 10);
- proposals to mine uranium (see Chapters 6, 7 and 8);
- tourism (see Chapters 11 and 12);
- the use of land for pastoral production (see Chapter 9).

The Commission has subdivided the Region into thirteen areas, each of which has been examined in relation to its present characteristics and uses and its suitability for various uses in the future. The thirteen areas are either natural geographical entities such as stream catchments, or areas defined by man-made boundaries such as those of pastoral leases or reserves. Some overlap occurs between the areas chosen; this is a result of the approach we adopted of considering readily definable portions of the Region. Together, the portions cover the whole Region.

Areas 1 and 2	Arnhem Land and Woolwonga Aboriginal Reserves
3–7	The individual catchments of Magela, Nourlangie, Jim Jim and Barramundi Creeks, and of the upper South Alligator River
8	The area west of the lower South Alligator River including the combined catchments of the West Alligator and Wildman rivers
9	Mudginberri and Munmarlary pastoral leases
10	Vacant crown land north of Mudginberri and Munmarlary
11	The main plateau area and escarpments
12	The Mt Brockman and Nourlangie Rock Massif

Area 13 — The narrow strip of land connecting the main body of the 1975 proposal for the Kakadu National Park with the East Alligator River

The factors examined were present land tenure, present and proposed land use, national park and conservation values, Aboriginal art and archaeology, mineral potential, other possible production values, tourism, environmental sensitivities and desirable features of ecological management. Alternative future land uses were then considered in the light of these factors.

A number of guidelines and conclusions emerge from this examination and from other considerations dealt with in this Report.

Aboriginal values

An Aboriginal land claim has been made for all the unalienated crown land in the Region. We have recommended, following the provisions of the Aboriginal Land Rights (Northern Territory) Act, that most of the land claimed be granted to a Land Trust for the benefit of groups of Aboriginals (see Chapter 15). From our discussions in Chapter 15 we conclude that Aboriginal interests and the use of the land as a national park are, in most respects, compatible and that the interests of the Aboriginals of the Region would, in the circumstances, best be served by making as large an area as possible into a national park.

The Woolwonga Aboriginal Reserve and Wildlife Sanctuary, which is within the South Alligator catchment, is now Aboriginal land under the Aboriginal Land Rights (Northern Territory) Act. The Northern Land Council has proposed, on behalf of the Aboriginal owners of this land, that it become part of the national park together with other areas within the Region which have been claimed as Aboriginal land.

The evidence shows, as discussed in Chapters 12 and 13, that the impact of development on the Aboriginals would depend largely on the number of Europeans brought into the Region. For this reason, and from our examination of the environmental impacts in this Report, we conclude in Chapter 12 that, if uranium mining is to proceed, it should do so in a carefully controlled way, with strict limitations on the number of Europeans living and working in the Region.

National park values

The Region is a large, mainly undeveloped area with a great diversity of landforms, vegetation types and fauna, the totality of which represents a natural resource of unique value to Australia. We accept the evidence of many expert witnesses that it is desirable in the national interest that a national park larger than that at present proposed and with more diverse land types should be planned and proclaimed (see Chapter 10). We recognise that the boundaries of a national park are flexible, although they are constrained by the distribution of natural land types and by the need for the park to be manageable.

Many expert witnesses have stated, and the Commission accepts, that it is desirable to include at least one large total river catchment in a regional national park. Whether or not uranium mining proceeds, the South Alligator River catchment is clearly the most suitable. It includes most of the area within the boundaries which were proposed in 1975 for the Kakadu National Park; it includes the valuable Woolwonga wildlife area; it comprehends most of the land types which exist in the Region; and it avoids major encroachment onto the Arnhem Land Aboriginal Reserve. To include this whole catchment, all of Goodparla and portion of Gimbat pastoral leases, in which the river and some of its tributaries have their headwaters, would have to be resumed. We are not sure whether this would be acceptable to the present leaseholders.

The upper catchments of Nourlangie and Jim Jim creeks extend into the Arnhem Land Reserve in plateau country not usually frequented. Unless major developments occur in that area in the future, they will be protected by the status of the land as an Aboriginal Reserve.

Mining The Region has been widely explored for uranium, and a number of proved or promising ore deposits have been located (see Chapter 2 and Map 9). Gold in significant quantities is associated with the uranium ore body at Jabiluka. Other minerals, including copper, silver, lead, nickel, cobalt and zinc, have been reported in the Region and several leases for these have been granted. The Commission has not received any evidence of the existence of major deposits of them or proposals to mine them. Exploration for uranium and other minerals has ceased over most of the Region since 1974 when large parts of it were reserved from mining. The Commission sees the need for future exploration for uranium to be a matter on which the proposed Uranium Advisory Council should advise. It does not have any evidence that exploration for other minerals in the Region is essential at the present time, although it recognises that the situation may change with national needs.

The economic value and ease of development of the known uranium ore bodies in the Region are strong arguments for their exploitation if mining of uranium in Australia is deemed desirable. The choice of land for uranium mining is limited to fixed locations of known ore bodies. However, future demand for uranium may not justify exploiting all deposits. Evidence dealt with in our First Report indicates that the Jabiru and Jabiluka deposits could probably satisfy the demand for Australian uranium for many years. Deposits outside the Region could be used to meet at least part of the demand in the future.

We conclude in Chapters 6, 7 and 8 that, if mining proceeds, very stringent environmental protection measures should be adopted but that, even so, the prevention of damage to the environment could not be guaranteed. It is clear that the technical and administrative difficulty of ensuring that the environment is protected would depend on, among other things, the number and location of mining ventures proceeding concurrently in the Region.

The Commission considers that it is most desirable, if uranium mining proceeds, that it should be restricted, west of the Arnhem Land Aboriginal Reserve, to one drainage basin, so that environmental damage from mining can be geographically contained. This should certainly apply until experience demonstrates the long-term effectiveness of environmental impact controls of waterborne contaminants.

The two major uranium deposits referred to earlier, at Jabiru and Jabiluka, are within the Magela drainage basin, as are also some of the promising areas for further discoveries. If mining is restricted to the Magela basin it would exclude the exploitation of the Koongarra deposit, in the Nourlangie Creek catchment, upstream from the extremely valuable Woolwonga Wildlife Sanctuary. We recognise that Noranda, the company concerned, will have expectations to develop this deposit. However the Woolwonga area is so valuable ecologically that we would oppose in principle any mining development upstream of it at least until it had been demonstrated by experience that it could take place without environmental damage. Moreover, as indicated in Chapter 8, we are not satisfied with the present plan proposed by the company for the storage of acid tailings.

The Commission is aware of the importance attached to the ecological and pastoral value of the Magela drainage system's flood plains and billabongs. We believe that, if mine and mill developments conform to the strict environmental protection standards which are proposed in this Report, little environmental disturbance will result from the developments themselves. However, we acknowledge that long-term effects, particularly of more than one mine, cannot be predicted. This is the major reason why we place considerable importance on restricting mining to one drainage; also, the Magela is the only one with proved ore reserves sufficient to meet foreseeable demands. We have indicated (see Chapter 5) that the one characteristic which distinguishes the Magela area from all others in the Region except the Oenpelli plain is the occurrence of sandstone plateau outliers close to flood plains and billabongs. This is a feature of the area running north of Jabiru to Cannon Hill, between the Mudginberri pastoral lease and the East Alligator River. Many scenic areas and Aboriginal art and old habitation sites exist there. The Ranger proposal would not directly affect the outliers. The proposed mine at Jabiluka would, however, involve the removal of a small section of them adjacent to the flood plains. Since water drains from the outliers to the plain, the outliers would not be affected by waterborne contaminants from mines.

The evidence indicates that the Magela basin includes a good sample of the wetlands of the Northern Territory, but is inferior to many other areas in this respect. For example, the swamplands in which magpie geese congregate for nesting are small in extent compared with others elsewhere. Disturbance by buffaloes has been greater in the Magela system than in the flood plains west of the Stuart Highway. Hence, if any wetland area is to be placed at risk, we believe the evidence leads to the choice of the Magela.

We have concluded that, if mining is to proceed in the area west of the Arnhem Land Aboriginal Reserve, mine development should be restricted to this basin for the foreseeable future. The question whether Nabarlek in Arnhem Land should proceed is not a matter on which we make any recommendation.

We discussed, in Chapter 10, the proposition that mining might be allowed in a national park. We conclude that if Ranger and Jabiluka are to proceed, those mineral lease areas should be excluded from the park. We also conclude that there should be no activities associated with mining, including exploration, within the park for the time being. In the future it should not be permitted except after very careful consideration. If it is found necessary it should be carefully controlled in accordance with a formally developed plan of management as provided for in the National Parks and Wildlife Conservation Act.

Pastoral values

In Chapter 9 we found that the pastoral industry's economic value is small compared with the potential of uranium mining, and its combined social and economic benefits are probably less than those which would be derived if the pastoral areas were used for national park and conservation purposes. The amount of meat which the whole Region is capable of producing could be provided by developments in many areas in other parts of Australia, probably more economically.

Within the Region, the most intensively developed pastoral area is the Mudginberri property, which includes the Magela basin. It is a valuable natural area, although significant parts of it have already been altered by clearing, pasture improvement and grazing. The evidence indicates further development could lead to more adverse effects on the natural environment. The pastoral industry does not appear to us to be a desirable form of land use in this Region.

The areas occupied by Mudginberri and Munmarlary would be important additions to a national park. If the leases were resumed, provision would have to be made for the control of the remaining feral buffaloes, in order that continued environmental degradation of the flood plains be avoided.

Agricultural values

The Commission sees little economic merit in using the lands of the Region for other forms of production, such as rice or forest plantations, which would significantly affect the natural environment (see Chapter 9). These have been excluded from consideration in the land use strategy plan. If market gardening is required for local supplies, the relatively small areas involved could be provided for in a national park plan of management.

Tourist values

The tourist industry was discussed in Chapter 11, where we concluded that management and control of this industry in the Region could probably be achieved most satisfactorily by associating tourist development with the development of a national park. An effect of the controls on the movement of people throughout the area, which would be a consequence of this, would be to limit the freedom of those visitors who have been accustomed to seek recreation in various parts of the Region in the past.

Regional accommodation

The selection of an area for a regional centre is discussed in Chapter 12, where it is recommended that its size be kept to the absolute minimum consistent with accommodating persons associated with any approved mining operations and their families. In Chapters 8 and 13 we have recommended that the activities of residents should be strictly controlled, so as to reduce their impact on the regional environment and the Aboriginals. It is our view that control would best be achieved if the regional centre were in the national park.

Proposed strategy

Consideration of all the foregoing matters has led us to the formulation of a land use strategy plan with the following major features:

1. The immediate objective should be to include in a national park the whole area between Arnhem Land Aboriginal Reserve and the eastern boundaries of Carmor Plain, Point Stuart, Wildman River, Annaburroo and Goodparla pastoral leases, and between the northern boundary of Gimbat pastoral lease and the coast, as well as Field and Barron Islands, but excluding mining areas at Jabiru and Jabiluka, if mining is to proceed, and the special purpose leases at Cooinda and the Roper Bar Trading Company premises. The inclusion in the national park of the land which is the subject of these two special purpose leases could usefully be further considered.
2. The proposal by the Northern Land Council that all Aboriginal land in the Region west of Arnhem Land Aboriginal Reserve should be incorporated in a national park should be adopted, except that the mining area at Jabiru should be excluded if it is decided that mining is to proceed.

   It seems likely that such an arrangement might be reached not only in respect to land areas which are the subject of the Commission's recommendations following hearings of Aboriginal land claims, and to Woolwonga Aboriginal Reserve, but also to other land in the Region which may become Aboriginal land following the hearing of future claims, e.g. the Mudginberri and Munmarlary lease areas (excluding the Jabiluka area, if it is expected that mining will take place there) and the portion west of the lower South Alligator.

3. If uranium mining is to proceed, it should, in the first instance, be restricted, west of the Arnhem Land Aboriginal Reserve, to the Magela drainage basin at least until such time as the national interest requires otherwise and experience has demonstrated that environmental damage can be controlled satisfactorily.

   If more than one mine is required, there should be an appropriate interval between their times of commencement in order to reduce cumulative environmental impact and possible undesirable economic effects.

   All areas likely to be subject to environmental change as a result of mining and mineral processing operations should be the subject of a comprehensive environmental monitoring program as discussed in Chapter 17, and all operations and associated activities should be controlled according to a plan of ecological management for the Region.

   Any area leased for mining purposes should be excised from the national park for the period of mining, but mining leases issued should require land occupied to be rehabilitated after mining ceases so that it is suitable for inclusion in the national park.

4. Mudginberri and Munmarlary pastoral leases should be resumed immediately and the areas, except for Jabiluka if it is expected that mining will take place there, incorporated in the national park.

   Consideration should be given as soon as possible to the resumption of Goodparla pastoral lease and part or the whole of Gimbat and their incorporation in the national park, thus permitting the inclusion of most of the headwaters of the South Alligator River.

5. Action should be taken either through agreement with the present holders of Mudginberri and Munmarlary pastoral leases, or by contracts let by a government authority, for buffaloes to be substantially reduced in numbers and preferably eliminated from the whole area between the East and South Alligator rivers north of Woolwonga and Jabiru. The abattoirs at Mudginberri should be continued in operation for such time as is necessary to cope with buffalo harvests.

6. When a decision is made on the area to be occupied by the regional centre, it should be incorporated in the national park. It is recommended in Chapter 12 that the area should not be included in Aboriginal titles.

7. The plan of management of the national park should include, with those things common to such a plan, special provisions for the control of commercial fishing in the Region, the control or elimination of buffaloes in various parts of the park, and the control of access via the existing Arnhem Highway to points on the South and East Alligator rivers currently frequented by visitors. The implementation of this plan is discussed in Chapter 18.

17 ENVIRONMENTAL RESEARCH, STANDARDS, MONITORING AND SUPERVISION

We have described in previous chapters the complex and sensitive nature of the regional environment. Its protection during mining will depend critically on the establishment of a carefully and competently designed monitoring program, and enforcement action based on information derived from it. We recommend the establishment of a comprehensive monitoring program both on and near the mine site and in parts of the Region likely to be subjected to environmental change. The establishment and operation of such a program will be technically difficult and will need to be based on and supported by a research program. We describe in this chapter the major elements which should in our view be built into the program and assess the resources which it will require. We propose that research and supervisory functions should be carried out to the extent practicable, by the appropriate existing agencies. We recommend the establishment of a Co-ordinating Committee of these bodies, to be chaired by a Supervising Scientist who would be in charge of a small research institute in the Region.

Research In order to detect environmental change it will be necessary to learn as much as possible about the 'before mining' situation.

In Chapter 5 we mention some of the problems in establishing precise ecological baselines. It is difficult in the present state of knowledge of the Region to specify those physical and biological features of the environment which are likely to prove of most practical value in a continuing monitoring program, and to indicate precisely how they can be reliably sampled and most usefully measured. These aspects will require considerable investigation of a research nature if an efficient and informative monitoring program is to be achieved.

As indicated in Chapter 5, the total program will involve studies in many disciplines. In order that it may concentrate on the essential and most useful aspects, we propose that a group of experts from the relevant scientific fields specified in Chapter 5 be assembled as soon as possible to advise on the selection of those biological, chemical and physical observations likely to be of most practical value to the monitoring program. The research program should be based on this selection, and should also be formulated and commenced as soon as possible, so that baseline information can be gained before mining commences.

Some of the experts will be drawn from existing agencies in the Territory. Some will come from organisations in other parts of the country. It is not envisaged that the group would have a continuing role in the environmental control program—its functions would be limited to advice on setting up the research program. The operating of this program, which will be an integral part of the ongoing environmental control program we propose, should be co-ordinated and supervised by an experienced, highly qualified scientist. We refer to him in this chapter as the Supervising Scientist. He should be appointed as soon as possible after any decision to permit mining, since it is clearly desirable that he be responsible for assembling the group of experts to which we have referred. A more detailed description of his proposed functions, and of the provisions for carrying out the research program, appears later in this chapter under the heading **Program execution and supervision.**

Standards A number of recommendations concerning general principles to be adopted in specifying release standards are set out in Chapters 6 and 7. Standards and procedures should be specified, and any necessary modifications to Ranger's proposals approved, by the supervising authority before construction commences. This applies particularly to the recommendations contained in Chapter 7. Results obtained from monitoring during the construction phase and the early years of mining would contribute to refining and revising release standards for contaminated water, sulphur dioxide, radon and other pollutants. Although a no-release water management policy is recommended (Chapter 7), formulation of water quality standards will be necessary to provide for the possibility that the policy cannot be continued after the first few years of mining.

If mining is to proceed, standards and procedures will have to be set for the following:

1. Contaminants in water from the mine site, including:

copper	molybdenum	ammonia
lead	iron	chloride
zinc	mercury	sulphate
uranium	chromium	nitrate
thorium	nickel	phosphate
radium	arsenic	bicarbonate
manganese	magnesium	suspended solids
cadmium	calcium	

2. Other water quality factors:
   pH
   total organic carbon
   total organic nitrogen
   temperature at the points of discharge

3. Conditions for release from retention pond No. 2 (volume of flow at Jabiru, through-flow to the East Alligator River, discharge rate, length of period of continuous discharge, concentration of contaminants and total contaminant load). Conditions for releases from retention pond No. 1 are to be derived from receiving water standards; they may have to be as restrictive as the conditions for release from retention pond No. 2.

4. Sewage from the mine site (biological oxygen demand, total oxygen demand, nitrate, phosphate, ammonia, total organic nitrogen, total organic carbon, pH and suspended solids).

5. Sewage from the regional town (as in 4 above).

6. Procedures to limit suspended solids in runoff during construction periods and to control erosion during operations.

7. Sulphur dioxide.

8. External ionising radiation.

9. Radon.

10. Ore dust.

11. Yellowcake dust.
12. Other dust, from road surfaces etc. during construction and operation.
13. Ground vibration during construction and operation.
14. Air blast vibration during construction and operation.
15. Noise during construction and operation.

In addition it will be necessary to specify standards or procedures to be adopted with respect to visual impacts of mine development, control of soil erosion, revegetation of disturbed areas and waste dumps, and general rehabilitation of the mine area.

Many of the data relating to contaminant releases and subsequent environmental effects are at present highly speculative, as pointed out in Chapter 6. Standards will have to be reviewed regularly as more information becomes available. If it becomes apparent that unacceptable environmental damage is occurring, standards will have to be made more restrictive. Special interim measures may have to be taken. Since it is assumed that the best practicable technology, as defined in chapter 7, would already have been employed, more restrictive standards would normally involve the special development of new environmental protection techniques. Again in accordance with the principle of the best practicable technology, the Commission believes provision should be made for the use of improved pollution control equipment which may become available in the future, even if environmental damage has not been detected. The supervising authority should be required and empowered to demand the use of such improvements. Relaxation of standards should not be allowed unless it is possible to prove conclusively that no damage will result. Clearly this proof will be most difficult to achieve in relation to many standards in the complex environment under discussion.

In this section, and elsewhere in this chapter, we use the term supervising authority in a generic sense to refer to the agency with statutory responsibility for the matter being discussed. There will be many agencies or branches of agencies involved in the setting of standards in relation to the Region. Some of them are listed later in this chapter under the heading **Program execution and supervision**. In that section we discuss the very real problems of co-ordination which will be met in supervising mining activity and controlling its effects. We recommend that a Co-ordinating Committee be established, comprising all the agencies with responsibilities in the environmental control program. The Committee would have no statutory role but it should be a requirement that all participating agencies keep it fully informed and contribute actively to the co-ordinating program. Standards and procedures should be formulated by the Committee and set by the supervising authority. Matters such as conditions for release of contaminated water should be referred to the Committee.

Monitoring

We recommend that, if mining is to proceed, a comprehensive meteorological–hydrological–water quality model of the Magela system be developed progressively as information becomes available. Such a model will be essential for interpreting monitoring data and predicting effects. It will be equally essential for planning any waste water releases. Information for this model should be obtained by continuous recording of rainfall, temperature, wind velocity and direction, and evaporation at appropriate locations within the Magela catchment. Stream flow at a number of sites and water levels in stationary water bodies should also be continuously monitored. The sites should include several representative backflow billabongs and swamps, and other points selected for combined physical and biological study, so that biological responses can be related to physical changes. The model will be a product of, and a vital component in, the integrated research and monitoring program.

The Commission believes that the details of both on-site and off-site monitoring programs should be developed by the Co-ordinating Committee. However, some broad principles relating to monitoring that have become apparent during the course of the Inquiry, and which we believe should be applied, can be stated now. They are discussed in the remainder of this chapter, together with our assessment of the areas on which special attention should be focussed.

Monitoring on and near the mine site

Ranger has proposed an on-site program involving monitoring of:

- water quality and water flows,
- dust quality and concentrations,
- radon and radon decay products,
- external ionising radiation levels,
- sulphur oxide emissions and concentrations,
- meteorological observations, and
- pit slope stability.

The Commission agrees that these will have to be monitored. Additional requirements are discussed later.

Close monitoring of the first of these, water quality and quantity, will be most important if mining proceeds, since runoff water releases and seepage are the main pathways by which contaminants will enter the environment from the mine site. This monitoring program will need to be particularly intense in the early years of operations, because of uncertainties in the data on which the proposed water management scheme is based.

Monitoring of water quality and quantity on and near the mine site should cover:

- Seepage from the tailings retention system, including seepage to shallow and deep aquifers.
- The quantity and quality of runoff into Gulungul Creek.
- The quality of the water above the tailings.
- The quantity of inflow into the pit and the quality of the pit water.
- The quantity and quality of water in the three retention ponds.
- Seepage from the retention ponds.
- Evaporation rates from the tailings dam and the retention ponds.
- The quality of Magela Creek water immediately upstream of the point of discharge, including the proportion of heavy metals in different forms, and that transported on suspended materials.
- The quantity and quality of water released from retention ponds No. 1 and No. 2.
- The pattern of dispersion and dilution of discharged water.
- The quantity and quality of runoff entering Georgetown billabong, and the level of contaminants in the water, sediments and selected biota of that billabong.

The Commission believes that continuous monitoring equipment should be used to measure flow along and into Magela Creek during releases from retention ponds No. 1 and No. 2, and to measure the temperature, conductivity and turbidity of the water. Samples of runoff, seepage and water in the pits and retention ponds should be taken at least fortnightly in the early stages of operation for analysis of the more important contaminants including lead, zinc, copper and radium. During critical times, such as the first flush of water in the early part of the wet season, it might be desirable to take samples more frequently. Other contaminants for which standards will have to be specified could be sampled at less frequent intervals. The details of the sampling program should be worked out by the Co-ordinating Committee.

Experience will probably indicate that monitoring frequency could be safely reduced in some areas and should be increased in others. The sampling program should be adjusted accordingly by the Co-ordinating Committee.

The on-site monitoring program for radiological contaminants is specified in considerable detail by the *Code of practice on radiation protection in the mining and milling of radioactive ores.* Ranger has indicated that it will follow the recommendations contained in the Code. The Commission believes these recommendations to be sufficient.

After monitoring on the site has progressed long enough for relatively accurate determination to be made of such physical parameters as runoff coefficients, evaporation rates and seepage rates into the mine pit, a decision will be possible on whether the 'no release' water management program discussed in Chapter 7 can be continued. The monitoring program will be the means of ensuring that Ranger complies with operational standards for, among other things, radon levels in the mine and mill area and heavy metal levels in water leaving the mine site. It should also enable regular reassessments to be made of the operation's performance, particularly with regard to water management.

The necessary equipment for monitoring should be installed and procedures established during construction of the mine and mill. Mining and milling should not be allowed to start until it is demonstrated that all components of the monitoring system operate satisfactorily.

The ecological effects of any controlled or uncontrolled releases of contaminants are likely to become apparent first in Coonjimba, Gulungul and Djalkmara Creeks and billabongs. An intensive program combining the monitoring of biological species and of contaminants in living organisms, water and sediments should be instituted in these areas as part of the wider off-site monitoring program for the whole Magela system.

Ranger proposes to provide the administrative and operating personnel, and analytical equipment, for the on-site monitoring program, and would undertake the sampling and analysis. It would keep records which would be available to the supervising authority. We agree with this proposal. Responsibility for off-site monitoring will rest with the supervising authority. There will be an area near the mine site, such as between the site and Gulungul Creek, where close collaboration between Ranger and the supervising authority will be essential. Details of this collaboration would be determined in the Co-ordinating Committee. The Supervising Scientist, who we believe should be chairman of the Committee, should be consulted before consent for release of contaminated water is sought or approved. Ranger has acknowledged the need for flexibility in any monitoring program, and has shown a willingness to adopt additional monitoring and supervision conditions that might be imposed by the supervising authority.

Off-site monitoring

The off-site monitoring program will necessarily be more broad ranging. There is a need to gain a better understanding of the receiving environment and of the behaviour of the contaminants which would be released into it by the mining operation. The information gathered by the off-site monitoring activities and the continuing research program will contribute to the reassessing of release standards.

The waterborne contaminants released from the Ranger site will be carried dissolved in the water or attached to small particles of solid material. Of the contaminants in controlled releases at times of peak flood, some will be carried right through the system and discharged into the East Alligator estuary and the rest will remain in the Magela system, either in soil, sediments or water bodies, or taken up by living organisms. Obtaining detailed knowledge of the proportion of the total contaminants remaining and their chemical form and distribution within the system should be a major initial aim of the monitoring program. During construction, and until intentional releases have to be made, if ever, the studies will be largely confined to the behaviour of contaminants occurring naturally.

The major objective of the water quality monitoring program should be to measure the effects of added contaminants in the Magela system on individual plant and animal species and on the ecosystems containing them.

Measurements of the concentrations of the various contaminants in the water at different times of the year and of the proportions dissolved and adsorbed onto particles will be essential. Wherever possible, samples for these measurements should be taken at the sites where stream flow monitoring is carried out. A systematic sampling of soils and sediments will also be required.

At least in the early stages, it will be necessary to adopt a research rather than a routine monitoring approach in taking these measurements, because of the lack of knowledge about the movement and fate of contaminants in the Magela system.

Identification and measurement of ecological effects of added water contaminants will be very difficult, largely because of the variations which occur naturally in both contaminant levels and ecosystems downstream of the mine site. It will be necessary to confine monitoring to a relatively small number of reliable biological indicators of ecological change. These might be the presence or absence of particular species or the size of their populations, observable responses of individual species such as roe condition in fish, breeding patterns or migration habits, or concentrations of contaminants in parts or the whole of particular organisms. Observations should be supported by laboratory studies of the toxicity of single or combined contaminants, in different chemical forms, to the most critical species.

A number of organisms have been proposed as indicators of change which might be useful for monitoring purposes. These include algae, fish, crustacea, insects with life stages spent in water (certain dragonflies and butterflies), mussels and large plants (e.g. *Pandanus* and *Eucalyptus* species). We recommend that the details of the initital program be determined by the Co-ordinating Committee on the advice of the proposed group of experts referred to earlier under **Research** in this chapter. The monitoring program should be modified if continuing investigations indicate that different procedures would give a better guide to ecological change.

Dispersion of the airborne contaminants sulphur dioxide, radon and dust from the mine site should be measured by a network of fixed recorders read at frequent intervals. Regular measurements of the pH of selected soils in the area likely to be exposed to sulphur dioxide should also be made. The records obtained should be collated with meteorological information obtained from the monitoring program in order to build up knowledge of atmospheric dispersion processes in the Region. Particular care should be taken to monitor the dispersion and fallout of atmospheric contaminants at the regional town site and other places where people live. Because of the possibility that sulphur dioxide could damage the sandstone cliffs and vegetation of Mt Brockman, recorders for that gas should be placed at suitable sites and long-term experiments designed with the aim of detecting any effects. The permission of the Aboriginals will be essential before setting up monitoring equipment on Mt Brockman.

It is clearly important that the off-site monitoring program pay special attention to recording environmental changes of consequence to human health. The program should include sampling of meat, fish and other foodstuffs produced in the Region and their analysis for contaminant concentrations. The health of livestock should also be carefully watched. In particular, levels of copper and manganese in the blood of livestock should be monitored.

If the pastoral industry in the Magela drainage system continues, it may add to pollution from the mine site, notably by the transport of fertiliser and sediments from pastures. The monitoring program should be designed to differentiate between contamination from this source and from Ranger.

A comparable kind of differentiation will be necessary if mining is undertaken at Jabiluka or other places within the Region as well as at Ranger. The Co-ordinating Committee should take account, in developing standards, of the cumulative effects on the environment of contaminant releases from each mining venture.

The off-site monitoring program which we suggest will clearly be a major undertaking. A network of automatic continuous recording instruments will need to be installed and operated. Adequate transport will be required, including a helicopter, to enable sampling and recording to be performed throughout the wet season. Special provision will have to be made for rapid maintenance, calibration and repair, or replacement, of instrumentation.

Responsibility for off-site monitoring will rest with the supervising authority. Its planning and execution should be an integral part of the environmental control program which will be developed by the Co-ordinating Committee.

Program execution and supervision

As we have said, various agencies will have responsibility for performing the major research and monitoring tasks at on-site and off-site locations. A very high degree of co-ordination will be necessary to avoid duplication of effort and to ensure that all agencies contribute in a productive way to a thoroughly integrated research, monitoring and environmental protection program. We have already mentioned a Co-ordinating Committee, to consist of representatives of all the agencies involved in the program, including the mining company and the national park authorities. Since we expect much of the land to become Aboriginal land, the Northern Land Council should also be represented on the Committee.

An important function of the Committee should be to co-ordinate the formulation of environmental control measures to be observed by Ranger. For this reason, the Committee should be established immediately following a decision to approve mining. The Committee would not only be concerned with the planning and oversight of the monitoring and research programs; it would also be the review body to consider any major changes in Ranger's operating procedures. While the program is being developed, frequent meetings of the Co-ordinating Committee will be necessary. Later, monthly meetings may be appropriate.

We recommend that off-site monitoring should be primarily carried out by Branches of the Department of the Northern Territory, with other Commonwealth and Northern Territory departments or agencies participating when appropriate.

The evidence presented to the Commission indicates that the following Branches of the Department of the Northern Territory at present have relevant supervisory responsibilities: Mines Branch; Water Resources Branch; Animal Industry and Agriculture Branch; Forestry and Fisheries Branch; Commercial and Industrial Affairs Branch; Forward Planning and Major Projects Co-ordination Branch; and Transport Planning Branch. Sections of the Northern Territory public service have relevant responsibilities, including environment, national parks and wildlife conservation, bush fire control and control of motor vehicles.

The Northern Territory legislation relevant to the responsibilities mentioned includes: the *Mining Ordinance* 1939–1976, the *Mines Regulation Ordinance* 1939–1962 (to be replaced by the *Mines Safety Control Ordinance* 1976 if it enters into force), the *Silicosis and Tuberculosis (Mineworkers and Prospectors) Ordinance* 1966–1972, the *Control of Waters Ordinance* 1938–1972, the *Stock Diseases Ordinance* 1954–1969, the *Abattoirs and Slaughtering Ordinance* 1973–1974, the *Noxious Weeds Control Ordinance* 1963, the *Soil Conservation and Control Ordinance* 1969–1970, the *Fisheries Ordinance* 1965–1974, the *Forestry Ordinance* 1959–1965, the *Wildlife Conservation and Control Ordinance* 1962–1976, the *National Parks and Gardens Ordinance* 1959–1974, the *Bushfires Control Ordinance* 1965–1970, the *Explosives Ordinance* 1964–1975,the *Inspection of Machinery Ordinance* 1941–1976, the *Scaffolding Ordinance* 1932–1961, the *Control of Roads Ordinance* 1953–1975, the *Motor Vehicles Ordinance* 1949–1976 and the *Traffic Ordinance* 1949–1976 (to name but a few!).

The Commonwealth Departments of Health and of Construction also have responsibilities complementary to certain of those of the Department of the Northern Territory.

Some responsibilities of the Department of the Northern Territory may in the future be transferred to the developing Northern Territory public service. What we say in relation to research and monitoring, and their co-ordination, will apply equally after any such rearrangement.

To the extent that the monitoring activities recommended by the Commission cannot be carried out adequately by the departments under existing legislation, amendment should be made to it or new legislation enacted.

The implementation of the monitoring activities recited, in addition to meeting the purposes so far mentioned, would also be relevant to the fulfilment by Australia of obligations it has under the Convention on Wetlands of International Importance especially as Waterfowl Habitat, the Convention concerning the Protection of the World Cultural and Natural Heritage, and the Agreement between the Government of Australia and the Government of Japan for the Protection of Migratory Birds in Danger of Extinction and their Environment.

With respect to radioactive contaminants, no legislation exists in the Northern Territory dealing with radioactive substances. *The Code of practice on* *radiation protection in the mining and milling of radioactive ores* specifies safe practices to be followed by operators and employees which are designed to provide protection against radiation arising from mining and milling of radioactive ores. The Code also requires the manager of the operations to make various notifications to, and obtain approvals from, 'the appropriate Statutory Authority'. For most matters this will be the Mines Branch of the Department of the Northern Territory or the Department of Health. Legislation should require compliance with the Code. In addition, 'the appropriate Statutory Authority' must have powers under legislation to ensure compliance with the provisions of the Code. This would involve the power to examine relevant records, to carry out supplementary monitoring (including the taking of samples of air, water and other materials suspected of being contaminated for independent testing and assessment), to enforce standards, and to order changes in operating procedures necessary to ensure compliance with standards. We recommend the enactment of legislation, complementary to the Code, to prohibit the holding or dealing with radioactive substances (and, if necessary, irradiating apparatus) without a licence. Reference should be had to existing State legislation on the subject. See, for example, the *Radioactive Substances Act*, 1957 (N.S.W.)

While the Code recommends appropriate dose limits to apply outside the mine site, it does not specify either off-site monitoring procedures or procedures to ensure that these dose limits are not exceeded. Therefore these should be specified in the standards and monitoring procedures formulated by the Co-ordinating Committee.

With respect to non-radioactive contaminants, it is recommended that powers of on-site inspection, monitoring and enforcement of standards similar to those relating to radioactive contaminants be given to the supervising authority.

The Commission stresses the need for thorough integration in the planning and conduct of all areas of study and monitoring, so that data from each field would be directly related to relevant data in other fields. Interpretation of data for the purpose of assessing effects or predicting future events would require the same degree of integrative effort. It is clear that the development and operation of such a scientifically competent, integrated research and monitoring system will require some skills and personnel which will not be available to the agencies who presently have supervisory roles in the Territory.

The present staff of the Department of the Northern Territory will probably have to be considerably augmented if it is to successfully undertake the extensive off-site monitoring program which we recommend. In certain fields, notably radiological protection and ecological monitoring, it is unlikely that the Department would have staff with the necessary expertise. We recommend that this problem be overcome by the secondment to or contract with the Department of skilled and experienced people from the Australian Atomic Energy Commission, the Australian Radiation Laboratory, CSIRO or elsewhere. During their period of secondment, they would be required to perform the monitoring activities and train Department of the Northern Territory staff to be able to take over in later years. Seconded staff should be responsible to the Department.

Further, to achieve the degree of integration required, it will be necessary to set up a type of organisation which will bring the various participants into regular contact and close consultation about the many different kinds of activities involved.

We recommend that a research institute type structure be established, to be headed by the Supervising Scientist. He should be assisted by a small number of highly qualified scientists appointed to assist in the development and management of the multidisciplinary, integrated programs which will be necessary.

The research institute would be located in the Region. It would be staffed largely by scientists seconded from agencies with appropriate expertise. It would provide a centre where research and monitoring staff can work together in the Region.

The research institute will be one of the few places in Australia, if not the only one, where the environmental problems of a large natural region are being studied in such a comprehensive manner. For this reason the information it obtains will be of value not only for this Region but also as a guide to the evaluation of other proposed developments in the future.

It is to be expected that the presence of the institute and its facilities will be seen as an opportunity for scientists and research students, supported by grants from their own institutions, to make special studies which would be useful supplements to those being conducted at the institute. It would be very worthwhile for the institute to make provision for accommodating a small number of such studies.

The Supervising Scientist would exercise a supervisory and integrating role over all research and monitoring programs agreed upon by the Co-ordinating Committee. He should have both administrative skills and scientific expertise in a range of fields relevant to the task.

We recommend that he be appointed to the Department of Environment, Housing and Community Development at a level equivalent to a Second Division officer, and that he be directly responsible to and report to the Minister for Environment, Housing and Community Development. He should provide an annual report on the results of monitoring for public information.

It is suggested that, because of his continuing supervisory role within the Region, he should be Chairman of the proposed Co-ordinating Committee. His appointment should occur before the establishment of the Committee. He should be legally empowered to require relevant information obtained by Ranger and by the agencies participating in the research and monitoring programs, and to inspect sites and operations.

Costs of and funds for the proposed program

It is clear that the combined monitoring and research programs will involve considerable expenditure.

It is not possible to provide details or an estimate of total costs at this stage, or to allocate costs to the various agencies involved. It will be necessary to determine an equitable method of apportioning these costs between Ranger, the relevant government departments and agencies, and any other companies that might establish uranium mines in the Region.

Costs of some of the off-site monitoring activities could be regarded as normal to various government agencies but in some instances they will represent a substantial increase in expenditure. These costs will be incurred for as long as uranium is mined in the Region, and for some time afterwards.

In Chapter 5 we listed the broad topics that an effective research program would have to cover. It is considered that the program would require at least ten research scientists, with suitable assistance, accommodation, equipment and operating facilities.

Because it is essential for the long-term welfare of the Region that the research and monitoring program should maintain continuity, a mechanism for ensuring adequate and assured funding will be necessary. It is proposed that funding for the research and monitoring programs should be allocated directly to the research institute. Funds could then be disbursed to the various government agencies which would contribute to the program on a contract basis as determined in the Co-ordinating Committee. Whatever arrangement is adopted, it is essential that it provide sufficient autonomy to the Supervising Scientist so that he can arrange for the carrying out of work which is essential to the program if the agency normally performing that work finds itself unable to do so.

18 FUTURE ACTION

We have elsewhere in this Report made the following recommendations, among others:

- Under the *Aboriginal Land Rights (Northern Territory) Act* 1976, that a certain area of land in the Region become Aboriginal land (Chapter 15).
- Under the *Environment Protection (Impact of Proposals) Act* 1974, that an area of land corresponding closely to the area just referred to, but having more regular boundaries, become Aboriginal land under the *Aboriginal Land Rights (Northern Territory) Act* 1976 (Chapter 15).
- That the Mudginberri and Munmarlary leases be resumed (Chapter 16).
- That a national park be established under the *National Parks and Wildlife Conservation Act* 1975 over the area of land extending from the eastern boundaries of the Carmor Plain, Point Stuart, Wildman River, Annaburroo and Goodparla leases in the west, to the western boundary of the Arnhem Land Reserve in the east, and from the sea in the north to the present northern boundary of the Gimbat lease in the south, but including Field and Barron Islands and excluding (a) the area the subject of the Ranger S.M.L. application, (b) the area the subject of the Pancontinental S.M.L. application to be set aside for the Jabiluka mine, if development of that mine is contemplated, and (c) the Cooinda and Roper Bar Trading Company leases (see Chapters 14 and 16). Part of this land (Woolwonga) is already Aboriginal land and more of it will become Aboriginal land if our recommendations in that regard are accepted. The creation of the park over what is, or becomes, Aboriginal land will need Aboriginal agreement, but we understand that there will be no difficulty in that connection (Chapter 15).

It is necessary to discuss in more detail the implementation of these recommendations. If a decision is made that uranium mining is not to proceed, or is to be delayed for a period, the only parts of this Report which will require early attention will be those respecting the granting of Aboriginal land rights and the creation of a national park. A decision that mining should proceed at Ranger should in our view be taken in conjunction with decisions respecting Aboriginal land rights and the national park. If our recommendations respecting these matters are accepted, a number of alternative courses are available for their implementation. For convenience we set out a series of steps which we recommend should be followed in order to implement the recommendations we have mentioned, and we add comments where appropriate:

1. The Minister for Aboriginal Affairs to create a Land Trust, or Land Trusts, under ss. 4 and 11 (1) of the *Aboriginal Land Rights (Northern Territory) Act* 1976, and the Governor-General to grant the land under s. 12. If the more regularly shaped area of land to which we have referred (above, and in Chapter 15) is to become the subject of a Land Trust, an amendment to the Act may be necessary. If it is to be possible for Aboriginal land to become part of a national park, an amendment to the Act to authorise that result would appear desirable, if not necessary.

If there is to be an amendment for either of those purposes, or any other purpose, it may be thought convenient for the land in question to be declared to be subject to a Land Trust by the same Act.

2. Mudginberri and Munmarlary to be resumed, or the leases thereof surrendered by agreement. Although it has been convenient to refer to Northern Pastoral Services Ltd as if it were the sole owner, the fact is that the lease of Mudginberri is in the name of a wholly owned subsidiary, Mudginberri Station Pty Ltd, and the lease of Munmarlary is in the name of Lord Pastoral Co. Pty Ltd, of whose shares Mudginberri Station Pty Ltd owns 70 per cent. The other 30 per cent of the shares are owned by Pendarvis Pty Ltd, 75 per cent of whose shares are owned by Mudginberri Station Pty Ltd. We say nothing as to the measure of compensation. If not agreed, it will be decided according to ordinary principles. The cost of resumption should in our opinion be regarded as part of the cost of the mining development. Under existing proposals the cost could appropriately be borne by the Commonwealth out of the income or revenue it will obtain from the mining operation.

   In our view it should be possible for some years to come to use the abattoirs and most of the facilities at Mudginberri itself. Pastoral activities can be continued, but according to a plan which provides for the elimination of the feral buffalo, so far as that can be achieved, and, in any event, for their control. The conduct of those activities is not only compatible with the land being part of a national park, but extensive killing of the feral buffalo will be necessary for the protection of the park.

3. If it is contemplated that mining at Jabiluka will or might proceed, that part of what was the Mudginberri lease covered by the S.M.L. application 61 should be set aside for that purpose.

4. An opportunity should be given for claims to be made and determined under the Aboriginal Land Rights Act in respect of the land formerly part of Mudginberri and Munmarlary (including Jabiluka).

5. Either under that Act (see s. 50 (4)) or as part of a plan of management under the National Parks Act, the situation of the Aboriginal people who reside on Mudginberri should be appropriately secured.

6. An agreement should be reached with the Northern Land Council, and any other Aboriginal group it is thought should be consulted, respecting the basis on which the Aboriginal land to which we have referred, and Woolwonga, are to become part of a national park. It may be desirable for this to be done before any of the land in question is made subject to a Land Trust. The implementation of the agreement will require an amendment to the National Parks Act, because, under that Act, only land in which 'all right title and interest is vested in Australia' can become part of a national park (s. 7 (1) (a)). The suggestion made to us on behalf of the Aboriginal people is that there be a lease in perpetuity to the Director of National Parks and Wildlife, but this is a special statutory concept which itself needs definition, and which, under some crown lands legislation, is sometimes regarded as the equivalent of an estate in fee simple. We suggest a lease for a term of 100 years. Depending on what is agreed, and how, some amendment to the land rights legislation may be necessary to authorise the proposed lease.

An amendment to the Land Rights Act should allow land rights claims to be made and dealt with notwithstanding that land has become part of a national park.

The amendments can take account of the terms actually agreed. They may in fact create the lease, but it may be preferable for its execution to be left to the Land Trust or Trusts involved. The special position of the Aboriginal people in relation to that part of the park constituted by their land, and their special position generally in relation to traditional matters, should be recognised and safeguarded.

7. The Kakadu National Park should be declared under s. 7 (2) (a). We recommend that the whole of the area we have mentioned should be declared at the one time. Consideration can be given in due course to the addition of the parts of Goodparla and Gimbat in the headwaters region of the South Alligator River.

   It is possible to deal with the matter in stages. A first stage could be the proclamation of an area corresponding roughly to that gazetted in May 1975 as the intended Kakadu National Park. Even so there would be two alterations to the boundaries then proposed, one of which might be regarded as essential and the other as desirable. The first is to omit Jabiluka and the other is to include a small triangular section of land near the Gimbat border which was not previously included.

   We suggest that in all the circumstances, having in mind our public investigation of the matter and the long history of proposals for a national park in the Region (see Chapter 10), the need for a report from the Director under s. 7 (11), or at least the need for him to notify it and receive representations about it under s. 7 (12), can properly be dispensed with; this can be attended to by an amendment made at the same time as the others to which we have referred.

8. Once an Aboriginal Land Trust is established which includes the Ranger mining area, negotiations can take place between the Northern Land Council and Ranger respecting the terms and conditions to which s. 43 (2) refers. Agreement cannot be arrived at without there being a knowledge of the terms and conditions of the intended lease or leases. Completion of an agreement will probably also depend on knowledge concerning the location of the national park and the scheme proposed for its management. If there is no agreement, arbitration will be necessary.

9. The Director of National Parks and Wildlife should proceed with the preparation of a plan of management for the park. This need not in the first instance embrace the whole park in full detail. Matters requiring early attention will include the regional centre and, if Mudginberri and Munmarlary have been resumed, the conduct of operations on that land. The plan of management should ensure that Aboriginal views, in respect of matters peculiarly the concern of Aboriginal people, be strongly represented. It is likely that the Northern Land Council will propose something in this connection, either at the stage when arrangements are being made for Aboriginal land to become part of the park or later. In our view the Northern Land Council should be consulted concerning all proposed plans of management, and should have the right to make representations with regard thereto to the

Minister for the time being responsible for the administration of the National Parks Act.

In our view plans of management should not, for the time being at least, make any provision for mining or exploration in the national park (see s. 10 (2) of the National Parks Act).

We have been told of a plan under which what has been called the day-to-day management of the park will be shared between the Director of National Parks and Wildlife and the Director of Territory Parks and Wildlife. The Legislative Assembly of the Northern Territory has passed the *Territory Parks and Wildlife Conservation Ordinance* 1976, but it has not yet been assented to. In many respects it is similar to the federal Act, but the Territory Director is given less autonomy. In particular, he is to work under a Commission. The Commission does not, under the Ordinance, have power to function in respect of a park created under a federal Act. There will therefore be a need to give close consideration to the way in which the arrangement mentioned is to work. If the Territory Commission is to have a function in management, Aboriginals should in our view be represented by at least two persons on it. In any event the Northern Land Council should have a right to make representations to the Minister at any time respecting the management of the park—a right which doubtless would only be exercised after consultation with the Director of National Parks and Wildlife.

Reliance principally on Aboriginal personnel for the supervision of any Aboriginal land incorporated in a national park should be mandatory, and in our view maximum employment of Aboriginals in management of areas of national park not on Aboriginal land should be established as a policy. The provision of training programs for Aboriginals for this purpose would be necessary; there is provision for training in the National Parks and Wildlife Conservation Act.

10. In Chapter 14 we point out some possible problems respecting the operation of the Northern Territory Mining Ordinance. If necessary, these can be attended to readily by amendment.

11. What is important is to secure strong environmental controls in relation to mining operations. These will have to be instituted by or under the lease, or the agreement made under s. 43 (2) of the Land Rights Act, or the general law. It is vital that they be prescribed, and enforceable. We refer in this Report from time to time to a supervising authority, which will prescribe or monitor standards, or do both those things. We use this as a generic term to encompass all relevant authorities. We have given consideration to recommending the establishment of an independent regional authority with a strong supervisory role, but, not without some doubt, we have finally concluded that it is best if appropriate governmental authorities, federal and territorial, be used.

Our doubt stemmed largely from the justifiable criticisms that have been made concerning the performance in the past of governmental agencies in the Northern Territory as protectors of the environment. An example is the quite reprehensible failure to take action in relation to serious pollution from the mill operations at Gove and, what is more, a disinclination to acknowledge that there was any neglect. It is apparent to us that if, as we hope they can, government departments assume effective roles in the various ways pointed out in this Report, close and energetic attention will have to be given to their appropriate organisation and staffing—and to ensuring that they are adequately funded at all times.

We make a specific recommendation for the establishment of a Standards and Monitoring Co-ordinating Committee, and the appointment of a Supervising Scientist, as head of a small research institute, to co-ordinate and integrate research, standards and monitoring operations. This machinery should be established before any substantial amount of construction work starts.

An expert radiation authority other than the Atomic Energy Commission should be available to the government agencies and officers concerned. We are satisfied that the Australian Radiation Laboratory of the Department of Health can and will perform this task, and we recommend accordingly.

12. It is our expectation, and part of our purpose, that the parks authority, and the Northern Land Council, having the interest to do so, will reinforce the environment protection machinery. It is important that they have readily available to them the information which will enable them to do this task, and we recommend that it be made mandatory, preferably by regulation, for Ranger (and other mining companies), and their contractors, to answer promptly any request for relevant information respecting themselves and their operations, made by either the Director or the Northern Land Council. Both the Director and the Northern Land Council should have appropriate rights of inspection. If necessary, the exercise of this right in both cases could be restricted to approved representatives. Further, the environment protection provisions should be made legally enforceable, and both the Director and the Northern Land Council given standing to enforce them. Both should be given the right to proceed by way of injunction to restrain any action which might reasonably be expected to do substantial damage to the environment in its social as well as its physical aspects, and to compel action which might reasonably be expected to avoid such damage. The Supreme Court should be given a wide discretion as to the exercise of its jurisdiction in such cases. The necessary provisions can be made by a special Ordinance or by way of amendment to existing Ordinances.

13. A deliberate and comprehensive program to minimise adverse social effects on the Aboriginals, and to assist them in coping with the stresses to which they will be exposed and in taking advantage of any benefits accruing to them, will be necessary. The program will have to be integrated with overall management of the Region. We make recommendations regarding these matters in Chapter 13.

14. In the First Report we recommend that the Government should retain the power to terminate or suspend mining operations, perhaps at very short notice. It is unlikely that any Government would wish to bring all mining operations to a complete, immediate and permanent halt unless the circumstances were extreme, but, for reasons we gave in the First Report, it is important that it be recognised from the outset that the Government has a power which at its extreme point may be exercised in the way mentioned.

15. It is also possible that Ranger may itself terminate or suspend operations before their natural conclusion, and of course it or a successor may encounter financial difficulties and go into liquidation. It is necessary to provide for protection of the environment in those situations, as well as upon the ordinary completion of mining activities. The provision of necessary security, by way of the creation of a fund or the establishment of a bond, is discussed in Chapter 6.

16. We recommend in our First Report (Chapter 16) the establishment of a national Uranium Advisory Council. The main purpose of that body is to advise Government. We see it as a part-time body with a small secretariat and research staff. Within reasonable limits its services should be available to bodies such as the Director of National Parks and Wildlife, the Northern Land Council and the Co-ordinating Committee, as well as the mine operators. In our view the Uranium Advisory Council should be established as soon as reasonably practicable. Its services will be valuable whether a decision is taken to proceed immediately with arrangements for supply or it is decided to postpone such arrangements. In either event, for example, it could give independent advice on progress being made about means of waste disposal.

17. In Chapter 19 we discuss marketing considerations and recommend the establishment of a marketing authority. The authority should be created before any further contracts for supply are entered into.

18. In our statement of Principal Recommendations we draw attention to changes in legislation which should be considered.

19 MARKETING AND CONTROL OF AUSTRALIAN URANIUM EXPORTS

In our First Report, we recommended that, because of the particular hazards associated with the nuclear power industry, there be stringent government controls over the mining and export of Australian uranium, and expressed the tentative view that the controls could best be achieved if mines were developed sequentially. We examine in this chapter possible institutional arrangements, both national and international, for the marketing of uranium and the interrelationship between these arrangements and those necessary in order to provide adequate safeguards. To put these matters into perspective, we begin the chapter with a discussion of important characteristics likely to emerge in the international market for uranium.

The role of long-term contracts

Both uranium mining companies and electricity generating authorities are likely to prefer long-term rather than short-term contracts to cover a substantial proportion of their uranium transactions. In the case of mining companies, the writing of long-term contracts reduces many of the risks associated with the establishment and operation of mining and milling operations. Also mining companies may be able to obtain substantial advance payments on contracts or borrow against the income expected from contracted sales. Electricity authorities are likely to favour making firm forward arrangements for a large proportion of their anticipated uranium requirements, so as to avoid the situation where attempts to obtain substantial quantities at short notice cause significant pressure on prices.

At first sight it appears, therefore, that almost all sales of uranium could be made under long-term contracts, enabling future uranium output to be tied firmly to the requirements of nuclear power programs. However, there are several factors working against this outcome.

Firstly, difficulty could be expected in trying to reach agreements on prices to be paid for uranium under these contracts. Cost changes arising from general inflationary conditions and from changes in exchange rates cannot be forecast accurately, and the possible advent of new uranium producers and the effects of change in mining and milling techniques are further complicating factors. Also electricity authorities would not generally be in a position to make firm forward commitments for all their long-term uranium requirements, principally because of the possibility of changes in demand for electricity. In the long term, neither the uranium requirements in a given time period nor the rate of growth of requirements can be predicted with precision. Generating station construction programs are generally flexible enough to enable construction to be postponed when forecasts of electricity requirements are revised downwards. Although stations intended to begin producing electricity in six to ten years are now either under construction or in the planning stage, the demand for uranium in this period may still be reduced by postponements. Lower levels of economic activity have been responsible for many construction programs being postponed in recent years. In the short term, that is less than six years, fluctuations in demand will be minimal because nuclear power stations once in operation are used preferentially for base load electricity generation, so that their uranium requirements are less likely to vary widely.

Revisions in nuclear and other power programs are likely to continue. As a consequence, electricity authorities will need to retain a considerable degree of flexibility in arranging their uranium supplies.

In order to provide for changes in uranium requirements from those covered in long-term contracts, it is desirable, from the viewpoints of both uranium producers and consumers, for a market mechanism to be available by which supplies of uranium can be obtained by electricity authorities at relatively short notice. However, the existence of such a market means that large fluctuations are likely to occur in prices for these transactions, as they have in the past. These fluctuations make 'market' prices at a point of time unsuitable as the basis for fixing prices for deliveries under long-term contracts. However, long-term trends in market prices may play an important role in providing a basis for agreement on prices paid under such contracts.

Some long-term contracts incorporate a 'base' price, together with provision for renegotiation of prices before uranium is delivered and provision for adjustments to the base price to provide for general cost increases. This latter provision helps protect supplying firms from erosion of their 'real' profits. However, there can be difficulty in agreeing on methods of making price adjustments, particularly when rates of inflation vary between supplying and purchasing countries and the effects of such changes are not offset by variations in the rate of exchange between the two currencies concerned.

One suggested method of dealing with these problems is to base contract prices on a 'cost-plus' formula, so that prices paid would be adjusted to take account of actual increases in uranium mining and milling costs in the supplying countries. This procedure has the advantage of allowing prices to be fixed in real terms, as far as the producer is concerned. However, general adoption of a 'cost-plus' system would result in lower prices being paid for uranium from high grade deposits than for the output of lower grade deposits, or greater price increases being given for those enterprises with higher rates of cost escalation. It is unlikely that such a situation would be generally acceptable to companies or countries with higher grade ores or lower inflation rates, since they normally expect to receive the same price as other suppliers of an identical commodity. Consequently, there seems little prospect of widespread agreement to adopt a 'cost-plus' system.

In the absence of some kind of intervention in the market, variations in demand for uranium seem likely to continue to be accompanied by strong fluctuations in prices for immediate and near-term deliveries and continuing difficulties in agreeing on prices for supplies under long-term contracts. We look now at the possible effects of intervention in the market by either corporations or governments.

Control of supply by uranium producing companies

One method of attempting to avoid market fluctuations would be for the various uranium producers to co-ordinate their production and marketing activities with the intention of keeping prices within agreed bounds. Experience suggests that attempts of this kind are likely to succeed only in relation to short-term fluctuations and then only when the number of producers is small and the commodity concerned is one for which no close substitutes are available. Even in these circumstances, producers often find it difficult to agree among themselves on prices to be charged, especially when unit costs of production vary substantially between them. In addition, it may be difficult for new producers to be accommodated into the marketing arrangements.

Although the number of large producers of uranium is likely to be relatively small, because of the capital-intensive nature of the industry, and although there is in the short term no close substitute for uranium as a fuel for nuclear reactors, the likelihood exists that any attempt by uranium companies to act together to set prices will meet with hostility from potential consumers and their governments. Action has already been taken by U.S. authorities to investigate the extent to which uranium producers have acted collusively in this area, and there can be little doubt that any future attempts to act in this way would meet substantial opposition.

In these circumstances, it appears that the only form of major intervention in the uranium market which might be acceptable internationally would be one which involved considerable participation by governments. A comprehensive international marketing agreement between governments could comprehend both marketing and safeguards arrangements.

Government intervention in markets

If the government of a country exporting uranium wishes to ensure that major fluctuations in demand and price do not cause adverse social effects within the country, it may consider it desirable to intervene in market transactions. It may also wish to avoid the situation where individual producers of a commodity are at a bargaining disadvantage with an importing country.

Minimum intervention could be achieved by surveillance of export contracts and if necessary, withholding of approval of exports in cases where prices were regarded as unsatisfactory. This approach has been used by various Australian Governments in relation to coal and other exports. It would be necessary for the government to monitor developments closely in the world uranium market, including prices for long-term and near-term transactions, if such a policy were to be implemented successfully. The principal advantage of this approach would be that mining companies would be relatively free to make contracts with purchasers of uranium and would be able to make full use of their marketing expertise to secure sales contracts. Competition between the mining firms might produce more effective mining and marketing operations, in which case such gains would tend to offset any losses arising from this competition, leading to lower uranium prices.

At the other end of the spectrum of possibilities for government intervention would be direct participation in mining and marketing by a governmental authority empowered to arrange both production and sales. An advantage of this course would be that fluctuations in output arising from changes in demand for uranium could be spread between individual mines in a manner designed to minimise undesirable social or environmental effects. Disadvantages of direct government intervention of this kind would include any losses in mining and marketing efficiency which might flow from reduced competition between mining firms.

It might be possible to arrange a form of government control lying between the two schemes mentioned. For example, a government agency could control marketing, allocating shares of available markets to the mining companies, but leaving mining operations to the individual firms. While this arrangement might be seen as avoiding the possibility of foreign exchange losses resulting from competitive marketing by individual companies, scope would remain for some competition between mining firms in achieving efficiency in mining operations.

Some government intervention is required in the export of Australian uranium to ensure that safeguards provisions are adhered to. It may help to avoid unrestrained development of the uranium industry leading to large fluctuations in the supply/demand relationship and consequent instability in market prices for uranium. The large proportion of international trade in uranium which Australian production may constitute makes this a possibility. Co-ordination of marketing activities, via a central selling authority, may achieve the desired strategic and economic results. While it is conceivable that these objectives could be pursued without a marketing authority, participation by the authority in the world market for uranium should ensure that these tasks are performed in a more effective and co-ordinated manner.

Control of supply by governments of producing countries acting together

In the past, governments of various countries dominating the supply of particular commodities have intervened in the market in attempts to stabilise prices and achieve other goals. The most important current example is the arrangement whereby OPEC sets the prices paid for internationally traded petroleum. The success of the OPEC arrangement stems mainly from the control exercised over supplies from the principal petroleum exporting countries. Controls of this type are most effective when the demand for the commodity concerned is not very responsive to price changes, when no close substitutes are available, and when important new producers of the commodity are unlikely to emerge. These circumstances apply in the case of petroleum.

Considerable difficulties have been encountered in attempts to devise arrangements to stabilise markets for other commodities. In a number of cases, the failure of one or more major producing countries to take part in the arrangements has proved a major obstacle. In others, the ability of consuming countries to produce their own supplies of the commodity, or close substitutes for it, has caused the attempts at control to fail.

In some cases, agreements among producing countries have led to charges by importing countries that prices are set above competitive levels. As a consequence, commodity agreements having only producing countries as members have sometimes given way to agreements involving both exporting and importing countries. The idea of including both types of countries in commodity agreements originated before World War II and is a feature of the long-established international agreements covering wheat, sugar and tin, as well as the more recently completed agreements covering coffee and cocoa.

In view of the fact that substantial uranium reserves have been found in a considerable number of countries, and the likelihood that additional potential suppliers will emerge if exploration and development continue, difficulties appear likely in reaching agreement on joint marketing arrangements involving exporting countries only. The existence of substantial uranium supplies in a number of important consuming countries, including the United States and Canada, increases the difficulties. These countries can be expected to rely more heavily on their own resources, or on supplies which might be secured from mines controlled by them in other countries, if exporting countries attempt to act in concert to significantly influence uranium prices. Consequently, the only type of intergovernmental agreement likely to be acceptable would be one in which both exporting and importing countries participated. The possibility of such an arrangement eventuating is increased by the fact that many governments already involve themselves in the uranium industry, because of its strategic importance. This trend is likely to continue. Recent actions by the U.S. Government indicate its commitment to governmental control of the industry.

International agreements involving exporting and consuming countries

One of the principal advantages of international commodity arrangements involving both producing and consuming countries is that intergovernmental arrangements can be developed covering both production and marketing. This advantage may be of overwhelming importance in the case of uranium, because of the necessity for close control, for strategic and environmental reasons, over its international movements. An agreement of this type would also be consistent with the expressed desire of OECD members and other countries to adopt a co-operative approach to the solution of energy problems. In addition, the economic advantages might be quite important if prices could be stabilised and the rate of production matched more closely to uranium requirements. However, it must be recognised that participation by both exporting and importing countries can make more difficult the attainment of agreement on the terms of commodity arrangements. This can reduce the effectiveness of such arrangements.

To control the production, sale and use of natural uranium, international agreement would be necessary to set up an agency responsible for these activities or to make an existing agency responsible for them. The agency concerned would need to establish firm links with production and marketing bodies in exporting countries and with consuming authorities in importing countries, either directly or through government instrumentalities in each country. Under such an arrangement, it might be possible for agreement to be reached on prices for uranium purchased both under long-term contract and for immediate or early delivery. However, agreement on prices is unlikely to be achieved easily, particularly as costs of production would differ between mines and countries and contracts would be written for different time periods and under different circumstances.

Similar difficulties in regulating prices have been encountered with other primary commodities covered by international agreements, and much attention has been given to devising methods to reduce price variations. Particularly relevant in this context is the International Tin Agreement. This is based on the 'buffer stock–buffer fund' principle under which a manager, appointed by member countries, has a supply of tin which he can sell when the market price rises above a certain level. He also has funds available to purchase tin on the market when the price falls below another level. Clearly the success of such a scheme depends on the stock of the commodity and the funds available for use in stabilising the market. If insufficient stocks or funds are available, it may not be possible to prevent large price fluctuations. The manager's activities may even serve to accentuate fluctuations if stocks or funds are exhausted before the underlying causes of the price variations are removed or new price levels established.

The constraints which would be placed on the market mechanism by an effective safeguards system cannot be predicted accurately. It may well be that a short-term marketing system of the traditional kind, with or without a 'buffer stock—buffer fund' arrangement, may not prove feasible in this context. It may be necessary for governments to provide many of the functions of a short-term market, in the context of an international agreement, and in particular to provide a stock-holding capacity.

As large quantities of uranium are currently held in stockpiles by government agencies in various countries, it may be possible for a scheme of this type to be provided quickly with supplies of uranium for its initial operations. Over time, the agreement could enable stocks to be built up to levels sufficient to allow the international agency, whether holding stocks itself or having access to stocks in member countries, to intervene to prevent market fluctuations which would otherwise occur as a result of variations in uranium requirements. Considerable care would be needed to ensure that excessive stocks were not built up, so as to avoid unnecessary pressure on prices.

Member countries would have to provide the management of such an international agency with sufficient funds to enable it to operate effectively. As both exporters and consumers would benefit from the operations of the scheme, it would be appropriate for contributions to support the agency to come from levies on the mining companies and electricity authorities concerned in the transactions.

Despite the formidable difficulties likely to be experienced, especially in the initial stages, effective international control of trade in this metal is necessary on environmental and strategic grounds. It would seem sensible for discussions concerning an international agreement on trade in uranium to proceed simultaneously with negotiations on more adequate safeguards and related matters.

Conclusions In order to avoid undesirable effects which may stem from large fluctuations in the price of uranium, an international agreement involving, if possible, all major producing and consuming countries should be negotiated. If considered desirable on environmental or strategic grounds, it may be possible for the international agency set up under such an agreement to handle all international transactions in uranium, fixing prices and the quantities exchanged. However, this might mean that production was allocated among countries on criteria not closely related to ordinary market forces and, from an economic point of view, a scheme which allowed market forces to play a more important role would be preferable.

An international agency intended to prevent large fluctuations in market prices would need to have access to sufficient resources to operate a 'buffer fund–buffer stock' arrangement. It would therefore require substantial backing by the governments concerned, including access to official stockpiles of uranium and to substantial funds. If there are no compelling environmental or strategic reasons why such an agency should have a major direct role in buying and selling uranium, it would be preferable for most transactions to take place between bodies in the various countries engaged in international trade in uranium. This procedure would have the advantage of allowing underlying cost and demand forces to play a dominant role in setting uranium prices. The agency would monitor the range of prices set in long-run contracts and decide on prices at which it should intervene in the market for short-term deliveries.

The international agency should acquire uranium at rates related to both current market conditions and maintenance of a level of stocks judged adequate to meet changing economic circumstances. Management of the agency would require considerable expertise and judgment, and would need to be carefully co-ordinated with the operations of other related international agencies and appropriate national bodies.

An international scheme of this kind would be compatible with arrangements in individual countries ranging from considerable autonomy for individual companies to national mining and marketing authorities. As it is generally recognised as undesirable that governments give up responsibility for control of production, trade and consumption of uranium, some form of government intervention is likely in each country concerned. This should facilitate the operation of an international agreement. The existence of a national authority with appropriate powers would be of considerable advantage in minimising dislocation to producers resulting from a Government decision to cease supplying uranium to a particular country.

Although Australia could establish a single body controlling both uranium mining and marketing, a central marketing authority, responsible only for oversight of Australian sales and administration of export policy, including safeguards requirements, may be appropriate.The authority would have the responsibility of monitoring the international uranium market and would have the advantage of being constantly in touch with market conditions. It would also be in a position to act quickly to end supplies to any country which the Australian Government decided was not conforming with Australia's requirements concerning the use of uranium.

The authority should be a body having government, mining company and other representation. It would have to maintain appropriate relationships with the proposed Uranium Advisory Council which should, in addition to its other responsibilities (see pp. 183–4 of the First Report), provide independent and disinterested advice to the Government on marketing considerations. We recommend that the marketing authority be established before any further contracts for the sale of Australian uranium are made.

20 CONCLUSIONS

The matters which have been debated before us are seen by some in the light of a contest between environmentalists and despoilers of the environment, between conservationists and developers. These contrasts are false. The question is a single one – what is best for the environment, that term being unlimited in relation to its physical and its social aspects. The contest is largely one between short-term and long-term interests of the environment, and ultimately one has to ask what reasonable and sensible balance can be struck between the two.

In terms of human welfare, it is a question of accepting responsibility towards future generations, as well as for those now living. Imponderable questions arise which must largely be dealt with as a matter of faith; questions such as how finite are our resources and what trust can be put in science and technology to find answers to our problems. Ethical judgments are involved at many points and are the ultimate determinant.

In Chapter 1 we have referred to the findings and recommendations of our First Report (which is to be read, with this, as one), and they are for convenience set out at Appendix X of this Report. We do not attempt to carry further our evaluation of the risks and dangers associated with the use of uranium in the nuclear power industry, contained in the First Report. What we have learned since then tends to confirm strongly the views we have expressed.

We have discussed in more detail in this Report (see Chapters 6 and 7) the particular problems of uranium mining, so far as they have a bearing on the Ranger project.

We have also carried further our examination of marketing and economic considerations including the possible effects of a large uranium industry on national and regional economies. We set out in summary form hereunder some conclusions on those matters which relate to the general question whether Australia should or should not mine uranium at all:

- The long-term market prospects for our uranium appear on the whole to be good, although fluctuations may be severe, and sudden.

- Except for sales from the stockpile held by the AAEC and production from the Mary Kathleen Mine (which can only be small), we cannot enter the market before the early 1980s. In any case it is doubtful whether there is any real place in it for us before then.

- The market may be affected, quite drastically, by a wide range of different events including fluctuations in the levels of economic activity, changes in the competitiveness of nuclear power, changed energy policies in overseas countries (which may be influenced by local environmental considerations), the development of conservation policies and of alternative energy sources, the development of further uranium mines, and policies about the development of reprocessing facilities and the fast breeder reactor. (Fast breeder reactors were discussed in the First Report. While their development could substantially reduce the demand for uranium in the long term, they will not have a marked effect on the uranium market this century.) Ordinary trade considerations will play their part, but are likely to be influenced strongly by governmental policies towards the development and use of resources. As we stated in our First Report, a particular market might have to be cut off precipitately by the Australian Government for a number of reasons; for example, if it is found or believed that a particular purchasing country is using our uranium for military purposes or allowing it to be used by other countries for such purposes. In most reactors uranium is used in an enriched form, and variations in the arrangements made concerning enrichment could have a substantial impact on the market for natural uranium.

- If conditions prove favourable, the net economic benefits from the sale of our uranium can be great. Both Ranger and a larger uranium mining industry in the Region are likely to be highly profitable and to contribute substantially to the income of the Northern Territory. Uranium mining could become an important industry in national terms.
- The most important markets at present envisaged are the highly developed industrial countries, particularly Japan, the United States of America and the countries of Western Europe.
- At present, and for at least fifteen to twenty years, most developing countries have, and will have, relatively little need for uranium; their requirements for electricity production can be met more cheaply and more satisfactorily from conventional fuels.
- No overseas country has an absolute need of our uranium, in the sense that it cannot acquire its needs elsewhere. A particular country may nevertheless wish to buy our uranium for special reasons, such as a desire to diversify sources of supply or because of our relative political stability.
- If we apply a strict policy concerning safeguards, and related matters, such as is recommended in our First Report, it is quite likely that we will refuse to supply some countries, including some developing countries.
- It is unlikely that Australia will require any substantial amount of uranium for electricity generating purposes this century, or early in the twenty-first century.
- The market for our uranium is likely to continue well into the next century. It cannot be said that the market will be any more or less profitable, or stable, in, say, the 1990s than it will be twenty or thirty years later.

A particular purpose of this Report has been to examine in detail the Ranger project. The general observations we have made about the uranium market apply to the prospects of Ranger, but the ore bodies proposed to be mined by it will probably be exhausted in under thirty, or even twenty, years, depending on the rate of production.

We have dealt with the environmental consequences of the Ranger proposal on the footing that a decision is not made, based on considerations of the nature discussed in our First Report, which is adverse to uranium development in Australia. So far as we were and are able to evaluate those considerations we did so in that Report. By proceeding as we have done, we have not meant to imply that a decision favourable to uranium development in Australia will or should be made.

Although we are dealing with the Ranger project, it has been necessary for us to take into account to some extent the proposal of Pancontinental to mine nearby. We do not do so for the purpose of making recommendations about what should be done in connection with that proposal; that should be the subject of separate investigation. Our purpose in considering the Pancontinental project, to the extent to which we do, is to enable us to make meaningful recommendations respecting the Ranger proposal. It is a possible view, but not one we recommend, that a decision on the Ranger proposal should wait until a decision on the Pancontinental proposal can also be made.

The Ranger proposal is contained in its Environmental Impact Statement and in a body of evidence which elaborates it and in some respects amends or qualifies it. An examination of the environmental consequences of a proposal requires a view to be formed as to the nature of the uses to which land likely to be affected will probably be put. It will often be necessary also to know the persons, or classes of person, who will own it or have the right to use it. The study of the environmental impact of its proposal made by Ranger assumed that there would or might be a national park to the east of the mine location, corresponding to the area of the Kakadu National Park as proposed in 1975; that Mudginberri and Munmarlary pastoral operations would probably continue; that there would probably be a regional centre to the west of the mine; and that immediately to the west of the regional centre there would be the Woolwonga Aboriginal Reserve. The rest of the land was seen as vacant crown land. The Aboriginal people were seen as living mainly at Oenpelli and Mudginberri and as making only occasional use of land further afield. This assumed pattern of land use coincided fairly closely with the position that existed, and Ranger did not postulate any major change.

Even on the basis on which it proceeded, the Ranger assessment in our view did not make adequate allowance for the impact on the Region of the increased population the mining operations would bring and it failed notably in its evaluation of the total impact on the Aboriginals in the Region.

It became apparent to us during the course of the Inquiry that the land use pattern to which Ranger had referred its environmental impact assessment was not a stable one, nor did it represent the best use of the land. A major change has been the recognition of Aboriginal rights in respect of land with which they have a traditional affiliation, and, as we have found, the land in the vicinity of the Ranger proposal comes into that category. A further important matter is that the pastoral operations on Mudginberri and Munmarlary are of doubtful economic viability and are likely to be adversely affected in some degree by the mining operations. The position became even more remote from that postulated by Ranger when it was submitted on behalf of the Aboriginal people that they would be willing for land which becomes Aboriginal land under the Land Rights Act to be made part of the national park.

The environment under consideration is a uniquely sensitive one. Its elements interact so closely that consideration of one without the others becomes impracticable and purposeless.

In all those circumstances we felt compelled to arrive at a land use plan ourselves, by reference to which the Ranger proposal could be judged. We have done so on the basis of the evidence and submissions presented to us. The relevant considerations are dealt with in a number of chapters, and the plan is discussed in Chapter 16. In short, the plan maximises the potentiality of the Region and takes full account of the position of the Aboriginals within it.

The Ranger project as proposed, and in the land use setting which was assumed, should not in our view be allowed to proceed. On the other hand, if the plan we propose is accepted, and the various matters we recommend in relation to it, and to the mining operations themselves, are carried out, the adverse environmental consequences of the proposal can be kept within acceptable limits. Every step in our recommendations is designed to ensure that a reasonable accommodation is reached between the proposed mining venture and the conflicting environmental values and interests.

For reasons discussed in Chapter 15 we have recommended that a large part of the Region, including the Ranger Project Area, on which the proposed mine is situated, become Aboriginal land. Aided by the Aboriginals' agreement to the proposal, we have also recommended that this land, excluding the area the subject of Ranger's application for a Special Mineral Lease, become part of the national park. A major national park in the Region has been contemplated for many years (see Chapter 10). The plan of management of the park should be established in collaboration with the Aboriginal people, and they should have an adequate say in its management (see Chapters 15 and 18). We have recommended that the Mudginberri and Munmarlary properties be resumed (Chapters 16 and 18), that an opportunity be given to the Aboriginal traditional owners to make claims in respect of them, and that, in any event, the land at present constituting those properties (excluding, if thought desirable, the area on which is located the proposed Jabiluka mine) should become part of the national park.

A town in the Region will be necessary for the accommodation of those employed in, or in connection with, the mine, and their families. We recommend that the number of its residents be kept to the minimum consistent with the operation of the Ranger mine, and that no tourist accommodation be provided within it. We are of the view that the town should not become Aboriginal land but should become part of the national park, and we have made recommendations with a view to achieving that result.

The greatest threat to the environment, and particularly to the welfare, well-being and culture of the Aboriginal people, may prove to be the large white population which the mining ventures will bring. We discuss the problems in Chapter 12, and in Chapter 11 we discuss the related matter of tourists. If the Ranger project proceeds, but the Pancontinental one does not, the problem, with care, will probably not become acute. If the Pancontinental mine is also developed, the position could become unacceptable. We have recommended courses designed to minimise the risk and in particular have recommended that the position be progressively re-examined in the light of experience.

It is our conclusion that if the Ranger proposal is to be allowed to proceed, it has to be on the basis that no other mining, with the possible exception of that proposed by Pancontinental, should, for the time being at least, be allowed in the Region west of the Arnhem Land Aboriginal Reserve. Present difficulties have been accentuated because companies were encouraged to explore, and were encouraged in the belief that mining would be allowed, before environmental consequences were fully examined. Great care should therefore be taken to ensure that no expectations are raised that further mining development will be permitted. For reasons which we give in Chapters 8 and 16, we are of the view that the Noranda mine should not be developed, at least for the time being.

We acknowledge that we adopt a sensitive approach to the position of the Aboriginal people. We appreciate that there will not be wanting others in the Australian community with knowledge of their ways and behaviour who will regard our solicitude for the welfare of the Aboriginal people as misplaced, and our recommendations unduly favourable to them. Such views are understandable and not so long ago would have prevailed. We see the Land Rights Act, with its acceptance of most of what Mr Justice Woodward said and recommended in his Reports, as an acknowledgement of a turning point. The changed attitude is not, as we understand, a matter of conscience, but of justice, based on a fuller and better understanding of Aboriginal people, their ways and their beliefs. It is now no longer expected of them that they adopt the customs and lifestyle of the white man, if they do not wish to do so.

We deem it to be a matter of the highest national interest that those many Aboriginal people who currently live less than what they themselves regard as dignified and purposeful lives should be given every possible encouragement and assistance to improve their position. It now seems accepted, and the Land Rights Act is a manifestation of the policy, that self-determination is a path to that end, and that relationship to land is central to the attainment of the necessary confidence, and purpose, and self-esteem.

It is our assessment that the planning of the Region with which we are concerned provides a great opportunity, perhaps the first on such a scale which has offered, to advance the welfare of the Aboriginal people and to demonstrate to them that the new attitude is real and meaningful. In this way a foundation can be laid for enduring harmonious relations with them. The approach which we favour cannot be followed without cost, and without the denial to white people of the power or advantages they might otherwise have expected. A negative consideration is that the cost in one form or another of not following such an approach may in the long run prove much greater.

We have examined in detail from the point of view of environmental consequences the plans of Ranger respecting the mines, the mill, the acid plant and other associated plant, and the tailings and other dams. We should say that in general they disclose a conscientious concern for the physical environment. We have however formed the view that some further measures must be taken, the most important of which are designed to minimise the escape of radon, and of polluted water, from the mine area and the tailings dam. We make recommendations in this connection which are discussed in Chapter 7.

For the protection of the environment, it will be necessary for standards to be established in relation to a number of matters, from radon concentrations to heavy metal releases. Some of these will also be necessary for the protection of workers. The standards will have to be monitored. In order to establish base data from which conclusions in respect of environmental damage can later be drawn, and in order to help plan the monitoring program, a small research unit will be required. We have considered these matters in Chapter 17, where we make recommendations respecting them. It is our view that the establishment of standards and the supervision of monitoring should be the responsibility of bodies which are independent of the Atomic Energy Commission and the mine operators.

An advantage of the recommendations we have made with regard to Aboriginal ownership of land and the creation of the national park is that there will be people who have the interest and knowledge to protect the environment from the consequences of the mining operations. Indeed, as we mention in Chapter 14, the Aboriginal people, through the Northern Land Council, will be in a strong position to look after themselves. We had for some time contemplated the establishment of an independent authority to ensure that appropriate standards were set and monitored, and to take action when significant damage to the environment, in any of its aspects, occurred or was threatened. In view of the considerations just mentioned, we do not now consider such a course to be necessary. It will however be necessary to ensure that the Northern Land Council and the Director of National Parks and

Wildlife can readily obtain necessary information and take appropriate action, and we make recommendations to that end.

As not a little will depend on how and when our major recommendations are implemented, we deal with this topic in Chapter 18.

The chief recommendation we propose concerning the Ranger project is apparent from what we have already said. If an adverse decision is not made on the basis of the wider considerations discussed in our First Report and summarised in Chapter 1 of this Report, the project should be allowed to proceed, but only in the circumstances stipulated in this Report and subject to the recommendations we make in it.

PRINCIPAL RECOMMENDATIONS

We set out below the principal recommendations which appear in the various chapters of this Report, but not always in exactly the same words, and sometimes their formulation draws on recommendations made in other chapters. They should be read in the context of the chapters in which they appear. The recommendation which we make on the question whether the Ranger project should proceed is in Chapter 20, and is repeated hereunder. Other recommendations relate to what is to be done if the project proceeds, and should not be understood as independent recommendations that it do proceed.

The findings and recommendations of the Commission under s. 11 (2) of the *Aboriginal Land Rights (Northern Territory) Act* 1976 appear in Chapter 15 and are not repeated here.

We were invited by some of the parties, other than Ranger or Pancontinental, to recommend payment of their costs, or part thereof, by the Government. This was substantially on the basis that they were non-profit organisations which had assisted the Inquiry by their participation. We acknowledge their assistance, but are of the view that we should not make any such recommendation. The whole matter of costs in cases such as the present is one which could well be the subject of appropriate regulations. In this regard we make reference to the Final Report of the Lake Pedder Committee (1974) at pp. 237 et seq. and 273–4, and a Report to the United States Nuclear Regulatory Commission (Nureg–75/071) (1975) on Policy Issues Raised by Intervenor Requests for Financial Assistance in N.R.C. Proceedings.

Chapter 1. **Introduction**

1. That no part of our proposals be varied unless it is clear that alternatives will be pursued which will just as satisfactorily achieve the same purposes and satisfy the same principles.

Chapter 6. **The Ranger proposal**

1. That a test procedure be developed for use during start-up of the calciner and after any interruption to its operation to ensure that, before ignition, the burners are operating properly.
2. That, in addition to Ranger's proposals to reduce the risk of fire in the sulphur stockpile, the stockpile be surrounded by an embankment.
3. That, before mining begins, small test blasts be carried out on site to predict ground vibration from blasting.
4. That explicit provisions relating to strict soil erosion control measures be included in any mining lease or authority to mine.
5. That the quality and quantity of runoff water entering Georgetown Creek and in Georgetown billabong be monitored by Ranger. If excessive contaminant levels exist, or if deterioration in water quality in the billabong is detected, the supervising authority (see Chapters 17 and 18) should require the interception of the most contaminated portion of the runoff before it reaches Georgetown Creek, so that it could then be released during periods of high flow.

6. That the following broad principles be applied in the development of water release standards for the Ranger operation:
   (a) The total amount of contaminants to be released from the operations should be minimised. This requires the introduction of all practicable modifications to the water management program which would result in diminished releases of contaminants, whether by runoff or by deliberate releases, both during and after mining.
   (b) Deliberate releases should only be permitted under conditions of high flow in Magela Creek (flow at Jabiru exceeding 20 cubic metres per second) and when there is a continuous flow between Jabiru and the northern end of the Magela plains.
   (c) Deliberate releases should not be permitted late in the wet season since there would be a greater risk then of contaminants being trapped in billabongs and swamps within the Magela system. The precise timing in any year would have to be determined by reference to the hydrological–meteorological–water quality model proposed in Chapter 17.
   (d) Initial release standards for toxic materials should be based on acute toxicity bioassay tests and application factors.
   (e) Release standards for other contaminants should be based on achieving the minimum practicable disturbance to the environment.
   (f) Standards for deliberate releases should take account of the total amounts of each contaminant discharged, the concentrations in the retention ponds, the dilution actually achieved in Magela Creek and the length of time of each release. If discharges are to be permitted directly into the flooded creek, a mixing zone, where initial rapid dilution of the effluent would take place, will need to be defined and the required dilution stated. Maximum contaminant levels in this zone should be restricted to below derived 'fish avoidance levels'.
7. That, for retention pond No. 1:
   (a) Adequate investigation be made by Ranger of the flow, mixing and dispersion characteristics that will exist in Coonjimba Creek at the times of proposed releases, before any release conditions are agreed to.
   (b) The information so obtained be used to develop release procedures which ensure that the receiving water quality standards specified by the supervising authority would be met.
8. That release procedures for retention pond No. 2 be specified by placing constraints on the following characteristics:
   (a) rate of discharge;
   (b) concentration of contaminants in water discharged;
   (c) total quantity of contaminants released in any one discharge and in any one year;
   (d) length of period of continuous discharge.
9. That release procedures for retention pond No. 2 include the following conditions:
   (a) The flow rate in Magela creek at the discharge point should exceed 20 cubic metres per second.

(b) There be continuous flow of water between Jabiru and the northern end of the Magela flood plain and a high probability that this will last long enough for discharges to reach the estuary.

10. That the approval of the supervising authority be obtained by Ranger before it makes any controlled release.

11. That, if possible, operations in the pits be planned so as to avoid the need for habitual use of respiratory protective devices.

12. That all required rehabilitative work and all measures required for the continuing protection of the environment be carried out by the operator, and at its expense. The following provisions for ensuring this will be necessary:
    (a) the operator and its successors should be bound by a legally enforceable obligation to do all necessary work;
    (b) the obligation should be enforceable by an authority or authorities which have the right and duty to enforce it;
    (c) performance of the obligation should at all times be fully secured;
    (d) the security should be available freely to the authority, or authorities, having the responsibility to enforce the obligation.

13. That the work to be done, and the amount of the security, be reviewed periodically.

14. That the security may be provided by way of a trust fund or bond, provided the principles mentioned above are inserted and observed and all ancillary provisions are inserted.

Chapter 7. **Possible changes to the Ranger proposal**

1. That the best practicable technology (developed anywhere, which can be applied to the uranium industry in Australia) to prevent environmental pollution and degradation be adopted from the outset.

2. That the Ranger project be permitted to commence only if there is a firm, legally binding undertaking by Ranger to replace in one or other of the pits the tailings and any stockpiles of low grade ore remaining after milling ceases.

3. That the supervising authority not have the ability to relax the requirement that the tailings and unused ores be returned to the pits.

4. That the use of an impervious membrane to seal both the walls and floor of the tailings dam should be investigated further. If the supervising authority decides not to require the use of such a membrane, a seepage collector system, consisting of pipes at the base of the filter zone in the dam embankment, should be installed. If the pipes become clogged, an open trench or pipe drain should be placed at the toe of the embankment.

5. That the water management system be established initially in a manner allowing no intentional releases to the environment, and that this system be maintained until it is shown that releases of contaminated water would have to be made.

6. That Ranger be required to reduce sulphur dioxide emissions from the acid plant by the installation of a stack gas scrubber.

7. That the existing proposal be modified to reduce losses of yellowcake dust.
8. That if tests verify the theoretical calculations of the energy of air vibrations caused by blasting which were presented in evidence, an alternative blasting procedure should be adopted.
9. That the main explosives magazine be relocated on a site at least 8 kilometres from the tailings dam and Mt Brockman.

Chapter 8. **Proposals for development of the uranium industry**

1. That construction of mines in the Region be commenced sequentially at appropriate intervals.
2. That the concept of a central yellowcake mill should not be adopted.

Chapter 9. **Rural and fishing industries**

1. That commercial fishing in the Region be confined to the areas which are defined in the Chapter.

Chapter 10. **Proposals for a national park**

1. That a major national park be established in the Region, the boundaries being arrived at as part of an overall land use plan.
2. That the park plan of management provide for the preservation of Aboriginal sites, and any program of preservation should provide for the participation of Aboriginal people.
3. That the guidelines developed by Mr Justice Woodward for Aboriginal participation be applied to the planning and management of the whole of any national park which is established in the Region, even though part of it may not become Aboriginal land.

Chapter 11. **Tourism**

1. That a large or sudden influx of tourists be prevented.
2. That tourist accommodation for the time being be found outside the park or at one or two carefully selected places within it; the choice to remain with the park authority, in consultation with the Northern Land Council.

Chapter 12. **Accommodation of mine workers and their families**

1. That Aboriginal title should be granted, the national park established, and the necessary control mechanisms set up, before any substantial amount of construction work is done on the Ranger project or substantial numbers of people are brought into the area.
2. That steps be taken to keep the number of people in construction camps to a minimum.
3. That, for the time being at least, accommodation not be provided in the town for tourists, or for anyone else who can reasonably be accommodated outside the Region.

4. That the number of residents of the town be kept to the minimum consistent with the operation of the Ranger mine. There should be a periodical review, in the light of experience, of the maximum number which the town should accommodate.

5. That the possibility of choosing a site for the town other than that presently proposed, be examined. If an alternative site could be found which is no less satisfactory than the presently proposed site on all other grounds, then that alternative should be preferred on radiation protection grounds.

6. That firm environmental controls be established and made known at the outset to all new arrivals, and their co-operation, and the co-operation of Ranger and others in the Region, be sought to ensure that they are observed.

7. That authority not be given for both the Ranger proposal and the Pancontinental proposal to proceed at the same time. As between the two proposals, the Ranger mine should be allowed to develop first, at least to some extent.

Chapter 13. **Impacts on Aboriginal society**

1. That Aboriginals, if they are willing, be employed as rangers in the national park.

2. That Aboriginal health workers be trained to work among their own communities.

3. That all reasonable steps be taken which will encourage those Aboriginals to work who are inclined to do so, and which will provide them with the necessary training and opportunities

4. That consideration be given to implementation of the scheme outlined in this chapter, which is designed to improve the morale of the Aboriginal people, enhance their welfare and reduce their alcohol dependence. If that scheme is not followed a scheme with the same objects should be implemented.

5. That consideration be given to the employment of a suitably qualified liaison officer to inform non-Aboriginal people coming to the Region about Aboriginal customs and traditions, through discussions, displays and visits.

Chapter 14. **The effect of the Aboriginal Land Rights (Northern Territory) Act 1976**

1. That the Land Rights Act be amended so as to move the southern boundary of the Ranger Project Area, as delineated in Schedule 2 of the Act, further away from Aboriginal sacred sites.

2. That s. 40 (1) of the Land Rights Act should be amended, so that the prohibition against granting a mining interest without consent will certainly include the common case of mining leases being approved by the administrator, but not formally granted.

3. That the *Mining Ordinance* 1939–1976 should be amended so as to regulate properly the grant of leases, bearing in mind the survey difficulties which at present lead to lease applications being approved but not formally granted.

4. That the *Mining Ordinance* 1939–1976 should be amended to ensure that ordinary mineral leases can contain covenants related to the protection of the environment.

5. That the *Atomic Energy Act* 1953 not be used for the grant of an authority to Ranger to mine uranium.

6. That s. 87A (2) of the Northern Territory *Mining Ordinance* 1939–1976 should be amended so that a uranium mining lease may be forfeited by the administrator without a recommendation from the Atomic Energy Commission.

Chapter 15. **Land Claim made under the Aboriginal Land Rights (Northern Territory) Act 1976**

1. That the land which constitutes the town, if one is built in the Region, not become Aboriginal land but become part of the national park.

2. That the Border Store, with the neighbouring land, become Aboriginal land and part of the national park, and be subject to the control mechanisms that that situation involves.

3. That Mudginberri and Munmarlary pastoral leases be resumed, and that opportunity be given for Aboriginal land claims to be made and determined in respect of those areas.

4. That development within the Region, west of the Arnhem Land Reserve, of more than the Jabiru and Jabiluka deposits not at present be contemplated.

5. Under the Environment Protection (Impact of Proposals) Act, that Aboriginal title be given in respect of the land within the boundary shown by blue edging on Map 16 (excluding the leases held by Opitz 'Cooinda' Enterprises Pty Ltd at Jim Jim and the site for the regional centre).

6. That consideration be given to amending the Land Rights Act to remove problems associated with the lack of survey of land boundaries which arise when it comes to establishing a Land Trust, and giving registered title to the land.

7. That the southern boundary of the Ranger mining area be a line running east–west through or close to the turn in the road (A.M.G. ref. approximately 8593920N, 0273290E) to which, on Exhibit 189, an arrow points which has against it the notation 'Chained road which J. Madjandi and T. Gangele were told on 12.5.76 was P. Balmanidbal's first line'.

Chapter 16. **Future development of the region**

1. That if possible the national park include at least one large total river catchment; the South Alligator catchment is the most suitable.

2. That the proposed Uranium Advisory Council advise on the need for future exploration for uranium in the Region.

3. That mining in the Region west of the Arnhem Land Reserve be restricted to the Magela drainage basin for the time being, at least.

4. That exploitation of the Koongarra deposit not be permitted, at least for the present.

5. That, if uranium mining proceeds, the Ranger S.M.L. area be excluded from the national park, and that, if the Pancontinental proposal proceeds, the area of its lease also be excluded.

6. (a) That there be no activities associated with mining (including exploration) in the national park for the time being.
   (b) That those activities not be permitted in the national park in the future except after very careful consideration. If found to be necessary, they should be carefully controlled in accordance with a formally developed plan of management as provided for in the National Parks and Wildlife Conservation Act.

7. That the use of the Region's land resources be based on a land use strategy plan with the following major features:
   - The whole area, including Aboriginal land, between the Arnhem Land Aboriginal Reserve in the east and the eastern boundaries of Carmor Plain, Point Stuart, Wildman River, Annaburroo and Goodparla pastoral leases, and between the northern boundary of Gimbat pastoral lease and the coast, as well as Barron and Field Islands, to be included in a national park, but excluding the mining area at Jabiru and the mining area at Jabiluka (if mining is to proceed there) and the special purpose leases at Cooinda and the Roper Bar Company premises.
   - Uranium mining west of the Arnhem Land Reserve to be restricted to the Magela catchment in the first instance.
   - Mudginberri and Munmarlary to be resumed immediately, and as soon as practicable thereafter incorporated in the national park. Consideration to be given to the resumption of Goodparla and part or all of Gimbat, with a view to their incorporation in the park.
   - Action to be taken to reduce the number of buffaloes and, if practicable, to eradicate them.
   - The area of the regional centre to be incorporated in the park.
   - The plan of management to include provisions for the control of commercial fishing, the control or elimination of buffaloes and the control of access to popular points on the South and East Alligator Rivers.

Chapter 17. **Environmental research, standards, monitoring and supervision**

1. That a comprehensive monitoring program be established both on and near the mine site and in parts of the Region likely to be subjected to environmental change.
2. That a research program, based on the advice of a group of experts, be initiated as soon as possible and continued for as long as is necessary after monitoring of the effects of mining has begun.
3. That a Co-ordinating Committee be established to include representatives of all the agencies involved in the research and monitoring program, the mining companies, the national park authorities and the Northern Land Council.
4. That the Committee should co-ordinate the formulation of environmental control measures to be observed by Ranger and be the review body to consider any major changes in Ranger's operating procedures.

5. That the Committee should be established as soon as practicable following a decision to approve mining.

6. (a) That a Supervising Scientist, having both administrative skills and scientific expertise in a range of fields relevant to the task, be appointed as soon as possible after a decision to approve mining. He should be appointed to the Department of Environment, Housing and Community Development and be directly responsible to the Minister for Environment, Housing and Community Development.

   (b) That the Supervising Scientist should be Chairman of the proposed Co-ordinating Committee and that his appointment as Supervising Scientist be made before the establishment of the Committee.

   (c) That the Supervising Scientist exercise a supervisory and integrating role over all research and monitoring programs agreed upon by the Co-ordinating Committee.

   (d) That the Supervising Scientist provide for public information an annual report on the results of the monitoring program.

   (e) That the Supervising Scientist be legally empowered to require relevant information from Ranger and the agencies participating in the research and monitoring programs, and to inspect sites and operations.

7. That a research institute be established in the Region to provide a centre where research and monitoring staff can work together. That funding for the research and monitoring programs be allocated directly to the research institute.

8. That the research institute be headed by the Supervising Scientist.

9. That standards and procedures be set for the environmental protection measures described in this chapter. They should be reviewed regularly, and made more restrictive if unacceptable environmental damage occurs.

10. That standards and procedures should be formulated by the Co-ordinating Committee and implemented by the supervising authority. Relaxation of standards should not be allowed in the absence of conclusive proof that no damage will result.

11. That the supervising authority should specify standards and procedures and approve any necessary modifications to Ranger's proposals before construction commences.

12. That the supervising authority be empowered to require the adoption of improved pollution control equipment if it becomes available in the future, even if environmental damage has not been detected.

13. That a comprehensive meteorological–hydrological–water quality model of the Magela system be developed progressively as information becomes available.

14. That equipment for monitoring be installed and procedures established during construction of the mine and mill.

15. That mining and milling not be allowed to start until it is demonstrated that all components of the monitoring system operate satisfactorily.

16. That on-site monitoring be undertaken with respect to water quality and flow, dust, radioactivity, atmospheric emissions, meteorological conditions and pit slope stability.

17. That an intensive program combining the monitoring of biological species and of contaminants in living organisms, water and sediments be instituted in and near the mine site as part of a larger monitoring program for the whole Magela system.

18. That extensive off-site monitoring of the whole Magela system be undertaken in accordance with the specifications in this chapter.

19. That off-site monitoring be carried out primarily by Branches of the Department of the Northern Territory, with other Commonwealth or Northern Territory government departments or agencies participating when appropriate.

20. That experienced personnel, who may come from the Australian Atomic Energy Commission, the Australian Radiation Laboratory or CSIRO, be seconded to the participating government departments to supplement the monitoring staff.

21. That, to the extent that the monitoring activities recommended by the Commission cannot be carried out adequately by government departments under existing provisions, appropriate legislative or administrative changes be made.

22. (a) That compliance with the *Code of practice on radiation protection in the mining and milling of radioactive ores* be made mandatory by legislation.

    (b) That 'the appropriate Statutory Authority' under the Code be given legal authority to ensure compliance with it.

23. That legislation for the Northern Territory be enacted to prohibit the holding of or dealing with radioactive substances without a licence.

24. That, with respect to non-radioactive contaminants, powers of on-site inspection, monitoring and enforcement of standards, similar to those relating to radioactive contaminants, be given to the supervising authority.

Chapter 18.
Future action

1. That a decision that mining should proceed at Ranger be taken in conjunction with decisions respecting Aboriginal land rights and the national park.

2. That the series of steps set out below be followed to implement the recommendations of the Report:

    (a) The Minister for Aboriginal Affairs to create a Land Trust or Land Trusts under ss. 4 and 11 (1) of the Land Rights Act, and the Governor-General to grant the land under s. 12.

    (b) Consideration to be given to amendment of the Land Rights Act to enable the land shown on Map 16 within the line edged blue thereon (apart from alienated land within that area and the site of the regional centre) to become the subject of a Land Trust or Trusts.

    (c) Amendments to be made to the National Parks and Wildlife Conservation Act to enable Aboriginal land to become part of a national park, and land rights claims to be made and dealt with notwithstanding that land has become part of a national park.

(d) Mudginberri and Munmarlary to be resumed, or the leases thereof surrendered by agreement.

(e) If it is contemplated that mining at Jabiluka will or might proceed, a sufficient part of what was the Mudginberri lease be set aside for that purpose.

(f) An opportunity to be given for claims to be made and determined under the Aboriginal Land Rights Act in respect of the land formerly part of Mudginberri and Munmarlary (including Jabiluka).

(g) Either under that Act (see s. 50 (4)) or as part of a plan of management under the National Parks Act, the situation of the Aboriginal people who reside on Mudginberri to be appropriately secured.

(h) An agreement to be reached with the Northern Land Council, and any other Aboriginal group it is thought should be consulted, respecting the basis on which the Aboriginal land to which we have referred, and Woolwonga, are to become part of a national park.

(j) Consideration to be given to the need to amend the Land Rights Act to enable Aboriginal land to be leased to the Director of National Parks and Wildlife for the necessary term.

(k) The Kakadu National Park to be declared under s. 7 (2) (a) of the National Parks and Wildlife Conservation Act; the whole of the area we have mentioned in this chapter to be declared at the one time.

(l) Consideration to be given to the amendment of the National Parks and Wildlife Conservation Act to enable the requirements for a report from the Director under s. 7 (11) of that Act and for him to notify it and receive representations about it under s. 7 (12), to be dispensed with, so far as concerns implementation of our recommendations.

(m) Once an Aboriginal Land Trust is established which includes the Ranger mining area, negotiations to take place between the Northern Land Council and Ranger respecting the terms and conditions to which s. 43 (2) of the Land Rights Act refers.

(n) The Director of National Parks and Wildlife to proceed with the preparation of a plan of management for the park.

(o) The Northern Territory Mining Ordinance to be amended, if necessary, to remove any possible problems respecting its operation (see under Chapter 14).

(p) Strong environmental controls to be secured in relation to mining operations.

(q) Immediately following approval to mine a Supervising Scientist to be appointed to co-ordinate and integrate research, standards and monitoring operations, and a Standards and Monitoring Co-ordinating Committee to be established.

(r) The services of the Australian Radiation Laboratory of the Department of Health to be available to the government agencies and officers concerned, as an expert radiation authority.

(s) Consideration to be given to providing by regulation that Ranger (and other mining companies), and their contractors, answer promptly any request for relevant information respecting their operations made by the Director of National Parks and Wildlife, the Northern Land Council and the Supervising Scientist; and the Director, the Northern Land Council and the Supervising Scientist to have appropriate rights of inspection.

(t) Legislative action to be taken to enable the Director and the Northern Land Council to enforce environment protection provisions, particularly by way of injunction to restrain or compel action, and to give the Supreme Court a wide discretion as to the exercise of its jurisdiction in such cases.

(u) A deliberate and comprehensive program to be established and implemented to minimise adverse social effects on the Aboriginals, and to assist them in coping with the stresses to which they will be exposed and in taking advantage of any benefits accruing to them.

(v) The existence of government power to terminate or suspend mining operations (perhaps at very short notice) to be recognised from the outset.

(w) Provision to be made for protection of the environment in the event of Ranger or its successors terminating or suspending operations or going into liquidation, before, as well as upon, the ordinary completion of mining activities.

(x) The advice and assistance of the proposed Uranium Advisory Council to be available to the Director of National Parks and Wildlife, the Northern Land Council, the Supervising Scientist, the Co-ordinating Committee and other agencies, as well as to the mine operators.

(y) The marketing authority (see Chapter 19) to be created before any further contracts for the supply of uranium are entered into.

Chapter 19. **Marketing and control of Australian uranium exports**

1. That a uranium marketing authority be established.
2. That the proposed Uranium Advisory Council, in addition to its other responsibilities, have a general role in advising the Government on marketing considerations.

Chapter 20. **Conclusions**

1. That the Ranger project, as proposed, and in the land use setting which was assumed, not be allowed to proceed.
2. That, if an adverse decision on the Ranger project is not made on the basis of the wider considerations discussed in our First Report (see Chapter 1 of this Report), it be allowed to proceed, but only in the circumstances stipulated in this Report and subject to the recommendations we make in it.
3. That the Noranda mine not be developed, at least for the time being.
4. That, if the Ranger proposal is allowed to proceed, no other mining, with the possible exception of that proposed by Pancontinental, be allowed in the Region, west of the Arnhem Land Reserve, for the time being at least.

APPENDIXES

APPENDIX I: FACT FINDING STUDY REPORTS

The following are the studies commissioned by the 'Alligator Rivers Region Environmental Fact-finding Study'. All reports appear under this umbrella title.

'To extend the study reported in 'Lands of the Adelaide–Alligator Area, Northern Territory', CSIRO Australia: Land Research Series No. 25 (1969), to cover the remainder of the Alligator Rivers study area.' Conducted by CSIRO Division of Land Use Research, Department of the Northern Territory and Macquarie University. Report: *Physical Features and Vegetation*, 2 volumes, comprising papers by R. Story, R. W. Galloway, J. M. Aldrick, M. A. J. Williams, L. C. Adams, N. Byrnes and M. Lazarides, (November 1973). Edited edition published as *Lands of the Alligator Rivers Area*, Northern Territory, CSIRO Australia: Land Resources Series No. 38 (1976).

'To survey, within limits of available resources, the insect fauna of the area . . .' Conducted by CSIRO Division of Entomology. Report: *Entomology. A Report on the insect fauna.* Comprising material from E. B. Britton, J. C. Cardale, D. H. Colless, I. F. B. Common, K. H. L. Key, R. W. Taylor, J. A. L. Watson, M. S. Upton and E. F. Riek of the Division of Entomology and H. A. Standfast and A. C. Dyce of the CSIRO Division of Animal Health (presented 1973).

'To assess the land vertebrate fauna and vascular flora of the survey area . . .' Conducted by CSIRO Division of Wildlife Research. Report: *Wildlife*, CSIRO Division of Wildlife Research. Comprising material from J. H. Calaby, H. G. Cogger (Aust. Museum, Sydney), P. N. Martensz and R. Schodde (presented 1973).

'To obtain an inventory of freshwater vertebrate fauna in the proposed study area.' Conducted by consultant H. Midgley, in association with the Department of the Northern Territory (Fisheries). Report: *Fresh Water Fish Inventory*. S. H. Midgley, Department of the Northern Territory (presented 1973), (see also Report No. 1, Project 6).

'To analyse and interpret existing climatic data.' Conducted by CSIRO Division of Land Use Research. Report: *Climate and Water Balance*, J. R. McAlpine (November 1973) (see also Project 12). Also published in CSIRO Australia: Land Research Series No. 38.

'To measure background levels of toxicants to find toxic levels of specific elements and compounds to certain of the biota. To measure storage levels of these toxicants in plants such as wild rice and, by sampling representative sectors of the food chain, determine levels of accumulation.' Conducted by Australian Atomic Energy Commission and Department of the Northern Territory. Reports: Report No. 1. D. A. Pollard. *Freshwater fishes of the Alligator Rivers 'Uranium Province' area (Top End, Northern Territory) with* *particular reference to the Magela Creek catchment (East Alligator River system)* (see also Project 4).

Report No. 2. M. S. Giles *Toxicity studies on aquatic organisms and grass-sedge communities in the Magela Creek area.*

Report No. 3. D. R. Davy and N. F. Conway. *Environmental Studies N.T. Uranium Province 1971–73.*

Report No. 4 D. R. Davy. *Environmental levels of Radon-222.* These four reports presented in 1973 appear in the Australian Atomic Energy Publication *AAEC/E 305* June 1974.

'To establish gauging stations to measure river flow, plains inundation, and obtain relevant hydrological data, and to obtain water samples for chemical and physical parameter measurements.' Conducted by Department of the Northern Territory, Water Resources Branch. Report: *Alligator Rivers Region. Water Resources.* Department of the Northern Territory Water Resources Branch (October 1973).

This was supported by a *Report on flooding of the Magela Creek in March 1973* by G. Chaloupka and R. Ash (June 1973).

'To establish an inventory and classification of scenic and recreation resources.' Conducted by Forestry, Fisheries, Wildlife, the Environment and National Parks Branch, Department of the Northern Territory. Report: *Landscape, Recreation and Forest Resource Inventory*, Forestry Section, Forestry, Fisheries, Wildlife, Environment and National Parks Branch, Department of the Northern Territory (November 1973).

'To assess geological resources of the area.' Conducted by Bureau of Mineral Resources and Exploration Companies. Report: *Geological and Geophysical Reports* by R. S. Needham, P. G. Wilkes, P. G. Smart and A. L. Watchman. Department of Minerals and Energy, Bureau of Mineral Resources Geological and Geophysical. Record 1973/208.

'To identify and classify sites of probably archaeological significance for subsequent detailed investigation.' Conducted by consultants Johan Kamminga and Dr Harry Allen. Report: *Report of the Archaeological Survey* by J. Kamminga and H. Allen (August 1973).

'To continue and expand survey to locate, record and classify sites of Aboriginal art.' Conducted by consultant R. Edwards. Report: *The Art of the Alligator Rivers Region*, Robert Edwards, Canberra 1974.

'To document the inversion climatology of the Alligator River Region using statistical and field research techniques.' Conducted by Ranger Uranium Mines Pty Ltd. Report: *Atmospheric Conditions in the Alligator Rivers Region, Northern Territory* prepared by Ranger Uranium Mines Pty Ltd (presented 1973).

A Review Report of The Alligator Rivers Region Environmental Fact-finding Study summarising and collating the material presented in the reports of the foregoing specialist projects and other source material.

First distributed as an interim report of limited edition in December 1973. Edited version submitted for publication February 1975. Authors C. S. Christian and J. M. Aldrick.

APPENDIX II: TABLES RELATING TO THE NORTHERN TERRITORY ECONOMY

Table A

Employed population by industry

	Australia 30 June 1971		Northern Territory 30 June 1971			Greater Darwin 30 June 1971		Greater Darwin 17 September 1975	
Industry	*Number*	*Percentage of total labour force*	*Number*	*Percentage of total labour force in Northern Territory*	*N.T. as percentage of Australian labour force in each industry group*	*Number*	*Percentage of total employed*	*Number*	*Percentage of total labour force*
Agriculture, forestry, fishing, hunting	386 407	7.3	3 123	8.0	0.8	249	1.5	129	0.7
Mining	76 023	1.4	3 857	9.8	5.1	309	1.6	75	0.4
Manufacturing	1 215 618	22.8	1 824	4.6	0.2	1 248	7.4	1 029	5.5
Electricity, gas, water	91 252	1.7	477	1.2	0.5				
Construction	412 229	7.7	5 282	13.4	1.3	2 220	13.0	3 747	20.1
Wholesale and retail trade	988 088	18.6	3 899	9.9	0.4	2 620	15.4	2 852	15.3
Transport and storage	271 713	5.1	2 332	5.9	0.9	1 368	8.0	1 325	7.1
Communication	103 485	1.9	590	1.5	0.6	408	2.4	412	2.2
Finance, insurance, real estate, business services	363 418	6.8	1 281	3.3	0.4	915	5.4	1 171	6.3
Public administration and defence	283 152	5.3	4 344	11.1	1.5	3 438	20.2	3 829	20.5
Community services	564 649	10.6	7 303	18.6	1.3	2 107	12.4	2 576	13.8
Entertainment, recreation, restaurants, hotels, personal services	267 511	5.0	2 045	5.2	0.8	1 026	6.0	871	4.7
Not classified	216 883	4.1	2 229	5.7	1.0	1 133	6.7	59	0.3
Total employed	5 240 428	98.3	38 586	98.2	0.7	17 041	100.0	18 075	96.9
Unemployed	90 060	1.7	709	1.8	0.8	—	—	581	3.1
Total labour force	5 330 488	100.0	39 295	100.0	0.7	. .	—	18 656	100.0

Source: Australian Bureau of Statistics.

Table B

Registered unemployment and related statistics for the Northern Territory, 1972–76

	Mar. 1972	*June 1972*	*Sept. 1972*	*Dec. 1972*	*Mar. 1973*	*June 1973*	*Sept. 1973*	*Dec. 1973*	*Mar. 1974*	*June 1974*	*Sept. 1974*	*Dec. 1974*	*Mar. 1975*	*June 1975*	*Sept. 1975*	*Dec. 1975*	*Mar. 1976*	*June 1976*	*Sept. 1976*	*Dec. 1976*
Registered unemployed by occupation																				
Rural	90	35	26	94	104	19	14	135	206	58	129	253	394	306	372	422	467	—	333	341
Professional	13	14	3	15	8	11	10	3	11	6	7	1	5	8	16	55	48	—	26	22
Clinical, administrative	194	201	131	100	196	156	80	56	197	158	260	49	132	134	178	156	366	—	286	267
Skilled mining	7	2	2	2	3	1	2	0	3	0	0	0	0	0	0	0	2	—	—	—
Skilled construction	37	32	29	32	36	22	11	6	45	18	26	32	41	58	51	28	129	—	47	54
Skilled metal trades	43	38	29	74	36	28	18	15	35	32	28	7	24	52	39	42	81	—	61	64
Other skilled	7	9	6	8	4	1	2	3	7	2	5	0	4	8	9	6	13	—	23	12
Semi-skilled	128	89	97	105	152	75	68	40	152	110	5	21	115	165	207	224	417	—	287	293
Unskilled	295	279	242	350	393	331	212	153	310	357	414	247	389	356	567	681	799	—	721	761
Service occupations	90	115	116	76	108	94	81	56	158	114	181	84	141	130	213	168	284	—	228	290
Total unemployed	904	814	681	856	1038	740	498	467	1124	855	1205	694	1245	1217	1652	1782	2606	1738	2012	2104
Registered vacancies	336	285	346	505	659	790	906	869	941	668	649	320	539	631	607	813	306	423	447	491
Unemployed as percentage of labour force																				
Northern Territory	2.2	2.0	1.7	2.1	2.5	1.8	1.2	1.1	2.5	1.8	2.7	2.2	3.6	3.3	4.5	4.1	6.1	n.a.	5.1	5.4
Darwin	2.3	2.1	1.7	2.3	3.0	1.9	1.2	1.2	2.4	2.2	2.8	0.8	2.3	2.4	2.8	2.3	4.9	n.a.	n.a.	n.a.
South Australia	2.1	2.3	2.3	3.2	1.8	1.7	1.4	2.2	1.5	1.4	1.9	4.1	4.2	3.3	3.5	4.9	3.7	3.1	3.3	3.4
Queensland	2.0	1.6	1.1	2.2	1.6	1.4	0.9	1.7	1.8	1.2	2.3	5.2	5.7	4.4	4.2	6.0	5.5	4.6	4.4	4.3
Australia	1.7	1.8	1.6	2.4	1.5	1.4	1.1	1.8	1.4	1.3	2.0	4.5	4.5	4.1	4.1	5.5	4.6	4.4	4.4	4.4

Source: Evidence of R. J. Wyatt, Department of Employment and Industrial Relations

Table C

Agriculture and other primary industry in the Northern Territory

	1971–72	*1972–73*	*1973–74*	*1974–75*	*1975–76*
Agriculture					
Crops—by area (hectares)					
Fruit	89	70	50	13	n.a.
Peanuts	40	13	23	n.a.	n.a.
Grain sorghum	5 638	11 032	3 990	4 235	n.a.
Vegetables	159	170	173	131	n.a.
Other crops (principally fodder)	1 458	862	722	3 631	n.a.
Total	7 385	12 147	4 937	8 010	9 461
Area under sown pastures and grasses	127 312	146 469	127 061	129 110	115 824
Balance of holdings	77 754 558	77 852 225	79 354 459	79 209 930	78 661 319
Total—rural holdings	77 889 230	78 010 802	79 486 489	79 347 058	78 786 604
Livestock numbers (31 March) (thousands)					
Cattle	1 166	1 237	1 321	1 434	1 603
Domesticated buffaloes	8	5	4	3	3
Pigs	5	7	8	7	n.a.
Full-time workers (no.)	2 159	2 215	2 108	1 651	1 316
Gross value of production ($m)					
Crops	1.2	1.8	1.2	1.0	0.7
Livestock	24.1	29.5	26.5	10.7	11.0
Total agriculture and pastoral	25.3	31.3	27.7	11.7	11.7
Prawns	2.6	4.0	5.8	3.1	8.0
Fish	0.2	0.4	0.7	0.6	
Forestry, hunting	0.1	0.3	0.1	—	—
Total—primary industry (excluding mining)	28.2	36.0	34.3	15.4	19.7

Source: Australian Bureau of Statistics.

Table D

Manufacturing and other establishments

	Number of Establishments	*Persons employed*	*Wages and salaries*	*Turnover $ million*	*Value-added $ million*
Manufacturing					
1969–70	65	944	4.2	20.2	8.6
1971–72	80	1194	5.8	28.8	11.3
1972–73	100	2236	14.0	43.0	27.9
1973–74	102	2450	18.0	87.0	50.6
1974–75	67[(a)]	2305	22.0	94.6	47.8
of which Food and Beverages	16	419	2.9	13.9	3.9
Mineral and metal products	33	1532	16.7	74.7	42.0
Retail and selected service establishments					
1968–69	553	3493	7.4	69.0	18.9
1970–71	691	4827	n.a.	n.a.	n.a.
1971–72	772	5361	n.a.	n.a.	n.a.
1972–73	817	5988	n.a.	n.a.	n.a.
1973–74	870	6338	21.6	162.6	n.a.
Wholesale establishments					
1968–69	113	879	2.8	35.7	7.8

Source: Australian Bureau of Statistics.
Note: (a) Not comparable with previous years.

APPENDIX III: SOME ECOLOGICAL CONCEPTS

A number of ecological concepts were referred to in the course of the Inquiry. The following brief notes illustrate the complexity of ecological interactions and the difficulty of predicting environmental effects.

Ecosystem A simple definition of ecosystem is:

> A community of organisms, interacting with one another, plus the environment in which they live and with which they also interact (*A Dictionary of Biology*, Penguin).

Sometimes the term is used simply to refer to a persistent grouping of species in a restricted habitat. However, interaction and interdependence are vital parts of the concept.

The persistence of any ecosystem depends on inputs including solar energy, water and nutrients, on interactions between individuals and species and their use of the physical and chemical resources of the system, and on the disposal of resultant outputs including oxygen, carbon dioxide, waste products of metabolic and decomposition processes, and heat.

Thus, although an ecosystem may present a picture of stability, a very dynamic state prevails internally as individual organisms grow, reproduce, die and decay at different rates, and as species utilise by-products of others, prey upon one another and compete for limited resources of water, light, nutrients and space. Different species have different roles in an ecosystem. Some utilise solar energy directly while others obtain energy by consuming those species and their chemical products. There is a complex energy flow through the system, and a continuous recycling of water and nutrients through a web of interrelated food chains in which each species plays one or more roles.

In any ecosystem species composition and abundance will vary in different parts of the area occupied, and from time to time, as inputs and outputs undergo natural fluctuations. Slow trends towards substantial long-term change in an ecosystem may be difficult to observe or measure.

Boundaries of ecosystems are rarely distinct. One ecosystem may merge with another; this can be seen, for example, in changes in vegetation between a valley floor and the top of a hill. Boundaries between ecosystems may change with time, as they do in the Region on the flood plains between the wet season and the end of the dry season. Demarcation of the limits of an ecosystem therefore often has to be done somewhat arbitrarily, for example on the basis of types of habitats. There is always scope for being more and more selective and defining ecosystems more narrowly. For instance, the billabong ecosystem could be subdivided into the ecosystems of the main water body, the water–dry land interface and the bottom sediments. However, all three interact and, for an ecological understanding, need to be studied together. Sometimes it is useful to describe widely varying systems collectively as, for example, the wetlands ecosystem. This would include a range of hydrological conditions and associated flora and fauna types, varying between the flood and the non-flood seasons of the year. Ecosystems inevitably affect and are influenced by other ecosystems and their outputs. Extending the concept to its limits, the whole world can be considered as one ecosystem.

If an ecosystem's physical conditions are changed, for example by impeding or accelerating drainage, or if inputs of energy, water or nutrients are reduced or increased, the relationships and abundance of species will change in response. An ecosystem as a whole is, however, necessarily tolerant of the stresses that occur naturally. These vary from place to place throughout the year and from year to year with such factors as rainfall, hours of sunlight, temperature, stream flow, seepage and nutrient inputs. If the stresses substantially exceed in magnitude, frequency or duration those which normally occur, or if a change in conditions differs in kind from those which occur naturally, some species may suffer. Others may be advantaged. As a result, the species composition and the structure of the ecosystem may be altered to such an extent that the original ecosystem as an entity no longer persists but is replaced by another or others.

Food chain

Within an ecosystem some species feed on, and so obtain energy from, other species. In turn they are consumed by and provide food and energy for others. The whole constitutes a food chain. The organisms at the bottom of the chain are plants which trap solar energy. Higher in the chain are animal species which feed on either plants or other animals. A food chain sequence could be decomposing organisms liberating plant nutrients from organic matter, large plants utilising these nutrients, insects living on the plants, small birds having insects as part of their diet, and larger birds preying on them.

All food chains contain producers (the plants) and consumers, of which there may be several levels. At all levels there are also the decomposers, such as bacteria and fungi, which return part of the energy to lower levels in the chain. Interference directly affecting any species in a food chain will indirectly affect all others.

Biological concentration

A pollutant may be concentrated in successive steps of a food chain, and may have deleterious effects on a species higher in the food chain than the species which first took it up. An example was given during the Inquiry of a species of leech, sensitive to a pollutant, being substantially reduced in numbers as a result both of the direct effects of the pollutant and of feeding on worms which concentrated the pollutant in their tissues without suffering severe damage themselves. A rapid increase in the number of worms followed the reduction in the numbers of predator leeches. If the progressive concentration is sufficient and a higher species is harvested for human food, it can affect people who eat the food.

Instances of aquatic species concentrating zinc, mercury and cadmium, with possible consequences to people eating them, were quoted in evidence. Many of the examples given were based on experience in other situations and did not provide factual data on the ecosystems of this Region. However, studies by the AAEC have produced some analytical data for several species in the Magela system and for the polluted Rum Jungle–Finniss River situation. It is evident that concentration in successive steps of a food chain does not always occur; hence information is needed about specific food chains which may be involved.

Many factors complicate biological uptake. For example, in some cases the uptake of an element by an organism increases with the concentration of the element in the environment, while in others the organism tends to maintain a maximum level in its system, reducing uptake as the concentration in the environment increases. Evidence was given that mussels in the Region behave in the latter way. Also concentration may vary between different parts of an organism; because of this, careful sampling is required for monitoring purposes.

Uptake by plants and animals sometimes varies with age or stage of the life cycle. In both, the presence of one element may influence the uptake or the effects of another. Uptake will also be affected by other environmental factors, such as acidity or alkalinity of soil or water, and low or high temperatures.

Survival strategies Survival strategies of organisms, that is the characteristics which enable them to survive environmental stresses, include:

- resistance to specific stresses (drought, for example).
- avoidance of stresses by physical action, such as by migration;
- avoidance of stresses biologically, for example, as in the case of many insects, by the production of a protected life stage which can persist through the period of stress;
- acclimatisation to progressively increasing stresses;
- rapid reproduction after a period of severe stress has reduced population numbers.

Some witnesses suggested that sensitive species in the Region are existing at the limits of tolerance of their environment, because of the natural stresses imposed late in the dry season, and that even a small detrimental change could be critical to their survival. Others argued, on the other hand, that as the ecosystems persist species must be resilient to the irregular occurrence of extreme conditions. Not nearly enough is known to estimate the adequacy of the survival strategies of species of the Region for coping with any man-made changes.

Exotic species Exotic species are those not occurring naturally in an ecosystem. The introduction of an exotic species into a natural ecosystem inevitably has consequences for the native species of the system. This is illustrated by the changes in the flood plain vegetation and consequently in waterfowl habitats resulting from grazing and trampling by buffaloes (see Chapter 5). The increasing density of palatable grasses in areas where buffalo numbers have been controlled indicates the scope for management to exercise some control over change.

Many biologists stressed during the Inquiry that, in order to protect the Region's natural ecosystems, there was a need for control of the introduction of exotic plants and animals. The Region is, at present, comparatively free of them.

APPENDIX IV: DIFFICULTIES IN ESTIMATING TOXIC EFFECTS OF WATERBORNE CONTAMINANTS

Predicting the effects of water pollutants involves much more than measuring their concentrations. A great deal of research has been conducted throughout the world in recent years on matters related to the toxic effects of contaminants on aquatic organisms, but much remains to be learned. The evidence points to the difficulty of extrapolating from laboratory tests to field conditions, and of simulating field conditions in the laboratory or making comparative trials of polluted and unpolluted aquatic habitats in the field. Factors which make the design and interpretation of experiments or field data complicated include:

1. The nature of the contaminant:
   Chemicals differ widely in their level of toxicity.
2. Chemical form:
   The toxicity of a heavy metal may vary according to its chemical form, e.g. in solution ionic copper is often more toxic than combined copper. Interpretation of analytical results giving total amounts of contaminants present may overestimate toxicity if it is assumed that they are all present in a toxic form.
3. Temperature:
   The toxicity of chemicals can vary with temperature.
4. Synergism:
   The toxicity of two contaminants together may be greater than the sum of their individual toxicities (e.g. copper plus zinc, in relation to fish).
5. Antagonism:
   One contaminant can offset the effect of another (e.g. selenium and mercury, in relation to humans).
6. Basic water quality:
   Some contaminants are more toxic in soft than in hard water because of difference in chemical form.
7. Water acidity:
   The toxicity of heavy metals such as copper, zinc and lead may increase with higher acidity (that is, lower pH).
8. Persistence of a chemical form:
   Although a contaminant may enter an aquatic environment in a certain chemical form, it may not persist in that form. Physico-chemical changes will vary with the aquatic environment.
9. The organisms:
   Species vary considerably in their sensitivity to different concentrations of contaminants. In the Finniss River, for example, one fish species has been observed to be consistently more abundant in the polluted zone than elsewhere, whereas all other species of fish were either less abundant or of similar abundance.
10. Biological concentration and direct toxicity:
    A contaminant may be directly toxic to some organisms when added to the aquatic environment. Other organisms may not be directly affected,

but may concentrate the contaminant in their tissues. Organisms consuming these may be directly affected. This includes animals consuming plants, animals consuming animals, and man consuming either.

11. Lethal and sub-lethal effects:
    A contaminant may cause the death of an organism at certain concentrations. At lower concentrations death may not occur, but an animal may be affected in some way such as reduced growth, impairment of reproduction or maturation, or by some behavioural response which may interfere with its movement, habitat or food selection, or self-protection responses. In the case of plants, reduced photosynthetic activity may result.

12. Life stage:
    The toxicity of a contaminant to an organism may vary with the organism's life stage, i.e. egg, larva, nymph, juvenile, adult etc.

13. Fate of contaminants in the system:
    A contaminant may be inactivated by chemical bonding with organic matter (chelation) or by strong attachment to sediments or soil particles (adsorption). Reactivation may occur; what happens in any situation will vary with the physico-chemical and biological characteristics of the environment. Contaminants which are attached to moving particles may be transferred from one place to another, and this can lead to concentration at a site if, for example, localised deposition of sediments occurs. If contaminants remain in solution or suspension, they may be removed from one system to another—for example, from a stream to a flood plain or from a flood plain to an estuary and to the sea.

15. Other stresses:
    If organisms are already stressed by some other factor in the environment such as high water temperatures or low levels of dissolved oxygen, which can be expected in billabongs at the end of the dry season in the Region, they are likely to be more sensitive to added contaminants. In such situations it may be difficult to differentiate between effects imposed by different forms of stress.

16. Acclimatisation:
    Some organisms can adapt to slowly increasing concentrations of contaminants to levels well above those which would normally be fatal if they were suddenly imposed. Thus some adaptation to increasing stresses as the dry season progresses can be expected.

Although all these phenomena have been recorded in particular circumstances, little is known about their general applicability. They are among the complexities which make it impracticable to predict the likely effects of the proposed discharges from the Ranger project except in the very broadest terms.

APPENDIX V: NATIONAL AND REGIONAL ECONOMIC EFFECTS OF A URANIUM INDUSTRY

The Commission considered some aspects of the potential national economic effects of the Ranger proposal, and of an enlarged uranium industry, in its First Report. Since that Report was published, we have been provided with copies of two reviews of our assessment of the economic effects. One was prepared by Professor B. L. Johns, of the University of Newcastle, and the other by W. D. Scott and Company, of Sydney. Both were commissioned by the Australian Uranium Producers Forum. In this Appendix we assess the principal economic issues in more detail than in the First Report and extend the discussion to include consideration of the potential effects of a uranium industry on the economy of the Northern Territory. We also discuss many of the matters raised in the reviews commissioned by the AUPF.

The assessments which follow are based on data supplied to the Commission and on information contained in official publications. These sources do not provide sufficient information to allow us to calculate with a high degree of precision the national and regional economic effects of uranium mining, but they do enable quantitative estimates of some of the more direct effects of the industry to be made. As indicated in a number of places in the text which follows, the Commission has declined to speculate about quantitative effects where there is no firm basis for making appropriate calculations. The estimates are based on assumptions which are designed to convey reasonably accurate indications of the range of possibilities which seems most likely in the light of existing knowledge. However, the data given cannot be interpreted as forecasts of what will happen; for the reasons given below, actual results may fall outside the possibilities covered by the assumptions made.

National economic effects

As stated in both our First Report and this Report, we believe that Australia should co-operate with other countries in an endeavour to limit the expansion of nuclear power. In making a recommendation to that effect, we are aware that it involves forgoing, or at least postponing, some potential economic benefits. Largely because of the recommendation, we have used in this assessment lower rates of production and export of Australian uranium than market considerations alone would suggest as being feasible. The use of these rates does not, however, imply that the Commission recommends that the uranium industry should be developed at a certain rate, or at all.

Production and sales

The quantities of Australian uranium sales assumed in the First Report were 2500 tonnes of uranium (about 3000 tonnes of U_3O_8) in 1980–81, rising by 2500 tonnes of uranium each year until 1991–92. The quantities for 1980–81 to 1984–85 were derived from information provided to the Commission about uncommitted requirements for uranium in the United States and western Europe. Australia's possible share of these uncommitted requirements was estimated by assuming three alternative possibilities. These were:

- that Australia would supply one-third of uncommitted western European requirements plus all the uncommitted imports which the U.S. would purchase if its imports from all sources made up a maximum of 20 per cent of its total requirements;

- that Australia would supply 25 per cent of all uncommitted western European and U.S. requirements, assuming that no import limit was imposed by the United States; and
- that Australia would supply 50 per cent of uncommitted western European requirements plus 50 per cent of uncommitted U.S. imports, assuming that the latter were restricted to 20 per cent of all U.S. requirements.

As shown in Table 9 of the First Report, all three assumptions resulted in broadly similar estimates of potential Australian sales in this period. The principal criterion followed in making these assumptions was that Australian sales would not be so large as to materially affect the price of uranium; if Australia obtained larger shares of these markets, it might be difficult to sustain this assumption. Insufficient evidence was provided on which to base alternative estimates of quantity and price combinations which might apply if Australia adopted a more aggressive policy of selling uranium at lower prices.

As discussed in Chapter 8 of the First Report, it is not possible to place much reliance on projections of total uranium demand beyond 1985. Many unknown factors, including rates of economic growth, particularly in the industrial countries which will be the main consumers of uranium, trends in costs of various fuels which compete with electricity, nuclear power's competitiveness with other methods of electricity generation, and environmental constraints will determine actual demand levels. In the First Report the estimates for the period after 1985 assumed that Australian sales would grow until they reached 30 000 tonnes of uranium in 1991–92. They were assumed to remain at 30 000 tonnes per year until 1999-2000, a rate of production which appeared to be the maximum attainable from a relatively rapid rate of development of Australia's presently known reserves.

The Commission regards the quantities used in the First Report as the maximum which could be achieved if (a) demand for uranium grows as projected in the studies referred to in that Report; and (b) the rapid development of Australian resources is not inhibited by administrative, environmental or economic constraints. Because of the Commission's view that the expansion of nuclear power should be limited, and because administrative, environmental and economic constraints seem likely to lead to a lower rate of development of Australian uranium resources, the estimates in this Report are based on the assumptions that construction activity associated with the first project commences in 1977–78, that production and sales begin in 1981–82, that 1500 tonnes of uranium are produced and exported in 1981–82, and that production and sales increase by the same quantity each year until a maximum figure of 21 000 tonnes of uranium is produced and exported in 1994–95. It is assumed that production continues at the rate of 21 000 tonnes uranium up to the year 1999–2000. For reasons explained in the First Report, we consider future events only to the end of the century.

Revenue

Revenue calculations in the First Report were based on one average price, US\$20 per pound of U_3O_8 (expressed in January 1976 price levels), which was converted to Australian currency at the rate of \$A1.00 equalling US\$1.26. In this Report, low and high average prices are assumed. The calculations based on these assumptions illustrate the effects of possible variations in both the price paid for uranium exports, expressed in U.S. currency, and the rate of exchange between the Australian and U.S. currencies, the latter being taken to represent the average rate of exchange between the Australian dollar and all other currencies in which sales contracts may be written.

Because of the importance of the United States as both a producer and consumer of uranium, it seems likely that the price required to make it profitable for U.S. producers to meet a high proportion of U.S. requirements will have a continuing major influence on world prices. The U.S. price will almost certainly be used as a yardstick for setting prices even when the U.S. does not participate in a transaction. Nevertheless, it is possible that substantial sales will be effected between other countries outside the range of prices applying to sales involving U.S. buyers or sellers. Taken over the long run, the rates of exploration, discovery and mining of uranium world-wide, and the factors affecting demand for uranium, will be the major influences on the average price received for Australian uranium. Given the lack of knowledge about available reserves and costs in many countries, it is an extremely hazardous exercise to attempt to forecast even a range of average prices.

However, present information suggests that it may be reasonable to use US$15 per pound of U_3O_8 (in January 1976 price levels) as the lowest average price. Some evidence suggests that this is the minimum which would be required to sustain U.S. production at the rate necessary to meet its own requirements in the next two decades. If U.S. requirements are much higher than appears likely, higher prices may prevail, making it profitable for less efficient U.S. producers to operate. An upper limit of US$30 per pound (in January 1976 price levels) seems a reasonable assumption for covering this possibility over the long term, and also for covering the possibility that demand in other countries might rise faster than supplies become available from lower cost areas of production. However, it is important to recognise that, although a wide range of prices is assumed, it does not encompass all the possibilities. Experience in the uranium industry, and the history of prices for other commodities, suggests that prices could vary over a very wide range, even when averaged over a long period.

On the question of exchange rates there appears, as we stated in the First Report, to be no reason to be pessimistic about Australia's balance of international payments in the long run. However, the widespread adoption of some degree of flexibility in setting exchange rates in recent years, and the Commonwealth Government's decision to follow this course late in 1976, suggests that it would be useful to consider the effects of a reasonably wide variation in the relationship between Australian and U.S. currencies. We have used outer limits of $A1.00 equal to US$1.50 and $A1.00 equal to US$1.00 in our calculations, the former being marginally above the highest value reached by the Australian dollar in recent years and the latter being somewhat below the lowest value reached after the devaluation in November 1976. These limits appear to encompass the most likely range of possibilities on the basis of existing knowledge and recent experience, but it has to be recognised that there could be variations outside these limits, particularly for short periods of time.

The assumed range of exchange rates increases the range of prices, expressed in Australian currency, from $A10 per pound of U_3O_8 (when the U.S. price is $15 per pound and the exchange rate is US$1.50 to $A1.00) to $A30 per pound of U_3O_8 (when the U.S. price is $30 per pound and the exchange rate is US$1.00 to $A1.00). As costs based on information supplied by Ranger indicate that Australian production would still be profitable if the price received was as low as $A10 per pound of U_3O_8 (in January 1976 price levels), the lower price estimate appears to be consistent with sustained Australian output.

Costs Changes in the exchange rate would affect production costs as well as revenue. The initial impact would be on the costs of capital equipment and other materials which are imported. If prices of imports remain unchanged in foreign currencies, a devaluation or depreciation of the Australian dollar directly increases the Australian equivalent by the percentage change in the relationship between the currencies, and a revaluation or an appreciation directly reduces the Australian equivalent accordingly. Since about 15–20 per cent of costs associated with uranium production seem likely to be spent directly and indirectly on imported goods, which is similar to the average import content of total expenditure in Australia, a variation of 20 per cent in the exchange rate would cause a direct change of 3–4 per cent in costs expressed in Australian currency.

The effects of exchange rate variations are not confined to direct impacts, but generally include very important 'flow-on' effects. This is particularly the case when, as in most developed countries including Australia, there are strong links between price levels and money wages. When money wages are adjusted to take account of changes in prices of goods and services, and when prices are adjusted to reflect variations in money wages and other costs incurred by firms, a change in the exchange rate is likely to trigger off a series of cost and price changes in the economy which greatly exceeds the initial effect. There is no way to predict accurately the final effects of changes in the exchange rate on overall price levels. It is conceivable that all of the initial effects of a change will be nullified by subsequent changes in costs, in which case there would be no change in the real value of costs and revenues. However, we have assumed, for purposes of illustration, that the maximum assumed variations in exchange rates, i.e. 20 per cent above and below a middle rate of $A1.00 equal to US$1.25, would be accompanied by a 15 per cent variation in costs. Because of this, the range of expenditures used in the calculations in columns (3) to (6) of Table E is from 15 per cent below to 15 per cent above the figures derived from the data presented by Ranger. This range can also be taken as allowing for uncertainties associated with Ranger's cost estimates and the application of these estimates to other mining proposals. Since we assume that the final change in costs resulting from an exchange rate variation will be less than the variation in the exchange rate, the outcome is to leave the Australian economy in a slightly more competitive position after a devaluation and in a slightly less competitive one after an appreciation.

The dissection of expenditure between wages and salaries and other types of expenditure is derived from estimates of costs which Ranger expects to incur in the first stage of production. It is evident that significant variations in costs (expressed in constant price levels) may occur for a number of reasons, including different grades of ore, locations of mines, economies of scale, the possibility of using different production methods in different locations, and varying costs of labour, stemming from such factors as industrial disputes, housing and other costs. No detailed expenditure figures, showing the sensitivity of results to variations in costs due to the operation of these factors, were available. Consequently, we have little option but to adjust Ranger data on a pro rata basis in order to estimate costs for other levels of total uranium output, whether from Ranger or from other ventures.

The Commission was given some information on two aspects of costs which could have an important bearing on the financial results of operations by uranium producers. The first relates to economies of scale, which may be important when higher rates of output are achieved from one operation. For

Table E

Estimates of revenues and costs associated with a national uranium industry
($A million; January 1976 prices)

	Quantity produced			*Capital expenditure*				*Operating expenditure*			
	thousand tonnes uranium	*Revenue*		*Wages and salaries*		*Other expenditure*		*Wages and salaries*		*Other Expenditure*	
Year	(1)	Low (2a)	High (2b)	Low (3a)	High (3b)	Low (4a)	High (4b)	Low (5a)	High (5b)	High (6a)	Low (6b)
1977–78	—	—	—	2	2	6	8	—	—	—	—
78–79	—	—	—	5	6	18	25	—	—	—	—
79–80	—	—	—	10	13	39	52	—	—	—	—
80–81	—	—	—	12	17	49	66	—	—	—	—
81–82	1.5	39	117	13	17	50	68	2	2	13	17
82–83	3.0	78	234	13	17	52	70	3	5	25	34
83–84	4.5	117	351	13	18	53	72	5	7	38	52
84–85	6.0	156	468	14	18	54	74	7	9	51	69
85–86	7.5	195	585	14	19	56	75	8	11	64	86
86–87	9.0	234	702	14	19	57	77	10	14	76	103
87–88	10.5	273	819	15	20	58	79	12	16	89	121
88–89	12.0	312	936	15	20	60	81	14	18	102	138
89–90	13.5	351	1 053	15	20	61	83	15	21	115	155
90–91	15.0	390	1 170	16	21	63	85	17	23	127	172
91–92	16.5	429	1 287	14	20	58	78	19	25	140	190
92–93	18.0	468	1 404	12	16	47	63	20	28	153	207
93–94	19.5	507	1 521	7	9	28	38	22	30	166	224
94–95	21.0	546	1 638	5	6	19	26	24	32	178	241
95–96	21.0	546	1 638	5	6	19	26	24	32	178	241
96–97	21.0	546	1 638	5	6	19	26	24	32	178	241
97–98	21.0	546	1 638	5	6	19	26	24	32	178	241
98–99	21.0	546	1 638	5	6	19	26	24	32	178	241
1999–2000 ..	21.0	546	1 638	5	6	19	26	24	32	178	241
Totals	262.5	6 825	20 475	234	308	923	1 250	298	401	2 227	3 014

Notes: (2a) = (1) × $26 000 per tonne
(2b) = (1) × $78 000 per tonne
(3), (4), (5), (6) based on Ranger's estimates
(7a) = (2a) − (3a) − (4a) − (5a) − (6a)
(7b) = (2b) − (3b) − (4b) − (5b) − (6b)
(8a) = (3a) + (4a) − (9a) for previous year
(8b) = (3b) + (4b) − (9b) for previous year
(9a) = 12½% (8a)
(9b) = 12½% (8b)
(10a) = (2a) − (5a) − (6a) − (9a)
(10b) = (2b) − (5b) − (6b) − (9b)
(11a) = (10a) × present worth factor
(11b) = (10b) × present worth factor

Net flow (Revenue – expenditure)		*Cumulative capital investment*		*Depreciation of capital*		*Profit (before income tax and royalties)*		*Present worth of net flow of revenue – expenditure*	
Low (7a)	High (7b)	Low (8a)	High (8b)	Low (9a)	High (9b)	Low (10a)	High (10b)	Low (11a)	High (11b)
−8	−10	8	10	1	1	−1	−1	−8	−10
−23	−31	30	40	4	5	−4	−5	−21	−28
−49	−65	75	100	9	12	−9	−12	−40	−54
−61	−83	127	171	16	21	−16	−21	−46	−62
−39	13	174	235	22	29	2	69	−27	9
−15	108	217	293	27	37	23	158	−9	67
8	202	256	346	32	43	42	249	5	114
30	298	292	395	36	49	62	341	15	153
53	394	326	440	41	55	82	433	25	184
77	489	356	481	44	60	104	525	33	207
99	583	385	520	48	65	124	617	38	225
121	679	412	556	51	69	145	711	42	238
145	774	437	590	55	74	166	803	46	247
167	869	461	622	58	78	188	897	48	252
198	974	475	642	59	80	211	992	52	256
236	1 090	475	641	59	80	236	1 089	56	261
284	1 220	451	608	56	76	263	1 191	62	266
320	1 333	419	564	52	70	292	1 295	63	264
320	1 333	391	526	49	66	295	1 299	58	240
320	1 333	366	492	46	61	298	1 304	52	219
320	1 333	344	463	43	58	301	1 307	48	199
320	1 333	325	437	41	55	303	1 310	43	180
320	1 333	308	414	38	52	306	1 313	39	164
3 143	15 502	–	–	887	1 196	3 413	15 864	574	3 591

example, Ranger indicated that the production of about 2500 tonnes of uranium (3000 tonnes of U_3O_8) per year would require the employment of about 250 workers, and that another 150 would be required if the rate of production were doubled. There were also indications in evidence that some economies of scale would apply in capital expenditure. The second aspect of costs is the rate of change in price levels associated with the principal components of Ranger's costs, when compared with the general rate of inflation in Australia. The evidence indicates that those price levels have increased at rates substantially greater than the general rate of inflation. This was said to be consistent with general experience in the mining industry, particularly in northern parts of Australia.

It appears, therefore, that there will be some economies of scale if larger scale production units are established; it is conceivable that these economies might extend to cases where mining ventures make common use of some facilities, although there was no indication that this would be a major element in reducing total mining costs. On the other hand, it seems probable that cost increases associated with these ventures will continue to occur at a faster rate than the general rate of inflation. Because of the absence of more precise information on these matters, no special provision has been made for them in the expenditure estimates.

In Table E we assume that construction work on the first mine begins in 1977–78 and that uranium is first produced in 1981–82 at a rate of 1500 tonnes of uranium per year. It is then assumed that capital is expended on expanding production capacity so that an average increase in annual production of 1500 tonnes of uranium is achieved in every year after production commences, until an upper production limit of 21 000 tonnes of uranium per year is reached. The costs per unit of production and the distribution of capital expenditure over time are assumed to be the same as Ranger's. Of course the actual rate of development of a mining industry would be unlikely to be constant; larger, more erratic steps in production rate would probably occur. However, the assumptions are adequate for illustrative purposes. On these assumptions, total capital expenditure would grow throughout the 1980s, reaching a maximum at the end of the decade and then declining as initial capital expenditures are completed. Capital expenditure in later years relates to the maintenance of existing facilities.

Net revenue

In deriving figures for the net flow of revenue less expenditure, shown in column (7) of Table E, and for profit, shown in column (10), low expenditure figures were deducted from low revenue figures since both are intended to reflect situations in which the Australian currency reaches the highest level assumed against the U.S. dollar (US$1.50 = $A1.00). Similarly, high revenue and expenditure figures were used to calculate high flows of net revenue and high net profits.

According to the calculations, revenues would begin to exceed total expenditure in the early 1980s, and net revenues to grow rapidly thereafter. The range of possible financial outcomes, derived from the assumptions made, is very wide; column (10) gives estimates of the accounting profit which would accrue to the mining enterprises under assumptions about depreciation of capital embodied in columns (8) and (9). Column (8) shows the cumulative capital investment resulting from the assumed levels of capital expenditure and a depreciation rate of 12½ per cent on the cumulative level of investment reached each year. The assumed rate of depreciation is based on the range of currently allowable deductions, based on the diminishing value method, which might apply to uranium mining. Actual depreciation allowances will vary, depending on variations in specific depreciation provisions applying to the industry and the general rate of investment allowances in force from time to time. Consequently the annual depreciation figures shown in column (9) are intended as approximations only. Column (10) shows that, after losses during the initial construction period, the assumptions result in substantial increments in profits up to the mid 1990s. Total net profits (before deduction of income tax) are estimated to range from $3413 million to $15 864 million.

As the operating expenditures include an imputed interest cost of 10 per cent per annum, the profit figures shown make provision for what might be regarded as a reasonable long-term average cost of borrowed capital. Of course a wide variety of arrangements for financing mining ventures is possible. Profits will vary according to the proportion of capital financed by borrowing and the amount of interest paid. As the profit figures exclude liability for income tax, such taxes would have to be deducted if the net return to equity owners of mining ventures was to be estimated.

Benefit–cost analysis

In this section, benefit–cost analysis is used to assess the net economic benefits likely to accrue to Australia as a whole if uranium mining proceeds at the rate assumed above and if the assumptions used in deriving the financial estimates hold. We begin the section by briefly summarising the methodological approach generally used in benefit–cost analysis. Some deficiencies of this type of analysis were referred to in Chapter 9 of our First Report, and are not repeated here.

In economic benefit–cost analysis, the expected net change in national income arising from a project can be estimated by finding the excess of the value of output from the project over all the costs incurred. Allowance must be made for differences between benefits and costs accruing to the nation as a whole and to the firms and other parties directly involved in the financial transactions associated with the project.

In summary form, net national benefits may be expressed as:

$$NNB = GV - C + E \ldots \text{(Equation (1))}$$

where NNB = net national benefit (defined as equal to the change in national income);

GV = gross value of the change in output directly resulting from the project;

C = cost of all resources used in the project;

E = 'external' effects (benefits less costs) arising from the project.

To quantify the elements of this equation in monetary terms, data are required for each year in which benefits and costs are expected to be incurred. The present worth of the stream of benefits and costs may be obtained by discounting future flows at an appropriate rate of discount. There is considerable controversy about the rate of discount that should be used. To illustrate the effect of discounting, we use a rate of 10 per cent per annum in the calculations of present worth in this section; this may be a reasonable approximation to the average rate of return on capital over the long run.

Equation (1) makes no allowance for overseas ownership of firms associated with a project, or for possible borrowing from abroad to finance capital expenditure. When there is overseas participation, part of the income generated accrues to non-residents. Taxes, royalties and similar payments made to the Commonwealth Government and other governmental authorities in Australia are the principal sources of additions to national income when overseas participation is substantial.

In the case of a project wholly owned by non-residents, net national benefits arising from productive activities may be expressed as:

$$NNB_f = t\,(GV - C - D - R) + R + E \ldots \text{(Equation (2))}$$

where NNB_f = net national benefit from foreign-owned projects;

t = average rate of income tax (including withholding tax) payable on net profits as assessed for income tax purposes;

GV = gross value of output;

C = current operating costs;

D = annual depreciation on capital expenditure allowable for income tax purposes;

R = royalty and lease payments (assumed to be deductible before calculating income tax);

E = 'external' effects.

When assessing the benefits and costs of projects with overseas participation, it is necessary to consider whether equivalent investment from abroad would have been used in Australia in the absence of the projects under consideration. If it would not, the capital inflow increases the available resources in the period in which it is received and reduces the net resources available when it is repatriated. In cases where the capital would have come to Australia whether or not the particular venture being considered was undertaken, no change in the net resource position can be attributed directly to the venture. Because of the participation of the Commonwealth Government and major Australian companies in the Ranger venture, it seems likely that any foreign capital used in the venture would also be obtainable for other uses in Australia. Although some other uranium companies have higher proportions of foreign ownership, it does not follow that capital inflow would be necessarily higher if their ventures proceeded, since the companies concerned might invest in other Australian ventures if uranium mining did not take place. However, because of the potentially high profits to be earned, it seems likely that the existence of the uranium mining industry would increase capital inflow from abroad. Though the induced capital inflow may be lower than that suggested by the proportion of overseas capital likely to be used in uranium ventures, calculations designed to show the benefits which may accrue from this inflow, shown in Table F, assume that 25 per cent of the industry is financed from abroad.

If, as in the case of some of the uranium mining proposals, ventures are partly domestically and partly foreign owned or financed, appropriate weights should be given to calculations based on equations (1) and (2).

Table F

Estimates of net national benefits from a national uranium industry, with foreign participation
($A million; January 1976 prices)

Year	*Cumulative capital inflow (25% of cumulative capital investment)* (1a) Low	(1b) High	*Annual capital flow* (2a) Low	(2b) High	*Tax on foreign profits* (3a) Low	(3b) High	*Net benefits from 25% foreign participation* (4a) Low	(4b) High	*75% of net benefits from domestic participation* (5a) Low	(5b) High	*Weighted net benefits* (6a) Low	(6b) High	*Present worth of weighted net benefits* (7a) Low	(7b) High
1977–78	2	2	2	2	—	—	2	2	−6	−7	−4	−5	−4	−5
78–79	7	10	5	8	—	—	5	8	−17	−23	−12	−15	−11	−14
79–80	19	25	12	15	—	—	12	15	−37	−49	−25	−34	−21	−28
80–81	32	43	13	18	—	—	13	18	−46	−62	−33	−44	−25	−33
81–82	43	59	11	16	—	4	11	20	−29	10	−18	30	−12	20
82–83	54	73	11	14	—	20	11	34	−11	81	0	115	0	71
83–84	64	86	10	13	5	31	15	44	6	151	21	195	12	110
84–85	73	99	9	13	8	43	17	56	22	223	39	279	20	143
85–86	81	110	8	11	10	54	18	65	40	295	58	360	27	168
86–87	89	120	8	10	13	66	21	76	58	367	79	443	33	188
87–88	96	130	7	10	15	77	22	87	74	437	96	524	37	202
88–89	103	139	7	9	18	89	25	98	91	509	116	607	41	212
89–90	109	147	6	8	21	100	27	108	109	580	136	688	43	219
90–91	115	155	6	8	23	112	29	120	125	652	154	772	45	224
91–92	119	160	4	5	26	124	30	129	148	730	178	859	47	226
92–93	119	160	0	0	29	136	29	136	177	817	206	953	49	228
93–94	113	152	−6	−8	33	149	27	141	213	915	240	1 056	52	230
94–95	105	141	−8	−11	36	162	28	151	240	1 000	268	1 151	53	228
95–96	98	131	−7	−10	37	162	30	152	240	1 000	270	1 152	49	207
96–97	91	123	−7	−8	37	163	30	155	240	1 000	270	1 155	44	189
97–98	86	116	−5	−7	38	163	33	156	240	1 000	273	1 156	41	172
98–99	81	109	−5	−7	38	164	33	157	240	1 000	273	1 157	37	156
1999–2000	77	103	−4	−6	38	164	34	158	240	1 000	274	1 158	34	142
Totals			77	103	425	1 983	502	2 086	2 357	11 626	2 859	13 712	591	3 255

Notes: (1a) = 25% (8a, Table E)
(1b) = 25% (8b, Table E)
(2a) = (1a) − (1a, previous year)
(2b) = (1b) − (1b, previous year)
(3a) = 12½% (10a, Table E)
(3b) = 12½% (10b, Table E)
(4a) = (2a) + (3a)
(4b) = (2b) + (3b)
(5a) = 75% (7a, Table E)
(5b) = 75% (7b, Table E)
(6a) = (4a) + (5a)
(6b) = (4b) + (5b)
(7a) = (6a) × present worth factor
(7b) = (6b) × present worth factor

Estimates of the present worth of net national benefits based on the data used in Table E are given in column (11), which assumes that there are no differences between financial and national costs, there are no external effects, and the industry is wholly owned and financed by Australians. On these assumptions, the present worth of the excess of benefits over costs generated by the industry, discounted to 1977–78, and expressed in January 1976 prices, would be between \$574 million and \$3591 million.

Table F shows our estimates of net national benefits with the assumed 25 per cent of overseas financing, and the same proportion of after-tax profits accruing to non-residents. Columns (1) and (2) show estimates of foreign capital consistent with the assumption that overseas participation in each time period would amount to 25 per cent of the estimated cumulative investment in the industry shown in Table E. The annual flows shown in column (2) are used to indicate the net addition to, or reduction in, resources available to Australia as a result of the capital transactions. Column (3) shows estimates of the income and withholding taxes on 25 per cent of the profits estimated in Table E. It is assumed that losses in early years are accumulated and that no income tax is payable until profits outweigh cumulative losses. An average tax rate of 50 per cent is assumed in the calculations, representing an approximation of the effect of the current corporate income tax rate of 42½ per cent combined with a withholding tax of 15 per cent on profits repatriated. The combined operation of these two taxes means a net tax rate of 42½ per cent plus 15 per cent of 57½ per cent, or 51⅛ per cent, of profits repatriated to other countries. Actual taxes paid would depend also on additional factors, including the effects of any tax concessions associated with mining ventures, actual depreciation allowances, the extent to which interest was used to finance the projects and was an allowable expenditure for taxation purposes, and the extent and timing of transfer of profits abroad. No separate calculations are made in respect of royalties and other payments to governments, as would be required by a strict application of equation (2). An examination of the changes to the estimates which would be required if current rates of royalties and other payments to governments prevail shows that their inclusion would not materially alter the figures shown in the Table.

Column (4) of Table F shows the estimates of net benefits arising from both capital flows and taxes on foreign profits. Column (5) shows the net benefits accruing from the assumed 75 per cent Australian ownership and financing based on the data in Table E. Column (6) shows the net benefits obtained by adding the figures for 25 per cent foreign participation and 75 per cent domestic participation. When expressed in terms of the present worth of the estimates, as in column (7), the low estimate is \$591 million and the high estimate \$3255 million.

The estimates discussed above made no allowance for possible differences between financial and national economic costs, or for 'external' benefits or costs. In this connection, it has to be borne in mind that no estimates of costs required to meet the environmental provisions recommended in this Report, or of governmental or other expenditure not included in Ranger's costs estimates, have been provided for in estimated expenditure. However, it is not expected that inclusion of such costs would alter significantly our conclusions.

An important difference between financial and national economic costs associated with uranium mining might arise if the industry's use of inputs, including labour, reduced the national level of underemployment of resources. This could possibly happen if persistent unemployment continues in Australia and expenditure by the industry helps achieve a higher level of employment.

However, since there are generally more effective ways of dealing with underemployment problems, it does not seem appropriate to attribute any substantial benefit from this source to the uranium industry. To justify such a benefit, it would be necessary to make a detailed study of the possible effects of the industry's expenditure on segments of the labour market and on other industries, and to consider the benefits and costs of alternative ways of reducing unemployment levels. Such studies are beyond the Commission's resources, but the effect of assuming that national costs would be 5 per cent lower than financial estimates was used to test the sensitivity of the results to the possibility of such effects being achieved. The effect of this adjustment to costs would be to increase the estimated present worth of net benefits by about 9 per cent in the case of the low estimates and by about 2 per cent in the case of the high estimates.

'External' effects, both benefits and costs, associated with the uranium industry include some which are associated with the effects of the use of uranium on the environment of the world as a whole, as discussed in the Commission's First Report, and others, considered in this Report, associated with the effects of mining on the local environment. If these effects could be expressed in monetary terms, they could be included in the benefit–cost assessment. However, this is not generally possible, and monetary values are normally used only to indicate the impact of 'external' benefits and costs of an economic venture which can be expressed in monetary units and which can be reasonably identified with a project. It is necessary to establish that the economic effects considered will accrue only from use of resources in the particular project before adding benefits or deducting costs under this heading.

Claims were made by proponents of uranium mining that the industry's existence would raise the profit levels of Australian firms supplying goods and services to it. A considerable amount of empirical research would be necessary to assess the possibility that the uranium industry, rather than other industries which could make alternative use of the resources concerned, could achieve such effects. No evidence was presented to the Commission which demonstrated that the industry would have any special features to justify any adjustment to the benefit–cost analysis. However, additional expenditure associated with uranium mining would affect incomes in the Northern Territory; the possible effects are discussed later in this appendix.

It was also submitted to the Commission that assessment of the indirect benefits should take account of the 'multiplier' effects of induced expenditure in the Australian economy which might stem from the incomes generated by the uranium industry. Such induced effects can occur when there are unemployed resources available in the economy. To the extent that such effects do occur, they are properly attributable as benefits arising from a particular project or industry only when it can be shown that equivalent benefits could not be achieved by use of the resources concerned in other projects or industries. No evidence was given which can be interpreted as showing that the uranium industry alone could achieve such benefits.

The estimates of present worth of net national benefits indicate that large economic benefits will accrue to Australia if the assumptions used in the analysis materialise. If the rate of growth of production and sales used in Table E and the average price levels assumed in the high estimates turn out to be correct, a very high level of profits would be derived from uranium mining. Even if the lower level of prices assumed is achieved, substantial profits would be made.

It is extremely important to emphasise that these estimates do not constitute a prediction of high profits in the industry. A much lower level of sales and prices may eventuate, particularly if economic growth in the major industrial countries remains at low levels for an extended period of time. A similar outcome may occur if nuclear power loses some of its existing competitive advantage in those countries or its growth is otherwise restricted. These outcomes would slow the rate of increase in demand for uranium, thus reducing the level of sales and/or the average price received.

Higher levels of national income would be shared between owners of the mining ventures and Australians as a whole, the distribution being determined principally by the effective rates of taxes and royalties levied on such income. Higher government revenues may make it possible for taxation rates to be reduced, or alternatively for public expenditures to be raised without increasing tax rates. Additional benefits might accrue to people not directly associated with mining ventures because of a reduction in the rate of unemployment of resources. Economic effects would be concentrated in areas in which uranium mining occurs, such as the Northern Territory. Because the establishment of new industry in the Territory would attract resources from the rest of Australia, its regional impact is likely to be much more important than its national effects. The effects are considered in more detail in the second part of this appendix.

Net national benefits and national income

National income in any year comprises the total of wages, salaries and supplements, and other incomes (principally rent, interest and profits) generated by economic activity. Estimates of national income are made by the Australian Bureau of Statistics in accordance with international conventions covering the types of activity to be included and the manner in which estimates are made. National income per person is the concept most frequently used in the measurement of a country's standard of living, although it is well known that it has significant deficiencies in this regard. These include various statistical problems, and the difficulties associated with trying to provide quantitative estimates of the value of the many aspects of life which yield considerable satisfaction to large numbers of people. Many people, particularly those who believe that the quality of life is increasingly determined by non-measurable aspects of living, do not regard quantitative estimates of national income and related concepts as appropriate indicators of overall well-being. However, such estimates provide the only comprehensive statistical measurements of national well-being currently available. Comparison of the net economic benefits which might accrue from uranium mining with projections of national income indicates the range of direct contributions which the industry might make to future levels of national income.

Table G contains projections of Australian national income, excluding indirect taxes, based on a figure of $56.6 thousand million in 1975–76 and assuming both a low average annual compound growth rate of 3 per cent and a high rate of 5 per cent. In our First Report, we assumed a 4 per cent growth rate. This is below the average rate experienced in Australia in recent decades, but the likelihood of slower population growth in the rest of the century suggests that it might be a reasonable assumption for this period. However, it is difficult to be certain about future rates of economic growth, and average rates of 3 and 5 per cent are used in the calculations in Table G to indicate the sensitivity to changes in national growth rates of the estimated percentage contribution of the industry to national income. The lowest and highest estimates of net national

Table G

Estimated net national benefits from national uranium industry as percentages of projected national income

	Estimated level of domestic factor incomes		Net national benefits from uranium mining		Net national benefits as percentage of national income	
	Growth at 3% p.a.	Growth at 5% p.a.	Low	High	High estimate and growth of national income at 3% p.a.	Low estimate and growth of national income at 5% p.a.
	(1)	(2)	(3a)	(3b)	(4a)	(4b)
Year	$ thousand million	$ thousand million	$ million	$ million	Percentage	Percentage
1977–78	60.0	62.4	−4	−1	−0.002	−0.006
78–79	61.8	65.5	−12	−5	−0.01	−0.02
79–80	63.7	68.8	−25	−12	−0.02	−0.04
80–81	65.6	72.2	−33	−21	−0.03	−0.05
81–82	67.6	75.8	−18	69	0.10	−0.02
82–83	69.6	79.6	0	158	0.23	0
83–84	71.7	83.6	21	249	0.35	0.03
84–85	73.9	87.8	39	341	0.46	0.04
85–86	76.1	92.2	58	433	0.57	0.06
86–87	78.3	96.8	79	525	0.67	0.08
87–88	80.7	101.6	96	617	0.76	0.09
88–89	83.1	106.7	116	711	0.86	0.11
89–90	85.6	112.1	136	803	0.94	0.12
90–91	88.2	117.7	154	897	1.02	0.13
91–92	90.8	123.6	178	992	1.09	0.14
92–93	93.6	129.7	206	1 089	1.16	0.16
93–94	96.4	136.2	240	1 191	1.24	0.18
94–95	99.2	143.0	268	1 295	1.31	0.19
95–96	102.2	150.2	270	1 299	1.27	0.18
96–97	105.3	157.7	270	1 304	1.24	0.17
97–98	108.5	165.6	273	1 307	1.20	0.16
98–99	111.7	173.8	273	1 310	1.17	0.16
1999–2000	115.1	182.5	274	1 313	1.14	0.15

Notes: (3a) = Table F, column (6a)
(3b) = Table E, column (10b)
(4a) = Column (3b) ÷ Column (1) × 100
(4b) = Column (3a) ÷ Column (2) × 100

benefits from uranium mining, based on the assumptions discussed above, are shown in column (3) of Table G. Column (4a) shows the highest projected percentage contribution of the industry to national income, derived by expressing the high estimate of net benefits in each year as a percentage of the lowest projected figure for national income. Column (4b) shows the low estimate of benefits expressed as a percentage of the highest projected figure for national income, and therefore the lowest percentage contribution of the industry to national income.

The high estimates suggest a contribution by the uranium industry to national income rising to about 1 per cent by the early 1990s and then to more than 1.3 per cent in the mid 1990s. The low estimates, on the other hand, suggest a maximum contribution of about 0.2 per cent of national income in the mid 1990s. In both cases, the estimated contribution declines later in the 1990s, because the industry's production level is assumed to remain constant while national income continues to grow.

Contribution to gross domestic product

An objection which may be raised against the use of comparisons of net economic benefits derived from benefit–cost analysis with national income is that benefit–cost analysis generally treats as costs all payments to primary factors of production, including wages and salaries, while national income figures include all payments to factors of production. A useful exercise is to compute an industry's potential total contribution to the value of national output, including payments for purchases from other domestic industries, which will in turn contribute to total payments to factors of production in the economy as a whole. Estimates of these contributions can then be expressed as a proportion of estimated gross domestic product at factor cost, which is the sum of total returns to factors of production in a given time period.

Table H, column (1), shows projections of gross domestic product based on assumed growth rates of 3 and 5 per cent per year. Column (2) shows estimates of the uranium industry's projected contribution to gross domestic product, derived from data in Table E by deducting the estimated imported component of the industry's operating expenditure (excluding wages and salaries) from its gross revenue. Column (3) gives projected contributions of the industry as a percentage of projected gross domestic product. The calculations suggest contributions to gross domestic product rising to about 0.3 per cent in the low case and to about 1.3 per cent in the high case.

Contribution to national employment

Another measure of the industry's potential contribution to economic well-being is its possible contribution to employment opportunities. In the context of the national employment situation, an industry's direct contribution to employment opportunities, i.e. the number of jobs made available directly as a result of its establishment and operation, is usually regarded as its major contribution to employment. However, like other industries, the uranium industry would also provide indirect employment opportunities by purchasing inputs from other sectors of the economy. Even if full details of the uranium industry's projected expenditure were available, it would be a complex task to estimate its impact on direct employment opportunities. Those details are not available and the Commission has not attempted this task.

In the case of the Ranger proposal, the Commission was told that about 600 direct employment opportunities would flow from construction activities for an output of 3000 tonnes of U_3O_8 (about 2500 tonnes of uranium) per year, and about 1000 from construction for double that annual output. The construction period was estimated to be approximately four years. If a number of projects were to proceed sequentially, in accordance with the timing of construction activities assumed in Table E, up to approximately 1500 workers could be employed in these tasks at any one time.

Ranger estimates that in the operating stage production of about 2500 tonnes of uranium (3000 tonnes of U_3O_8) per annum would provide direct employment for 250 workers, and the higher production rate direct employment for about 400. Consequently, if production in Australia rose to a total rate of 21 000 tonnes of uranium (about 25 000 tonnes of U_3O_8) per year, a total workforce of between 2000 and 2500 would probably be directly employed in the industry.

It was suggested in evidence that supporting economic activities, particularly in the towns directly linked with mining activities, might provide further jobs equal to about 25 per cent of direct employment in mining itself. The number of opportunities created in this way would depend heavily on the extent to which

Table H

Estimated contribution of national uranium industry to projected gross domestic product

Year	*Estimated level of gross domestic product*		*Gross product of uranium industry*		*Industry's contribution as percentage of gross domestic product*	
	Growth at 3% p.a.	*Growth at 5% p.a.*	*Low*	*High*	*High estimate and low growth of GDP*	*Low estimate and high growth of GDP*
	(1a) $ thousand million	(1b) $ thousand million	(2a) $ million	(2b) $ million	(3a)	(3b)
1981–82	83.1	93.3	37	114	0.14	0.04
82–83	85.6	97.9	74	229	0.27	0.08
83–84	88.2	102.8	111	343	0.39	0.11
84–85	90.8	108.0	148	458	0.50	0.14
85–86	93.5	113.4	185	572	0.61	0.16
86–87	96.3	119.0	223	685	0.71	0.19
87–88	99.2	125.0	260	791	0.80	0.21
88–89	102.2	131.2	297	915	0.90	0.23
89–90	105.3	137.8	334	1 030	0.98	0.24
90–91	108.4	144.7	371	1 144	1.06	0.26
91–92	111.7	151.9	408	1 259	1.13	0.27
92–93	115.0	159.5	445	1 373	1.19	0.28
93–94	118.5	167.5	482	1 487	1.25	0.29
94–95	122.0	175.9	519	1 602	1.31	0.30
95–96	125.7	184.7	519	1 602	1.27	0.28
96–97	129.5	193.9	519	1 602	1.24	0.27
97–98	133.4	203.6	519	1 602	1.20	0.25
98–99	137.4	213.8	519	1 602	1.17	0.24
1999–2000	141.5	224.5	519	1 602	1.13	0.23

Notes: Column (2a) = Table E, Column (2a) – 15% Column (6a)
(2b) = Table E, Column (2b) – 15% Column (6b)
(3a) = Column (2b) ÷ Column (1a) × 100
(3b) = Column (2a) ÷ Column (1b) × 100

new towns were established and small businesses and government authorities established additional facilities for servicing mining activities. If mining workers were housed in existing towns, where dwellings, business and government facilities already existed to meet their requirements, very few additional jobs would be created in this way. On the other hand, important additional employment opportunities would be created locally, in both the construction and operating phases of mining, if new townships were created. In this case it would be necessary to establish, before reaching a conclusion about the effects on total employment opportunities, whether the employment represented a transfer of activities from other locations or the creation of new opportunities.

Additional employment would be created in industries, located elsewhere in the Northern Territory and in other parts of Australia, which would supply the mining ventures if it were necessary for supplying firms to take on additional labour to meet requirements. As already indicated, it is not appropriate to attribute any such employment effects to a particular industry in a benefit–cost analysis, unless it can be shown that other industries using the resources concerned would be unable to create similar effects. It seems likely that many industries which would supply the uranium mining ventures would not require additional resources, since they would be affected only in a marginal way and could use existing equipment and labour to meet requirements. On the other hand, there may be some which would need to undertake expansion programs to meet the uranium industry's requirements.

The possibility that supplying industries would need to expand would obviously increase if the uranium industry achieved the higher levels of production and sales assumed in Table E. No detailed information was presented to the Commission on this matter and, in the absence of a detailed study, it does not seem useful to speculate about the total additional employment which uranium mining might generate in Australia. Even if employment created indirectly were considerably greater than the direct effects, it seems very unlikely that it would constitute a major proportion of employment opportunities in Australia. Nevertheless, both direct and indirect effects could make some contribution to reducing unemployment levels if suitable job opportunities were provided for those who would otherwise be unemployed.

Comparisons with other industries

According to estimates provided to the Commission by Ranger, an average price of about $A12 per pound of U_3O_8 would result in a rate of return of 22 per cent on capital invested, an average of $A16 per pound would increase the rate of return to 34 per cent, and an average of $A20 per pound would raise it further, to about 39 per cent. Estimates of rate of return can also be derived from the assumptions embodied in Tables E and F. If the low estimates of revenues and expenditure eventuated, the rate of return on resources used in the industry would be about 26 per cent. If the high estimates eventuated, the rate of return would exceed 50 per cent.

No evidence was presented to the Commission concerning rates of return achieved elsewhere in the economy. However, the Commission notes that figures based on evidence given by twenty-seven large mineral producers to a recent inquiry by the Industries Assistance Commission revealed an average rate of return on funds employed between 1967–68 and 1973–74 ranging from 11.4 per cent of 16.4 per cent (Industries Assistance Commission, *Report on Petroleum and Mining Industries*, May 1976, Table A3.11). For the same period, the IAC's annual survey showed average rates of return in the manufacturing sector of the economy ranging from 11.4 per cent to 13.0 per cent. While comparisons of this kind involve major difficulties, these data appear to confirm the view that, provided prices received do not fall below levels assumed, the uranium industry would be likely to produce rates of return on capital invested substantially higher than the average rates experienced in mining and manufacturing industries in Australia.

The information contained in Table I enables comparisons to be made between the potential contribution of uranium mining to the economy and similar contributions of other major mining industries. The table shows that mining of black coal is currently the largest contributor in the mining sector to employment, to wages and salaries, to the value of minerals produced, and to purchases from other industries. Total employment in black coal mining is much higher than in iron ore, the next most important mining industry, but value added per employee is higher in the iron ore, bauxite and other fuels (principally petroleum) categories than in black coal.

We estimated in the previous section that, if the uranium industry expanded to a capacity to 21 000 tonnes of uranium per annum, it would provide direct employment for 2000–2500 workers. If that occurred, it would be a larger employer than bauxite mining is now, but would provide substantially fewer

Table I

Statistics of Australian Mining Industry, 1974–75

	No. of establishments (a) (1)	*Persons employed (b)* (2)	*Value of minerals produced $ million* (3)	*Purchases and selected expenses (c) $ million* (4)	*Wages and Salaries $ million* (5)	*Value added (d) $ million* (6)	*Value added per employee $* (7)
Metallic minerals							
Bauxite	5	1 696	(g)	(g)	17.1	125.7	74 116
Copper	32	6 811	170.3	79.0	72.4	129.0	18 940
Iron ore	24	7 668	613.2	309.9	78.6	428.1	55 829
Silver, lead, zinc	11	6 858	276.4	70.6	69.8	237.8	34 675
Total metallic minerals (e)	208	35 072	1 573.1	630.0	336.2	1 234.9	35 210
Fuels							
Black coal	127	21 720	874.9	342.8	232.4	733.6	33 775
Other fuels (f)	14	2 956	498.3	57.7	32.8	473.0	160 014
Construction materials	697	6 562	238.0	96.8	53.0	149.4	22 767
Other (non-metallic) minerals	269	2 812	120.4	47.3	22.2	50.2	17 852
Total (e)	1 315	69 122	3 304.6	1 174.7	676.6	2 641.1	38 209
Percentages of total							
Black coal	9.7	31.4	26.5	29.2	34.3	27.8	
Iron ore	1.8	11.1	18.6	26.4	11.6	16.2	
Silver, lead, zinc	0.8	9.9	8.4	6.0	10.3	9.0	
Copper	2.4	9.9	5.2	6.7	10.7	4.9	

Source: Australian Bureau of Statistics

Notes:
(a) Excludes some very small establishments
(b) Includes working proprietors
(c) Includes materials, fuels, repairs and maintenance, transport costs etc
(d) Turnover (adjusted for stock changes), less purchases and selected expenses
(e) Includes groups not shown separately
(f) Principally crude petroleum and natural gas; includes brown coal (not available separately)
(g) Not available

jobs than other major mining industries, including black coal, iron ore, copper mining and the silver, lead and zinc industry.

If uranium mining achieved the high levels of sales revenue shown in Table E in the mid 1990s, this revenue would be equal to approximately half of the value of all minerals produced in Australia in 1974–75.

The low estimates of uranium sales for the mid 1990s are about two-thirds of the value of black coal produced in 1974–75. Since coal, iron ore, bauxite and other mining industries depend on the growth of export markets and the growth of the Australian economy, they are also likely to grow substantially, provided there is continued economic growth in the major industrial countries. While it seems unlikely that the uranium industry will achieve the value of production likely to be reached by black coal or iron ore in the 1990s, it could make a much greater contribution to the value of total mineral production than other existing mining industries, such as silver–lead–zinc and copper.

Contribution to exports

The potential sales revenue from exports of uranium can also be compared with the foreign exchange earned by other industries. Values of Australian exports in recent years are shown in Table J. If the low levels of revenue assumed in Table E eventuate, the uranium industry would not reach the same level of contribution to export earnings as traditional major export industries such as wool and wheat, though it would eventually contribute about the same amount as beef and veal have contributed to exports in recent years. If the high levels of revenues eventuate, the uranium industry's earnings would eventually exceed the earnings in recent years of any of the other industries mentioned in Table J. If economic growth continues in the industrial countries, the export earnings of both traditional rural industries and other mineral industries should also continue to grow.

Estimates of export earnings do not show the final effects of projects or industries on the overall balance of international payments. Capital inflow and outflow, direct and indirect imports of goods and services, and profits and other income sent abroad need to be estimated for this purpose. But, without making those calculations, it is evident that the uranium mining industry will provide substantial net increments in foreign exchange if it develops in the manner assumed in Table E.

The foreign exchange earned by the uranium industry would make it possible for Australia to purchase additional goods and services from the rest of the world. However, as shown by events in recent years, very large increments in foreign exchange may prove a mixed blessing for the Australian economy, since they may lead to adjustment problems for other industries. When exchange rates are held steady, a heavy foreign exchange inflow makes it difficult to control the supply of money, which in turn increases difficulties experienced in controlling inflation. When exchange rates are allowed to fluctuate, some of the undesirable effects on the money supply may be reduced, but the accompanying currency appreciation reduces the international competitiveness of other industries in the economy and may make it difficult for some of these to remain economically viable. Undesirable effects on the employment of labour and other resources may follow. Sudden increases in economic growth in other parts of the economy can also cause adjustment problems. Consequently, the Government may wish to secure steadier growth of industrial output. While it is unlikely that revenue from the uranium industry will dominate future export earnings or national product, steadier growth of exports may make it easier for the rest of the economy to adjust. The Commission's recommendation that growth of the uranium industry should be controlled may help to contribute to

Table J
Value of Australian exports—1972–73 to 1975–76

Item	*1972–73 $m*	*1973–74 $m*	*1974–75 $m*	*1975–76 $m*	*Annual average 1972–73 to 1975–76 $m*
Rural products					
Wool	1 262	1 248	814	1 032	1 089
Meats—beef and veal	652	636	322	488	524
—other	180	131	101	150	140
Wheat	286	539	1 085	960	717
Sugar	250	223	644	570	422
Other crops	201	254	410	459	331
Dairy products	141	160	163	203	167
Other	347	320	324	369	340
Total rural products	3 319	3 511	3 863	4 231	3 730
Minerals					
Copper	90	159	163	140	138
Lead	95	139	145	130	127
Zinc	84	117	139	135	119
Aluminium	186	217	335	480	304
Iron ore	439	492	705	770	601
Pig iron	27	60	62	40	47
Steel ingots, blooms	48	64	149	160	105
Mineral sands	61	72	121	126	95
Black coal	290	327	661	974	563
Other	61	55	100	106	82
Total minerals	1 381	1 702	2 580	3 061	2 181
Other exports of goods	1 310	1 475	1 991	2 051	1 707
Total exports of goods	6 010	6 688	8 434	9 343	7 618
Services	946	1 092	1 488	1 621	1 287
Total exports of goods and services	6 956	7 780	9 922	10 964	8 905

Sources: Bureau of Agricultural Economics, Australian Bureau of Statistics.

this aim. The marketing arrangements proposed in Chapter 19 may also help to contribute to a more stable growth of earnings than would otherwise be achieved.

Effects on Northern Territory economy

The data used to estimate the national economic effects of uranium mining may also be used as a basis for assessing the possible effects of mining on the economy of the Northern Territory. As in the case of the national effects, we consider here the implications for both income and employment of the construction and operating stages of the industry.

For the national development of uranium mining to occur on the scale assumed in Table E, some mines would probably have to be established outside the Northern Territory. For the purpose of assessing regional economic effects we assume, in the assessment which follows, that the maximum output reached in the Territory will be 12 500 tonnes of uranium per year. However, as the Commission is not able to make accurate estimates of the timing of developments in other parts of Australia, no dates are attached to the estimates in this section.

Estimate of income in the Northern Territory

No official estimates are available of the income generated by economic activity in the various States and Territories. However, in order to estimate the possible contribution of uranium mining to the Northern Territory's economy, an estimate of the value of output and income in the Territory is required.

Gross product is the aggregate normally used to indicate the value of production in a given area. The concept of gross domestic product, as defined by the Australian Bureau of Statistics, is used for this purpose, since it provides an adequate approximation to the value of production in an area. Inter-industry transfers of materials are excluded when this figure is calculated, since this avoids the double-counting which would be involved in adding together the gross values of production of separate industries. However, gross product is not satisfactory as a measure of the net incomes received by residents of an area, partly because it does not allow for depreciation of fixed capital equipment used in the production of goods and services and partly because income produced within an area does not necessarily accrue to residents of that area. In the case of the Northern Territory, a large part of the capital used in production is owned by non-residents. This means that a large proportion of the profits, interest and rent generated in the Territory is not part of the income of its residents. Also, the large number of people in the labour force who are not permanent residents raises questions as to whether a distinction needs to be made between 'permanent' and 'transient' contributors to production and whether the income received by transients should be counted as part of the income of Territory residents.

It appears reasonable to take the total number of people in the labour force in the Territory in mid 1974 as a figure for estimating the income accruing to both permanent and what might be regarded as the 'normal' level of transient residents. Those in the latter category probably would not spend as great a percentage of their earnings locally as would more permanent residents, but their incomes clearly form an important component of total income earned and they are normally replaced by others when they leave the Territory. Use of the mid 1974 figures avoids complications which would follow from trying to estimate the effects of Cyclone Tracy on later levels of economic activity. It is assumed that an estimate based on mid 1974 employment levels is a reasonable indicator of the Territory's income in normal circumstances.

The value of gross product per employee in Australia as a whole is used as a starting point for estimating the Territory's gross domestic product. Average levels for 1973–74 of the two components of gross product—wages and salaries, and gross operating surplus (defined as operating surplus before deducting depreciation, dividends, interest, royalties, land rent and direct taxes)—are shown in columns (1) and (2) of table K. Column (4) shows the number of employees in the Northern Territory in June 1974. Columns (5) and (6) show the estimates of the two separate components of gross product, and column (7) the estimate of gross product as a whole, for each industry group in the Northern Territory. The figures were obtained by multiplying the number of employees by the national average per employee for each of the components.

Table K

Estimate of gross product of the Northern Territory

	Australia — gross domestic product per employee, 1973–74				*Estimate of N.T. gross product*		
Industry group	*Wages, salaries etc.* $ (1)	*Gross surplus* $ (2)	*Total* (3)	*No. of employees in N.T. June 1974 (thousands)* (4)	*Wages, salaries etc.* $ million (5)	*Gross surplus* $ million (6)	*Total* $ million (7)
Agriculture, forestry etc.	4 617	29 172	33 789	2.8	12.9	81.7	94.6
Mining, quarrying	7 880	13 940	21 819	3.2	25.2	44.6	69.8
Manufacturing	5 235	2 055	7 289	1.8	9.4	3.7	13.1
Electricity, gas, water	5 672	6 613	12 286	0.5	2.8	3.3	6.1
Construction	6 622	2 213	8 835	5.6	37.1	12.4	49.5
Wholesale and retail trade	5 008	3 004	8 012	4.7	23.5	14.1	37.6
Transport, storage, communication	6 074	2 720	8 794	3.2	19.4	8.7	28.1
Public administration (including defence)	7 048	—	7 048	8.2	57.8	—	57.8
Finance, property, business and community services	4 936	1 347	6 283	14.0	69.1	18.9	88.0
Total				44.0	257.2	187.4	444.6

Source: Columns (1), (2), (4), Australian Bureau of Statistics.

Notes: (3) = (1) + (2)
(5) = (1) + (4)
(6) = (2) + (4)
(7) = (5) + (6)

As shown in the table, this method produces an estimate of the Territory's gross product in 1973–74 of about \$445 million (in price levels current at that time). This estimate is subject to a wide margin of error, mainly because national averages are not necessarily very good indicators of local product per person. This is because the mix of particular industries within broad industry groups may differ substantially between the Territory and the country as a whole and because there may be important differences in productivity. Despite these difficulties, the estimate for the wages and salaries component, \$257 million, is broadly consistent with a separate estimate based on the average level of employee earnings in the Territory.

The extent to which gross operating surplus adds to the pre-tax income of local residents depends on the extent of local ownership of profits, rent and interest. As column (6) of Table K shows, about two-thirds of operating surpluses generated in the Northern Territory originate in primary industries, in which the level of non-resident ownership is high. Although no ownership data are available, it seems likely that a greater proportion of surpluses generated in manufacturing, commerce and service industries would remain in the Territory. Taking these considerations into account, \$300 million appears to be a reasonable estimate of income accruing to permanent and transient residents of the Territory in 1973–74. Allowing for inflation, this would be equivalent to about \$400 million when stated in January 1976 prices.

Effects on income from construction activities

The Commission was told that construction activities associated with the Ranger proposal for an initial production capacity of 3000 tonnes of U_3O_8 (about 2500 tonnes of uranium) per year were estimated to cost \$118 million (in January 1976 prices), and that about \$36 million of this would be spent in the Northern Territory. If all the local expenditure, which includes wages and salaries, were added to the incomes of Territory residents and spread evenly over four years, it would add about 2¼ per cent per year to the estimated level of total income of people living in the Territory. Allowing for variations of 15 per cent in the expenditure figure because of assumptions about the exchange rate, the annual addition would vary between \$8 million and \$10 million, i.e. between 2 and 2½ per cent of Territory income.

Although full details of these expenditure figures were not provided, it is clear that they do not include any estimate of 'multiplier' effects which may occur as a result of respending of incomes generated. In a national context, such respending effects are not normally regarded as economic benefits, since they would also occur as a result of other uses of the resources concerned. However, they may result in higher local incomes if expenditure would not otherwise have occurred in the region concerned; they may thus represent a transfer of incomes from other areas of the nation, e.g. from elsewhere in Australia to the Northern Territory.

To estimate accurately the extent of the respending effects, it would be necessary to have details of the expenditure likely to occur in the Territory and to examine its effects on output and income in the area. This is a complex task, beyond the Commission's resources. However, it is generally the case that, in an area without substantial local industries supplying consumer goods, the induced effects on expenditure are much smaller than in the country as a whole. This is due to the high proportion of income which is diverted from the area, because of the substantial import content of consumer goods, remittances to other areas, tax payments to the Commonwealth Government and savings not made available for use in the local economy. In the Northern Territory, the import content is probably more than half the total value of final expenditure on goods and services, and the other 'leakages' are also important. In these circumstances, it is unlikely that 'multiplier' effects would amount to more than 25 per cent of the initial effects on local incomes, unless the activities under consideration were to stimulate directly further investment in the area. Such additional investment effects probably would not be important in the case of the Ranger proposal. This factor may assume greater importance if there is an increase in the overall rate of construction activity in the Northern Territory, but no evidence was given to suggest that construction activity associated with the uranium industry would enlarge permanently the Territory's industrial structure.

If 25 per cent is added to the estimates of annual construction expenditure on Ranger, to allow for respending effects, the annual addition to Territory incomes would be between $10 million and $12.5 million, i.e. about 2.5 to 3 per cent of total Territory incomes.

In order to assess the total effects of construction on annual regional incomes, it is assumed that construction of the total expected capacity in the Territory would take twelve years and work would commence on the equivalent of creating new capacity to produce 2500 tonnes of uranium about every two years. Annual expenditure in the Territory would reach a peak of between $18 and $22.5 million per annum (in January 1976 prices). If induced effects on consumer spending equal to 25 per cent of the initial expenditure are added, the total increment to incomes comes to between $20 and $25 million, or between 5 and 6¼ per cent of the estimated recent level of total incomes of people living in the Northern Territory ($400 million).

Effects on income from mining operations

The evidence suggests that about 40 or 50 per cent of the Ranger project's annual operating expenditure would result in increased incomes for people living in the Northern Territory, depending on whether or not lime was imported. Table L shows the effects on Territory incomes of applying the lower percentage to the low estimates of operating expenditures implicit in the evaluation of national effects, and the higher percentage to the high expenditures estimates used.

Table L also shows the effects of including an estimate of the stimulus to local expenditure that the establishment of governmental services in towns associated with the mining ventures might provide. It was stated in evidence that most of the expenditure associated with the provision of these services would be recovered by charges to users of the services, and therefore would not add to total local spending. However, experience with townships of the type envisaged suggests that a considerable annual deficit would be incurred in the towns' operations, and this would have to be met either by mining companies or government authorities. An annual figure of $1 million for each 2500 tonnes of uranium capacity is included to cover additional local expenditure from this source.

For reasons already given, it is probably appropriate to add 25 per cent to the estimated initial income effects to allow for induced effects on local incomes. Our calculations (see the final two columns of Table L) indicate that operating expenditures of Ranger producing about 2500 tonnes of uranium (3000 tonnes of U_3O_8) per year would probably add about 3.5 to 5 per cent to the total incomes of people living in the Territory, with commensurate increases for

Table L

Estimates of effects of regional uranium mining operating expenditure on estimated Northern Territory incomes
($A million; January 1976 prices)

Level of production (tonnes uranium per annum)	*Direct N.T. impact of operating expenditure*		*Additional expenditure on providing services*	*Total*		*Total estimated increase including induced effects*		*Percentage of estimated current income*	
	Low $ million	High $ million	$ million	Low $ million	High $ million	Low $ million	High $ million	Low $ million	High $ million
(1)	(2a)	(2b)	(3)	(4a)	(4b)	(5a)	(5b)	(6a)	(6b)
2 500	10	16	1	11	17	14	21	3.50	5.25
5 000	19	31	2	21	33	26	41	6.50	10.25
7 500	29	47	3	32	50	40	62	10.00	15.50
10 000	38	63	4	42	67	52	84	13.00	21.00
12 500	47	79	5	52	84	65	105	16.25	26.25

Notes: (4a) = (2a) + (3)
(4b) = (2b) + (3)
(5a) = 1.25 (4a)
(5b) = 1.25 (4b)
(6a) = (5a) ÷ 400 × 100
(6b) = (5b) ÷ 400 × 100

higher levels of output. If output rose to 12 500 tonnes of uranium per year, the additional income would range from about 16 to 26 per cent of estimated income currently accruing to residents of the Territory. If construction activity on expanding uranium production capacity in the Territory takes place while plants constructed earlier are already producing, the total impact of both construction and operating expenditures could reach approximately the levels shown in Table L two years before production reaches the levels shown.

We have not attempted to estimate the effects on income which would arise if the existence of the uranium industry induced further important industrial development in the Northern Territory. It was suggested in evidence that some additional small-scale manufacturing might be established, after mining began, to service the mines' requirements. However, it seems unlikely that these developments would be of major importance, in view of the relatively small overall market which would continue to exist for manufactures in the Territory. The income effects of higher levels of uranium production could, nevertheless, stimulate the establishment of important additional business and government services in the Territory. In turn, this would increase the demand for housing and related facilities.

Without allowing for any such effects, however, it is clear that construction and operation activities associated with uranium mining and milling, especially if carried out on the higher scales of operation shown in Table L, could make an important contribution to incomes earned in the Territory. Taking into consideration the induced effects on other types of investment which seem likely to occur at higher levels of output, it appears that considerable pressure may be put on human and physical resources available in the Territory if development occurs at too rapid a rate. Consequently, it may be necessary to regulate the rate of uranium development to avoid undesirable effects on the regional economy.

Effects on employment

The 600 workers expected to be employed by Ranger in construction activities associated with an output of about 2500 tonnes of uranium (3000 tonnes of U_3O_8) per year would comprise about 1.5 per cent of the Northern Territory's present labour force of about 40 000. Some additional jobs might be created in servicing the construction activities, probably in Darwin, but no detailed evidence is available on which to base estimates of these possibilities.

During Ranger's operations, employment of 250 people for the lower planned output and 400 for the higher output rate would represent additional employment of about 0.6 and 1.0 per cent respectively of the current Territory labour force. It was suggested by the proponents of mining that additional local employment opportunities would be created for about seventy people at the lower rate of output and for about 100 people at the higher rate. If these estimates are correct, employment opportunities created would amount to about 0.8 and 1.25 per cent respectively of the existing labour force.

Higher rates of uranium output would make greater contributions to employment opportunities. If other operations resulted in similar employment opportunities to Ranger's, production of 10 000 tonnes of uranium per year in the Territory would increase employment opportunities, including those associated with local services, to approximately 1000, equal to about 2½ per cent of the present labour force. Total production of 12 500 tonnes uranium per annum would probably raise the number to between 1250 and 1500, equal to about 3 to 4 per cent of the existing work force.

As in the case of employment on construction, these estimates do not include any additional effects occurring indirectly as a result of expenditure on goods and services produced in the Territory or as a result of respending by the recipients of initial income. In the case of respending effects, changes in employment may not be proportional to income effects, since the existing labour force, and the capacity already available, may permit considerable expansion in turnover. Consequently, it is not possible to make any accurate calculations of these effects. However, the size of the estimated income effects, particularly those associated with higher levels of uranium output, suggests that meeting the additional demand for consumer goods, and business and community services, including those provided by governmental authorities, could give rise to very important additions to employment opportunities in the Territory. If these effects eventuated, they could most likely be accompanied by an acceleration in employment opportunities for building and construction work in the areas affected.

Conclusions

There is a great deal of uncertainty about future rates of expansion in world demand for uranium, principally because of the difficulty of projecting future rates of growth of economic activity in most countries and continuing doubts about the extent to which nuclear power will be used to meet future electricity requirements. As shown in the Commission's First Report, both economic and environmental issues will have an important bearing on the final outcome. It is the Commission's view, stated in the First Report, that expansion of the nuclear industry should be restricted, at least until major problems associated with its extended use are satisfactorily resolved.

In this appendix relatively wide ranges of potential revenues and costs were used in an attempt to show the possible variations in the economic and financial implications of the establishment of a major uranium industry in Australia. It cannot be stressed too strongly that the assumptions made do not represent the limits of possible outcomes, and that the Commission is not advocating the industry's expansion in line with any of those assumptions.

However, if the levels of sales, revenues and costs used in this appendix eventuate, the establishment of a large-scale uranium mining industry in Australia will bring very considerable profits to owners of uranium mining ventures, principally because of higher tax revenues which may be used to provide additional governmental services or reduce other taxes to Australians as a whole. Those firms particularly concerned with supplying the industry with its requirements may also receive an important stimulus to their activities.

The industry would probably provide direct employment opportunities for about 2000 to 2500 people. The employment effects associated with construction and operation of the projects could provide an important stimulus to employment opportunities in the Northern Territory, but it seems unlikely that the industry would make a very important contribution to total employment opportunities in a national context. Its expansion therefore seems more likely to raise national income than to substantially increase total employment opportunities in Australia.

The estimates of economic effects flowing to the Northern Territory from the establishment of a substantial uranium industry in the Region indicate that the Territory's economy would be substantially enlarged by this activity. The industry's development could thus provide the stimulus required to achieve a much faster rate of economic growth in the area than would otherwise occur.

However, the possible size of these effects suggests that too fast a rate of expansion may put undesirable pressure on human and physical resources in the Territory. The rate of expansion of the industry needs to be regulated to avoid these effects, as well as to ensure compliance with the environmental objectives recommended in this Report.

APPENDIX VI: ECONOMIC EFFECTS OF DELAYING URANIUM DEVELOPMENT–TABLES

Table M

Estimate of Economic Effects of Delaying Ranger
($Amillion; January 1976 prices)

		Present worth of net national benefits		
	(1)	(2)	(3)	(4)
Year	*Estimated Revenue–Expenditure*	*No Delay*	*Delay of 2 years*	*Delay of 5 years*
1977–78	−13.5	−13.5	–	–
78–79	−32.2	−29.3	–	–
79–80	−49.7	−41.1	−11.2	–
80–81	−25.7	−19.3	−24.2	–
81–82	29.8	20.4	−33.9	–
82–83	69.2	43.0	−16.0	−8.4
83–84	69.6	39.3	16.8	−18.2
84–85	69.3	35.6	35.5	−25.5
85–86	70.3	32.8	32.4	−12.0
86–87	69.2	29.3	29.4	12.6
87–88	72.7	28.0	27.1	26.6
88–89	76.4	26.7	24.2	24.4
89–90	75.0	23.9	23.2	22.1
90–91	73.8	21.4	22.2	20.4
91–92	–	–	19.7	18.2
92–93	–	–	17.6	17.4
93–94	–	–	–	16.7
94–95	–	–	–	14.8
95–96	–	–	–	13.3
Totals	554.2	197.2	162.8	122.4

Present worth of reduced economic benefits–		
2-year delay Col. (2)–(3)	34.4	
5-year delay Col. (2)–(4)		74.8

(1) = First Report, Table 10, Column (4)
(2) = (1) × Present Worth Factor
(3) = (1) advanced two years × Present Worth Factor
(4) = (1) advanced five years × Present Worth Factor

Table N

Estimate of Economic Effects of delaying Development of a Uranium Industry
($Amillion; January 1976 prices)

	Present worth of net national benefits					
	No delay		*Delay 2 years*		*Delay 5 years*	
Year	*Low* (1a)	*High* (1b)	*Low* (2a)	*High* (2b)	*Low* (3a)	*High* (3b)
1977–78	−8	−10	0	0	0	0
78–79	−21	−28	0	0	0	0
79–80	−40	−54	−7	−8	0	0
80–81	−46	−62	−17	−23	0	0
81–82	−27	9	−33	−44	0	0
82–83	−9	67	−38	−52	−5	−6
83–84	5	114	−22	7	−13	−17
84–85	15	153	−8	55	−25	−33
85–86	25	184	4	94	−28	−39
86–87	33	207	13	126	−17	6
87–88	38	225	20	152	−6	42
88–89	42	238	27	171	3	71
89–90	46	247	32	186	10	95
90–91	48	252	35	197	15	114
91–92	52	256	38	204	20	129
92–93	56	261	40	208	24	139
93–94	62	266	43	212	26	148
94–95	63	264	47	216	29	153
95–96	58	240	51	220	30	156
96–97	52	219	52	219	32	160
97–98	48	199	48	199	35	162
98–99	43	180	43	180	38	165
99–2000	39	164	39	164	39	164
2000–2001	–	–	36	149	36	149
01–02	–	–	32	135	32	135
02–03	–	–	–	–	29	123
03–04	–	–	–	–	27	112
04–05	–	–	–	–	24	101
Totals	574	3591	475	2967	355	2229
Reduction in Totals			99	624	219	1362

(1a) = Appendix Table E, Col. (11a).
(1b) = Appendix Table E, Col. (11b).
(2a) = Appendix Table E. Col. (7a). lagged 2 years × Present Worth Factor (PWF)
(2b) = Appendix Table E. Col. (7b). lagged 2 years × PWF
(3a) = Appendix Table E. Col. (7a). lagged 5 years × PWF
(3b) = Appendix Table E. Col. (7b). lagged 5 years × PWF

APPENDIX VII: ABORIGINAL LAND CLAIM AREA

I Exploration Licences, Mining Tenures and Applications

Exploration Licences, Mining Tenures, applications therefor, and Mining Reserves

Type of interest	*Applicant or holder*	*Date applied for (A) or granted (G)*
A. Exploration Licence (E.L.)		
E.L. 158	A. Allan Stewart, P. M. Cameron, J. F. Bowditch, A. J. Young and Wolpers and Law	7.5.72 (G)
E.L. 159	A. Allan Stewart, P. McD. Cameron, F. S. Bowditch and A. J. Young	26.10.71 (A)
E.L. 393, 394 and 395	Estate of G. D. Stevens, C. M. Chomley and P. N. Craven	3.8.72 (G)
E.L. 1402	Goulburn Island Progress Assoc. and Ocean Resources N.L.	13.9.76 (A)
E.L. 1406	A.O.G. Minerals P/L	14.9.76 (A)
B. Mineral Lease (M.L.)		
M.L. 247A	Peko Mines Ltd and Electrolytic Zinc Company of Australasia Ltd	8.1.70 (G)
M.L. 248A	Peko Mines Ltd and Electrolytic Zinc Company of Australasia Ltd	21.2.70 (G)
M.L. 266–275A	Peko Mines Ltd and Electrolytic Zinc Company of Australasia Ltd	25.6.70 (A)
M.L. 276–279A	Peko Mines Ltd and Electrolytic Zinc Company of Australasia Ltd	7.7.70 (A)
M.L. 280A	Peko Mines Ltd and Electrolytic Zinc Company of Australasia Ltd	10.7.70 (A)
M.L. 281–282A	Peko Mines Ltd and Electrolytic Zinc Company of Australasia Ltd	22.7.70 (A)
M.L. 283–285A	Peko Mines Ltd and Electrolytic Zinc Company of Australasia Ltd	27.7.70 (A)
M.L. 286–288A	Peko Mines Ltd and Electrolytic Zinc Company of Australasia Ltd	31.7.70 (A)
M.L. 289–292A	Peko Mines Ltd and Electrolytic Zinc Company of Australasia Ltd	5.8.70 (A)
M.L. 299–300A	Noranda Australia Ltd	9.9.70 (A)
M.L. 302–305A	Noranda Australia Ltd	23.9.70 (A)
M.L. 312A	Geopeko Ltd	7.10.74 (G)
M.L. 314A	Peko Mines Ltd and Electrolytic Zinc Company of Australasia Ltd	12.10.70 (A)
M.L. 316A	Geopeko Ltd	23.10.70 (A)
M.L. 320–322A	Noranda Australia Ltd	30.11.70 (A)
M.L. 332A	G. D. and C. M. Stevens and P. N. Chomley	1.7.71 (A)
M.L. 425A	G. D. and C. M. Stevens and P. N. Chomley	9.9.71 (A)
M.L. 476–478A	Geopeko Ltd	18.6.73 (A)
M.L. 526–532A	Geopeko Ltd	29.11.73 (A)
M.L. 537–542A	Geopeko Ltd	3.12.73 (A)
M.L. 556–561A	Geopeko Ltd	4.12.73 (A)
M.L. 594–598A	Dampier Mining Co. Ltd	17.7.74 (G)
M.L. 643–645A	Peko Mines Ltd and Electrolytic Zinc Company of Australasia Ltd	21.7.75 (A)
M.L. 646–681A	Dampier Mining Co Ltd	29.7.75 (A)
M.L. 776–783A	Dampier Mining Co Ltd	21.6.76 (A)

Type of interest	Applicant or holder	Date applied for (A) or granted (G)
M.L. 794–800A	Dampier Mining Co Ltd	20.9.76 (A)
M.L. 879–886A	Peko Mines Ltd and Electrolytic Zinc Company of Australasia Ltd	22.10.76 (A)
M.L. 899–906A	Peko Mines Ltd and Electrolytic Zinc Company of Australasia Ltd	26.10.76 (A)
C. Special Mineral Lease (S.M.L.)		
S.M.L. 63	Peko Mines Ltd and Electrolytic Zinc Company of Australasia Ltd	19.7.74 (A)
S.M.L. 69	Noranda Australia Ltd	2.9.76 (A)
D. Gold-mining Lease (G.M.L.)		
G.M.L. 99–136A	Noranda Austalia Ltd	22.10.76 (A)
E. Mineral Claim (M.C.)		
M.C. 47–50A	J. N. Crago	7.10.70 (A)
M.C. 51–60A	Jingellic Minerals N.L.	12.10.70 (A)
F. Dredging Claim (D.C.)		
D.C. 17–19A	Geopeko Ltd	11.1.74 (G)
G. Business Area (B.A.)		
B.A. 7A	K. S. and G. J. Hill	21.10.65 (G)
H. Garden Area (G.A.)		
G.A. 27A	W. Alderson	24.7.64 (G)
G.A. 39A	K. S. and G. J. Hill	15.10.66 (G)
I. Residence Lease (R.L.)		
R.L. 4A	Peko Mines Ltd and Electrolytic Zinc Company of Australasia Ltd	24.8.70 (A)
J. Residence Area (R.A.)		
R.A. 11A	W. Alderson	24.7.64 (G)

II Mining Reserves

M.R. 355
M.R. 357
M.R. 374
M.R. 563

APPENDIX VIII: LIST OF ADDITIONAL WITNESSES

Mr L. C. Ah Toy
Mr A. Bishaw
Mr B. Bourne
Prof. S. T. Butler
Mr A. P. Campbell
Mr P. J. Carroll
Mr L. H. Charlebois
Mr P. W. R. Crohn
Mr R. W. Gee
Mr D. L. Grey
Mr W. T. Hare
Mr K. S. Hill
Mr J. W. Lawler
Mr N. G. Mackay
Mr N. McLaren
Mr G. McMahon
Mr O. W. Marshall
Mr V. T. O'Brien
Mrs J. R. Opitz
Prof. J. D. Ovington
Mr J. M. Rames
Mr P. J. Wells

APPENDIX IX: LIST OF EXHIBITS

The following abbreviations are used in this list:

AAEC	Australian Atomic Energy Commission
CSIRO	Commonwealth Scientific and Industrial Research Organisation
IAEA	International Atomic Energy Agency
NUEXCO	Nuclear Exchange Corporation
OECD	Organisation for Economic Co-operation and Development
OECD-IEA	International Energy Agency of the OECD
OECD-NEA	Nuclear Energy Agency of the OECD
UKAEA	United Kingdom Atomic Energy Authority
USAEC	United States Atomic Energy Commission
USERDA	United States Energy Research and Development Administration
USNRC	United States Nuclear Regulatory Commission

1. General conditions of contract, Ranger Uranium Mines Pty Ltd. Annexure I: *Instructions for environmental protection at Jabiru.*
2. General conditions of contract, Ranger Uranium Mines Pty Ltd. Annexure H: *Safety regulations to be observed by contractors and employees for construction work at Ranger mine site, Jabiru, N.T.*
3. Ranger Uranium Mines Pty Ltd. *Environmental Impact Statement*, February 1974, and *Supplements No. 1 and No. 2*, May 1975.
4. Davy, D. R. 1975. Tables 1–17 of *An assessment of the water management program proposed in the Ranger EIS and its environmental implications.* Evidence presented to the Ranger Uranium Environmental Inquiry.
5. Australian Department of Health. 1975. *Code of practice on radiation protection in the mining and milling of radioactive ores.* Canberra.
6. National Health and Medical Research Council—75th Session, November 1972: Appendix: *National emission standards for air pollutants.*
7. National Health and Medical Research Council. 1975. *Atmospheric contaminants.* AGPS, Canberra.
8. Holy, Z. J. 1975. *The environmental impact of nuclear power.* Environment '75 Conference, Sydney.
9. Two photographs of Magela Creek in flood, taken near Jabiluka, March 1973, by G. Chaloupka
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APPENDIX X: PRINCIPAL FINDINGS AND RECOMMENDATIONS OF THE FIRST REPORT

These findings and recommendations are to be read and understood in the context of the Report as a whole and with particular reference to the sections of the Report in which they are respectively discussed.

1. The hazards of mining and milling uranium, if those activities are properly regulated and controlled, are not such as to justify a decision not to develop Australian uranium mines.
2. The hazards involved in the ordinary operations of nuclear power reactors, if those operations are properly regulated and controlled, are not such as to justify a decision not to mine and sell Australian uranium.
3. The nuclear power industry is unintentionally contributing to an increased risk of nuclear war. This is the most serious hazard associated with the industry. Complete evaluation of the extent of the risk and assessment of what course should be followed to reduce it involve matters of national security and international relations which are beyond the ambit of the Inquiry. We suggest that the questions involved are of such importance that they be resolved by Parliament. In Chapters 15 and 16 we have gone as far as the terms of reference and the evidence permit in examining the courses open and in making suggestions.
4. Any development of Australian uranium mines should be strictly regulated and controlled, for the purposes mentioned in Chapter 16.
5. Any decision about mining for uranium in the Northern Territory should be postponed until the Second Report of this Commission is presented.
6. A decision to mine and sell uranium should not be made unless the Commonwealth Government ensures that the Commonwealth can at any time, on the basis of considerations of the nature discussed in this Report, immediately terminate those activities, permanently, indefinitely or for a specified period.
7. Policy respecting Australian uranium exports, for the time being at least, should be based on a full recognition of the hazards, dangers and problems of and associated with the production of nuclear energy, and should therefore seek to limit or restrict expansion of that production.
8. No sales of Australian uranium should take place to any country not party to the NPT. Export should be subject to the fullest and most effective safeguards agreements, and be supported by fully adequate back-up agreements applying to the entire civil nuclear industry in the country supplied. Australia should work towards the adoption of this policy by other suppliers.
9. A permanent Uranium Advisory Council, to include adequate representation of the people, should be established immediately to advise the Government, but with a duty also to report at least annually to the Parliament, with regard to the export and use of Australian

uranium, having in mind in particular the hazards, dangers and problems of and associated with the production of nuclear energy.

10. The Government should immediately explore what steps it can take to assist in reducing the hazards, dangers and problems of and associated with the production of nuclear energy.
11. Policy with regard to the export of uranium should be the subject of regular review.
12. A national energy policy should be developed and reviewed regularly.
13. Steps should be taken immediately to institute full and energetic programs of research and development into (a) liquid fuels to replace petroleum and (b) energy sources other than fossil fuels and nuclear fission.
14. A program of energy conservation should be instituted nationally.
15. The policy of the Government should take into account the importance to Australia, and the countries of the world, of the position of developing countries concerning energy needs and resources.

Our *final recommendation* takes account of what we understand to be the policy of the Act under which the Inquiry was instituted. It is simply that there should be ample time for public consideration of this Report, and for debate upon it. We therefore recommend that no decision be taken in relation to the foregoing matters until a reasonable time has elapsed and there has been an opportunity for the usual democratic processes to function, including, in this respect, parliamentary debate.

APPENDIX XI: LEGAL REPRESENTATIVES

Ranger Uranium Mines Pty Ltd:
- Mr D. F. Rofe, Q.C., and
- Mr T. Naughton, instructed by Messrs Minter Simpson and Co., Solicitors, Sydney
- Mr L. Brown of Messrs Minter Simpson and Co.
- Mr J. Heath, Senior Legal Officer, Electrolytic Zinc Company of Australasia Ltd

Australian Atomic Energy Commission:
- Mr D. M. J. Bennett, instructed by the Commonwealth Crown Solicitor

Australian Conservation Foundation:
- Mr E. H. St John, Q.C., and
- Mr R. Tonner, instructed by Messrs F. J. Church and Grace, Solicitors, Sydney

Pancontinental Mining Ltd:
- Mr J. T. Hiatt, Q.C.,
- Mr M. H. McLelland, Q.C., and
- Mr D. H. Lloyd, instructed by Messrs Perkins, Stevenson and Linton, Solicitors, Sydney

Conservation Council of South Australia, Inc.:
- Mr R. Millhouse, instructed by the Australian Legal Aid Office

Northern Pastoral Services Ltd:
- Mr D. G. McGregor, Q.C., and
- Mr R. B. Murphy, instructed by Messrs Freehill, Hollingdale and Page, Solicitors, Sydney
- Miss D. Truss of Messrs Freehill, Hollingdale and Page
- Mr C. McPhillamy of Messrs Freehill, Hollingdale and Page

Friends of the Earth:
- Mr G. D. Woods, instructed by Messrs G. D. Campbell and Co., Solicitors, Sydney

Northern Land Council:
- Mr E. C. E. Pratt, instructed by Mr S. McGill, Legal Officer with the Northern Land Council
- Mr H. Bradley of Ward Keller, Barristers and Solicitors, Darwin

Oenpelli Council:
- Mr E. C. E. Pratt

The Commonwealth of Australia:
- Mr R. V. Gyles, Q.C, and
- Mr D. M. J. Bennett, instructed by the Commonwealth Crown Solicitor

Australian Uranium Producers Forum:
- Mr D. G. Williamson, Q.C., instructed by Paveys, Solicitors, Melbourne

Professor S. T. Butler:
Mr T. R. H. Cole Q.C., and
Mr J. Amor-Smith, instructed by Messrs Murphy and Moloney, Solicitors, Sydney

Dampier Mining Company Limited:
Mr H. Nathan, instructed by Mr G. J. Skene, Solicitor for Dampier Mining Company Limited

Groote Eylandt Mining Company Pty Ltd:
Mr P. G. Willis, Solicitor for Groote Eylandt Mining Company Pty Ltd

K. S. and G. J. Hill:
Mr D. Mildren of Mildren and Partners, Barristers and Solicitors, Darwin

Noranda Australia Limited:
Mr E. D. Lloyd, Q.C., and
Mr J. George, instructed by Messrs Weigall and Crowther, Solicitors, Melbourne

Opitz 'Cooinda' Enterprises Pty Ltd:
Mr D. Mildren of Mildren and Partners, Barristers and Solicitors, Darwin

Roper Bar Trading Pty Ltd:
Mr T. F. Coulehan of Cridland and Bauer, Barristers and Solicitors, Darwin

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