THE RUM JUNGLE REHABILITATION PROJECT

FINAL PROJECT REPORT



NORTHERN TERRITORY DEPARTMENT OF MINES AND ENERGY

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FINAL PROJECT REPORT

Darwin
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Prepared by :
Northern Territory Department of Mines and Energy for
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Cover: View looking north-east across Rum Jungle Mine Site showing the extent of rehabilitation in May 1986. In the foreground are Intermediate Open Cut and Intermediate Overburden Heap. Whites Open Cut is in the centre of rehabilitated areas; Copper Heap Leach Pile area in front, area of Whites North Heap to the right, Old Tailings Dam area to the left, and Treatment and Stockpile areas to the rear. Dysons Open Cut and Dysons Overburden Heap are visible to the right in the background.

ABSTRACT

The Rum Jungle Rehabilitation Project which was carried out over a four year period commencing in July 1982 was a Commonwealth funded project managed by the Northern Territory Government. The Project was aimed at substantially reducing the adverse environmental effects of the mining and milling of uranium and other metals at Rum Jungle between 1952 and 1971. The Project was, with the exception of some minor works and the ongoing monitoring and maintenance programme, completed in June 1986.

The rehabilitation programme is expected to be completed within the escalated budget of $16.2 (in 1982 values).

The monitoring programme, established as an integral part of the Project, has demonstrated the effectiveness of the rehabilitation measures implemented during the programme. It has provided positive evidence of reductions in the heavy metal burden being carried by the East Branch of the Finniss River, thus confirming a reduction in the pollution from the Rum Jungle mine site.

The Rum Jungle Rehabilitation Project is an example of the successful application of mine rehabilitation techniques, and of the successful cooperation between the Commonwealth and Northern Territory Governments.

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T J VERHOEVEN
Editor

1.1 Summary

The Rum Jungle Rehabilitation Project was funded by the Commonwealth Government and managed by the Northern Territory Government. This was done under an Agreement signed by the two Governments on 4 March 1983. The Agreement identified the objectives of the rehabilitation programme, the scope of measures to be adopted, the timeframe, and the administrative arrangements for the execution of the programme.

The Project was undertaken following studies carried out by the Commonwealth Government aimed at identifying the causes and extent of the environmental pollution that resulted from the mining and treatment of uranium and other metals at Rum Jungle, and at identifying an appropriate rehabilitation strategy to reduce this pollution. A plan of the site prior to rehabilitation is shown in Figure 1.1.

The objectives of the rehabilitation programme established in the Agreement (Sub-clause 7.2) were to achieve:

(a) major reduction in pollution in water courses feeding the East Branch of the Finniss River and in particular the reduction of the average annual releases of copper, zinc and manganese into the river by 70%, 70% and 56% respectively, as measured at the junction of the river with the Finniss River;

(b) reduction in public health hazards and in particular reduction of radiation levels at the site at least to the standards set out in the Code of Practice on Radiation Protection in the Mining and Milling of Radioactive Ores published by the Australian Government Publishing Service (Reference 15);

(c) reduction of pollution contained in the open pits known as Whites and Intermediate; and,

(d) aesthetic improvements including revegetation.

The following major works were completed under the Project, which was carried out over a four year programme starting in 1982 (see Figure 1.2).

1. The rehabilitation of Whites, Whites North, Intermediate and Dysons Overburden Heaps.

2. The treatment of the water contained in Whites and Intermediate Open Cut pits.

3. The removal of the tailings contained in the Old Tailings Dam to Dysons Open Cut and the rehabilitation of the area previously occupied by the tailings.

4. The removal of the low grade copper ore from the Copper Heap Leach Pile to Dysons Open Cut, and the rehabilitation of the Copper Heap Leach Pile area.

5. The rehabilitation of the Treatment Plant and Stockpile areas.

6. The partial rediversion of the East Branch of the Finniss River and the removal of the Acid and Sweetwater Dams.

An environmental monitoring programme was established as an integral part of the Project, aimed at, amongst other things, establishing the extent to which the rehabilitation programme achieved the stated objectives.

1.2 Conclusions

1.2.1 Whilst the monitoring programme will continue until 1988, analysis of the results to date show that the rehabilitation programme has been successful in reducing the levels of heavy metal pollution released from the Rum Jungle mine site, and that the objectives as set out in the Agreement will be achieved.

1.2.2 As at June 1986, the total expenditure on the Rum Jungle Rehabilitation Project was $18.6 million dollars and, after making due allowance for the programmed monitoring and maintenance for the period up until June 1988, it is expected that the Project will be completed within the Commonwealth Government's commitment to fund the Project.

1.2.3 It is important to emphasise that the rehabilitation works were never expected to eliminate all of the pollution sources. Minor sources of pollution will remain but the effect will be very small by comparison with that prior to rehabilitation.

1.3 Recommendations

A number of conclusions drawn from the Project warrant consideration as recommendations.

1.3.1 The long term effectiveness of the rehabilitation measures depends on the integrity of the rehabilitation works. While these works have been designed to withstand the impact of animals and a wide range of weather conditions, their integrity could be compromised as a result of some human activities or of very unusual weather conditions. It is therefore recommended that the following management measures be implemented:

(i) Permanent habitation should not be allowed on the Rum Jungle Mine Site.

(ii) The mine site should be declared a "Restricted Use Area" under the provisions of the Soil Conservation and Land Utilisation Act 1978, and all activities carried out on site should be closely supervised.

(iii) The integrity of the rehabilitation measures should be safeguarded by the implementation of a management programme. Up to June 1988, this programme is to be funded by the Commonwealth and carried out by the Northern Territory. Details beyond June 1988 are still to be agreed to by both Governments.

1.3.2 The environmental response to the rehabilitation of the Rum Jungle mine site has predictably been relatively slow, due to the amount of pollution accumulated within the environment. Additionally, although trends have been established and the rehabilitation objectives achieved, the site remains disturbed, in environmental terms. It is therefore recommended that the monitoring programme continue for a period of two years to 1988, as provided for in the Agreement, to enable the longer term effects of the programme to be established.

1.3.3 In order to safeguard the water resource of the Finniss River system, it is recommended that monitoring of the Finniss River and the East Branch of the Finniss River be continued at a level to quantify trends in changes in water quality. This should be reviewed in mid 1988.

1.3.4 For similar reasons, it is recommended that monitoring of the water contained in the open cut pits should be continued on a regular basis to 1988. The need for monitoring beyond 1988 is then to be reviewed.

1.3.5 The following additional surveys should be carried out five years after the completion of the approved monitoring programme, or after a time when the water monitoring programme shows there to be little change in water quality:

(i) East Branch and Finniss River flora and fauna survey.

In order to establish the effects of the rehabilitation programme on the flora and fauna of the Finniss River system, the survey reported by the Australian Atomic Energy Commission (Reference 64) should be repeated, and the results compared with the pre-rehabilitation survey.

(ii) East Branch and Finniss River radiation survey.

In order to confirm the long term radiological safety of the Finniss River system, and to establish the effects of the rehabilitation programme, the radiological survey reported by the Australian Atomic Energy Commission (Reference 64) should be repeated. At the same time, a complete radiological survey should be carried out over the Rum Jungle mine site.

1.3.6 One of the aspects of the maintenance programme which has received considerable attention, but is not yet fully understood, is the effect of tree growth on the rehabilitated surfaces. It is recommended that this be further investigated, as part of the monitoring programme to 1988, in particular with respect to the following aspects.

(i) The extent of and effect of root penetration into the cover system from the various tree and shrub species native to the Rum Jungle area.

(ii) The role of trees in the establishment of a permanent vegetative cover system, in particular the role of native species.

(iii) The extent of and effect of root penetration into the cover system from the various pasture grass species used in revegetation at Rum Jungle.

1.3.7 It is recommended that the settlement of the fill in Dysons Open Cut should continue to be monitored as part of the programme of work to 1988.

1.3.8 It is recommended that chemical activity and rainfall infiltration rates in Whites and Intermediate Overburden Heaps should continue to be monitored by the Australian Atomic Energy Commission until long term trends have been established.

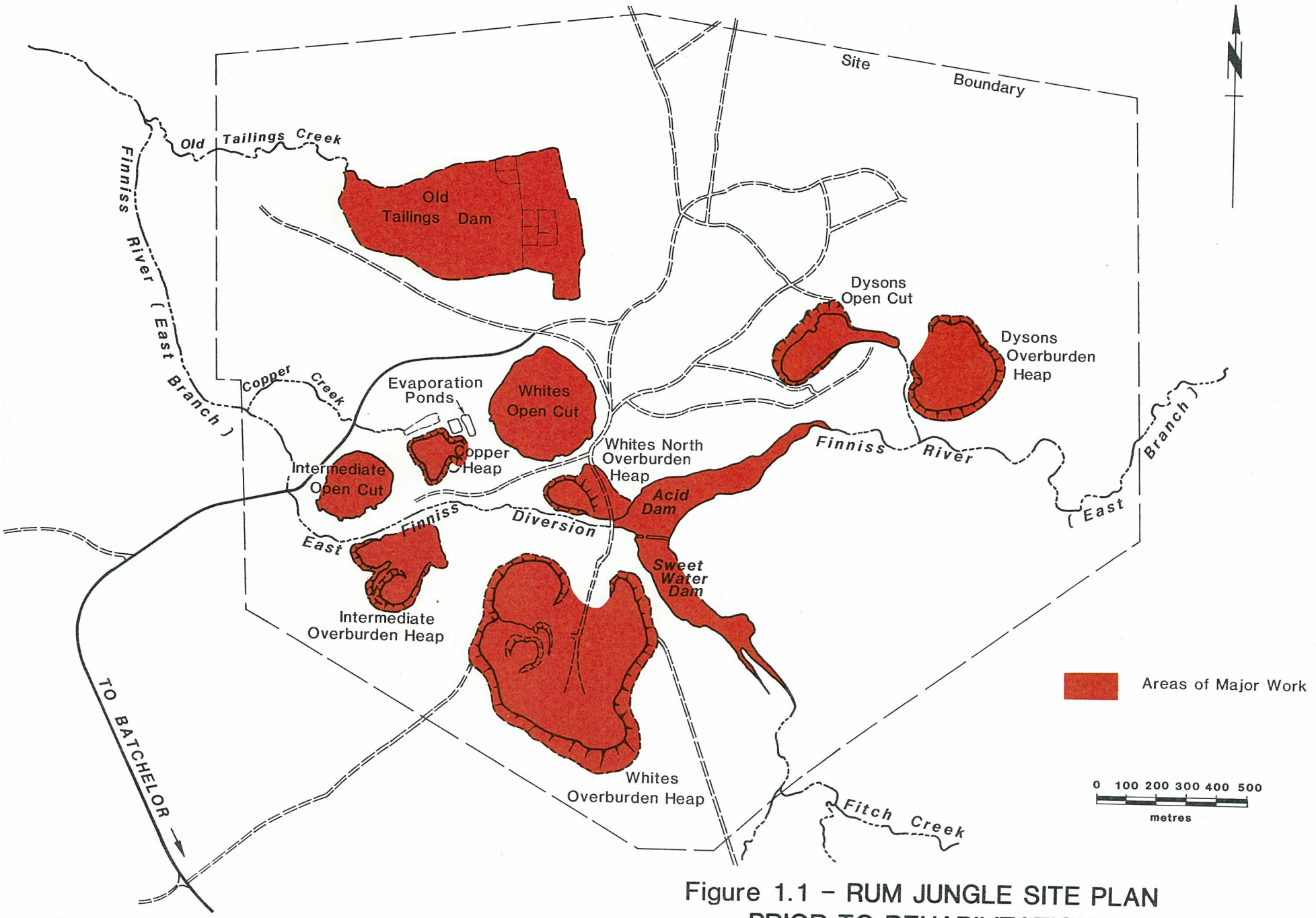


Figure 1.1 – RUM JUNGLE SITE PLAN PRIOR TO REHABILITATION

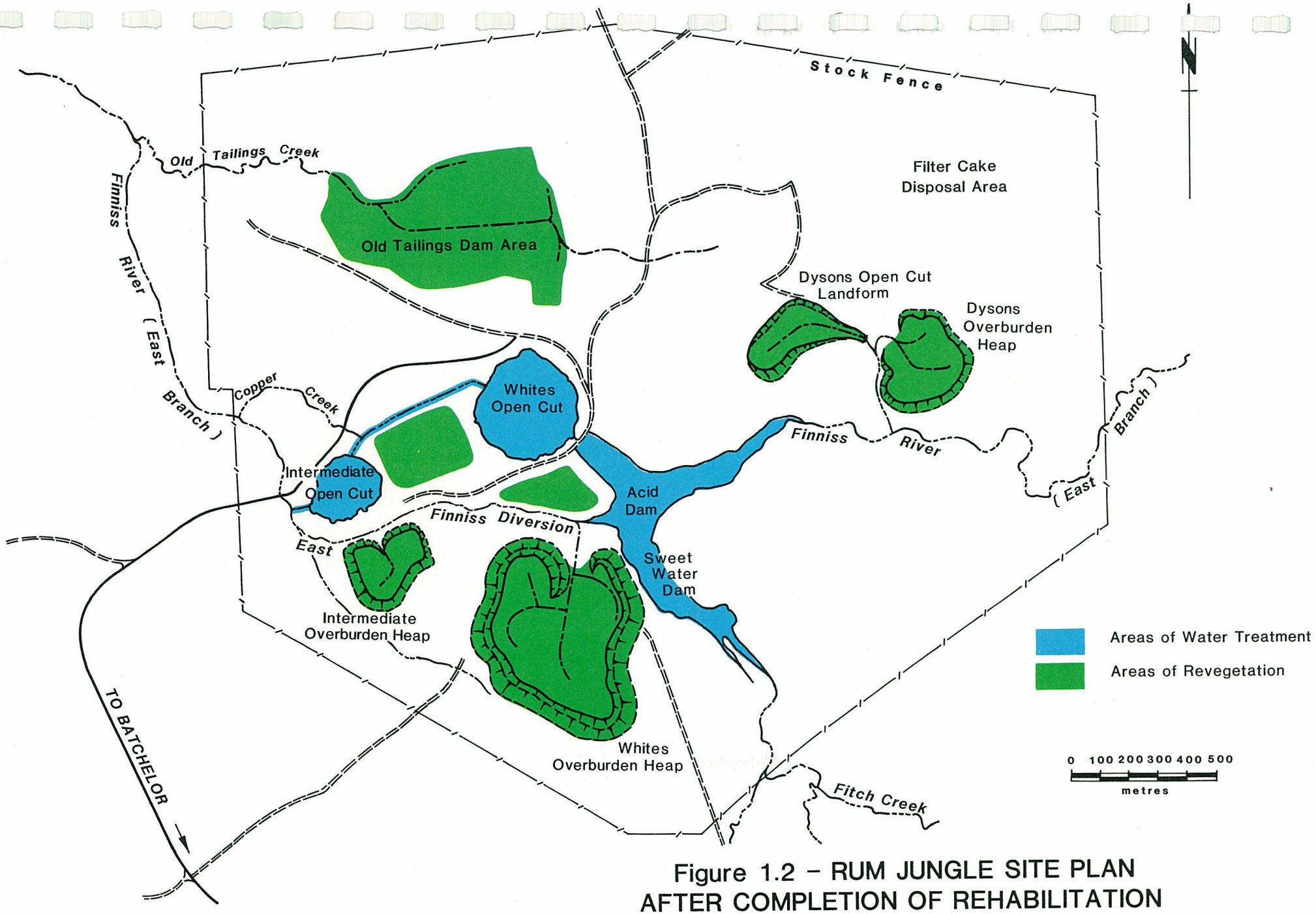


Figure 1.2 – RUM JUNGLE SITE PLAN
AFTER COMPLETION OF REHABILITATION

2. INTRODUCTION

The Rum Jungle Rehabilitation Project was a Federally financed programme, managed by the Northern Territory Government, aimed at reducing the environmental pollution that resulted from mining and processing activities at the now abandoned Rum Jungle mine site.

The Rum Jungle mine site is located approximately 65 kilometres south of Darwin, in the "Top End" of the Northern Territory. The mine is located on the East Branch of the Finniss River, an important tributary of the Finniss River system (see Figure 2.1).

The presence of uranium mineralisation was first noted around the beginning of this century and a uranium deposit was reported in the Rum Jungle area in 1949 by a local land owner, Mr J White. Subsequent exploration defined what proved to be at the time, the largest uranium orebody in Australia. In 1953, Consolidated Zinc Pty Ltd (now known as CRA Pty Ltd) set up a company called Territory Enterprises Pty Ltd (TEP) to manage the development and operation of the Rum Jungle uranium project as an agent of the Commonwealth Government. The production of uranium oxide commenced in 1954 (mine development and plant construction having commenced in 1952) and continued until the mine was closed in 1971. During that period the mine produced approximately 3,5ØØ tonnes of uranium (as uranium oxide) and, in addition, some 2Ø,ØØØ tonnes of copper concentrate.

Ore for treatment at Rum Jungle was extracted principally from five open cut mines, Whites Open Cut, Dysons Open Cut, Intermediate Open Cut (copper only), Rum Jungle Creek South Open Cut and Mount Burton Open Cut. The latter two mines were at some distance from the treatment site. They were judged as not being significant contributors to the environmental pollution of the Finniss River system and hence were not included in the rehabilitation project.

Towards the end of the life of the mining operation the Australian Atomic Energy Commission undertook a series of studies aimed at identifying the extent and degree of environmental damage and the likely sources of the pollution (Reference 64). This study was also intended to identify a rehabilition strategy for Rum Jungle, but due to time constraints and the intervention of Cyclone Tracy this phase of the study was never completed.

The Atomic Energy Commission's report (Reference 64) identified the principal sources of pollution and their effects as:

The Overburden Heaps

The three overburden heaps known as Whites, Intermediate and Dysons were oxidising, both chemically and bacteriologically, producing acid mine drainage which contained heavy metals and acid. This acid mine drainage was entering the environment of Rum Jungle through the surface water and the groundwater systems and was contributing significantly to the overall pollution levels in the Finniss River system.

The Open Cut Pits

Whites and Intermediate Open Cut pits had filled with water which became polluted with heavy metals and acid to the extent that the pH of the water in the pits had been lowered to approximately 2.4 and 3.5 respectively. This polluted water was entering the environment via seepage to groundwater. As with the overburden heaps, this contributed to the pollution levels in the Finniss River system and was hazardous to public health. Both Whites and Dysons Open Cuts had been used as tailings disposal sites during the operating life of the mine.

The Old Tailings Dam

Some of the waste from the ore treatment process was discharged unneutralised into the area known as the Old Tailings Dam. These wastes were acidic, contained heavy metals and were a low level source of radioactivity. Wind and rain eroded these tailings and dispersed them to the environment with the result that an estimated 150,000 tonnes had entered the river system, further contributing to the overall pollutant load.

The Copper Heap Leach Pile

The Copper Heap Leach Pile was constructed from low grade copper ore from Intermediate Open Cut in an experiment to extract copper by heap leaching with acid. The experiment was largely unsuccessful and it has been estimated that, at the end of the mine life, some 3,500 tonnes of copper remained in the heap (Refernce 64). The copper ore continued to oxidise and had released significant amounts of heavy metal and acid to the environment.

The overall effect on the environment of pollution from these sources was the depletion of aquatic flora and fauna from the East Branch of the Finniss River, the denuding of various areas of the site, and the public health hazards associated with the tailings dam and the open cut pits. Estimates of the time for the environment to naturally recover from the effects ranged from 100 to 1,000 years.

In 1977 the Commonwealth Government carried out an initial cleanup at the mine-site. This was confined to the removal of most of the debris remaining from the mining and milling activities. This action, aimed at improving the safety of

the site, was never intended to address the environmental problems remaining from the mining and treatment activities.

In 1977, the Commonwealth Government set up a Working Group of interested parties, convened by the Department of the Northern Territory to enquire into alternative measures and to identify an appropriate strategy for the rehabilitation of the Rum Jungle mine site. Reporting in 1978, the Working Group recommended a range of rehabilitation strategies from which the Commonwealth Government endorsed the following actions:

Old Tailings Dam
- cover and establish vegetation

Dysons Open Cut
- cover tailings and establish vegetation

Acid and Sweetwater Dams, Water Courses etc.
- clear, grade streams and revegetate

Intermediate Open Cut
- treat water and divert East Finniss River through open cut

Heap Leach
- dump into Whites Open Cut, cover with Dysons overburden

Overburden Heaps
- landscape, cover and establish vegetation

Whites Open Cut
- partly refill, treat water

Fence Site

Implementation of this endorsed strategy was estimated in 198Ø to cost approximately twelve million dollars (198Ø values, Reference 66) over a four year programme and was expected to achieve the following:

. Aesthetic rehabilitation of the area by landscaping and the establishment of permanent vegetation;

. Reduce or eliminate public health and safety risks; and

. Reduce continuing pollution originating from the site.

In March 1981, the Commonwealth Government accepted an offer from the Northern Territory to carry out the rehabilitation work on its behalf, and the strategy was further developed. In 1982, the Northern Territory Government presented the "Final Engineering Report", containing the results of investigations and preliminary designs for the works outlined in the above strategy as well as a detailed programme for implementation of the rehabilitation project. The Commonwealth and Northern Territory Governments subsequently agreed that the Northern Territory was to manage the implementation of the Rum Jungle Rehabilitation Project with the financial assistance of the Commonwealth.

The administrative arrangements between the Commonwealth and the Northern Territory were formalised on 4 March 1983 when respective Ministers signed a Memorandum of Agreement

for the purpose of rehabilitating the Rum Jungle Mine Site (Reference 125).

This report details the implementation phase of the Project, from the initial studies by the Working Group to the assessment, on the information currently available, of the extent to which;

(i) the Measures To Be Adopted, as defined in the Agreement, have been completed; and,

(ii) the objectives of the rehabilitation works as set out in the Agreement have been met.

This report also contains recommendations on the future maintenance and management requirements of the site including land use limitations.

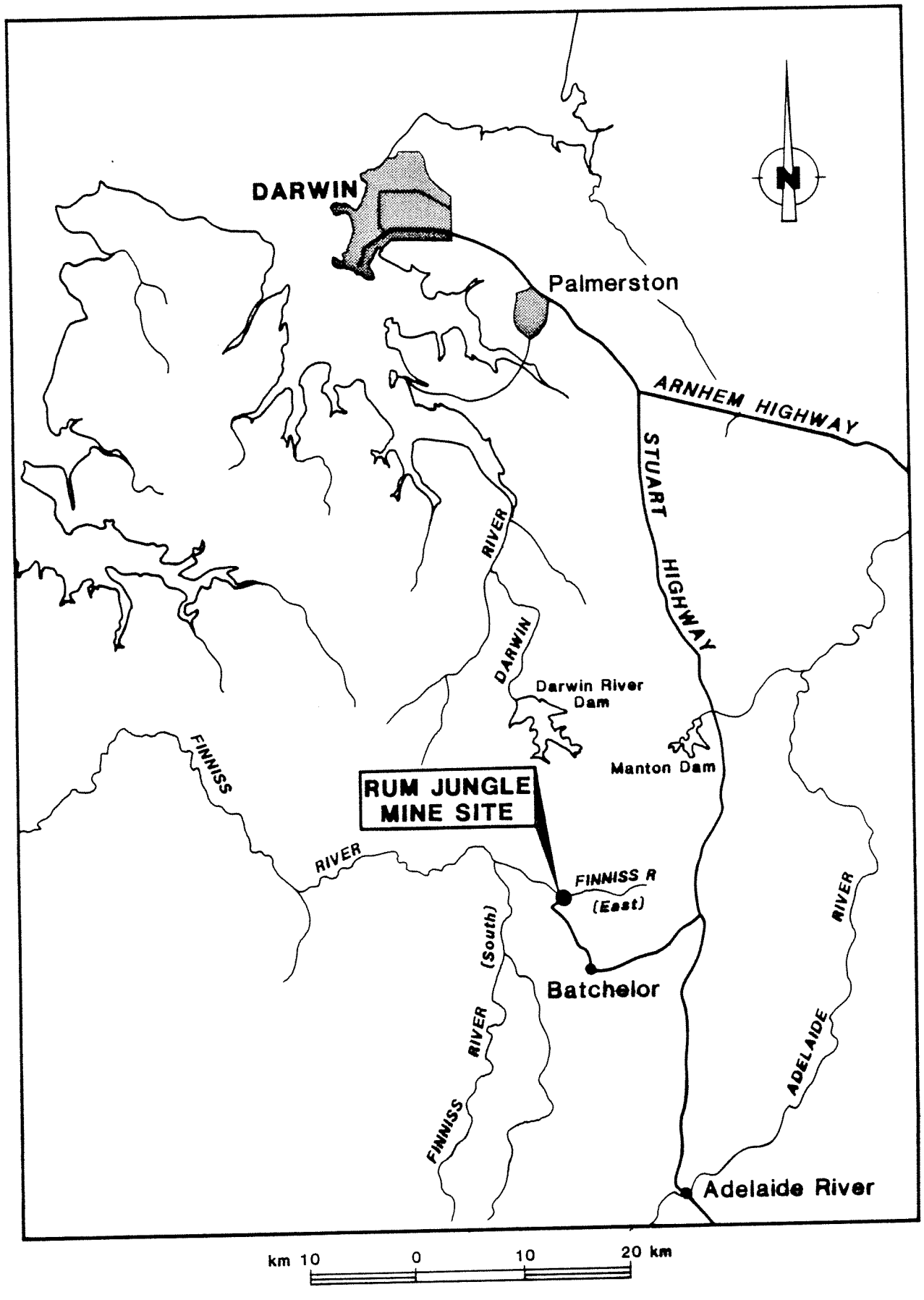
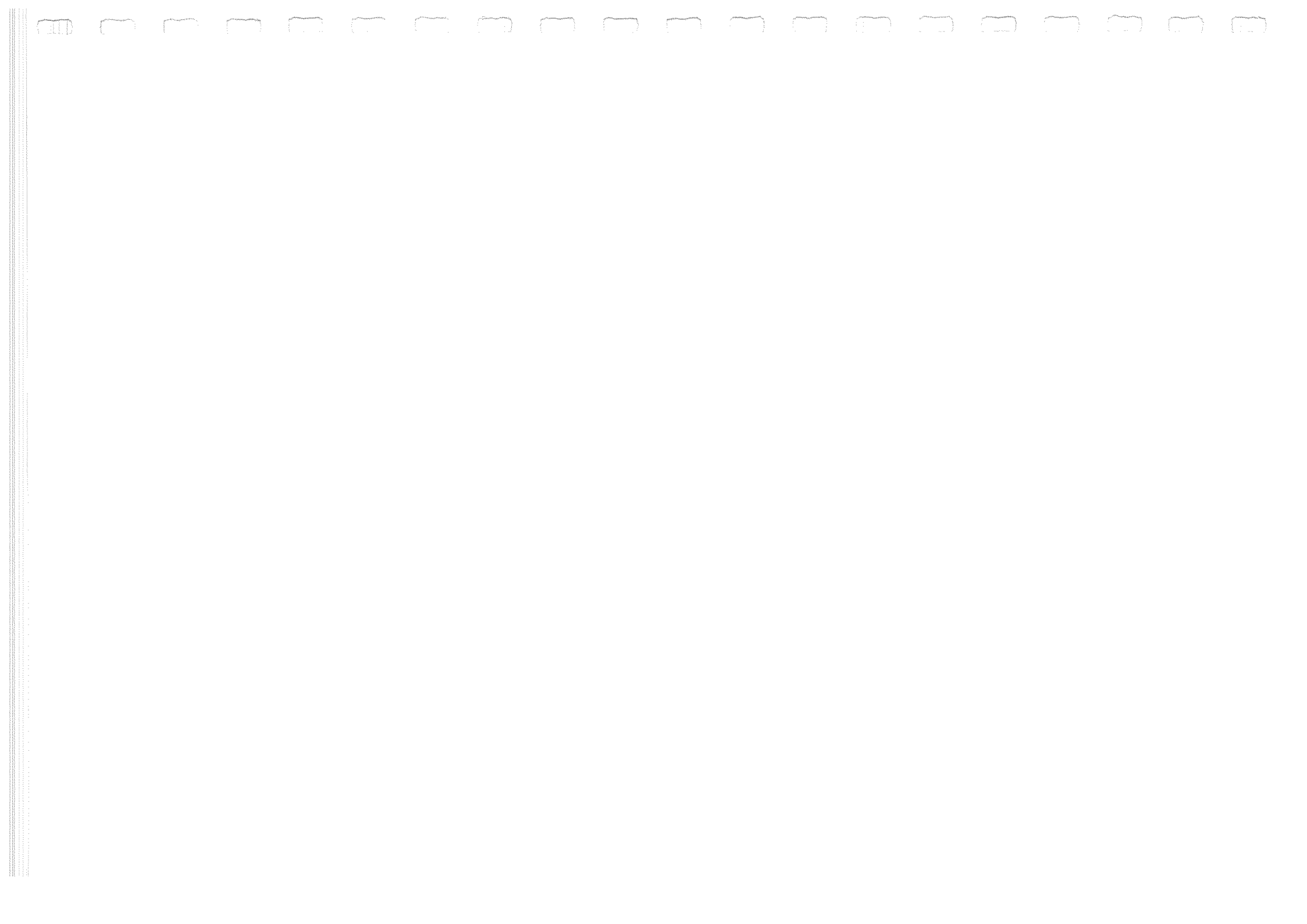


Figure 2.1 – LOCATION OF RUM JUNGLE MINE SITE



Subsequent to the publication of the report "Rum Jungle Environmental Studies" by the Australian Atomic Energy Commission in 1975 (Reference 64), there were three further investigations carried out into the rehabilitation of Rum Jungle. The first, reporting in April 1978 and carried out by a Working Group convened by the Department of the Northern Territory, reported on an examination of the alternative rehabilitation measures (Reference 67). The second entailed development of the engineering strategies, indicative costs, and implementation proposals for selected options by the Department of Housing and Construction (Reference 66). From these studies a preferred option was recommended and adopted by the Comonwealth Government. The third investigation, undertaken by the Northern Territory Department of Transport and Works (Reference 119), was a preliminary study of the particular engineering aspects of the strategy endorsed by the Commonwealth Government. The first and third studies are now described in more detail

3.1 The Report of the Working Group

In an announcement to Federal Parliament concerning the development of Australia's uranium resources on 25 August 1977, the then Deputy Prime Minister stated that "The Department of the Northern Territory will co-ordinate a study of a comprehensive programme of rehabilitation of the whole area" - the area being the Rum Jungle mine area and the pollution which had resulted from the mining and treatment operations.

Following this announcement the Department of the Northern Territory convened a Working Group of interested parties whose terms of reference were to examine alternative rehabilitation measures, including their costs and important factors relevant to a further rehabilitation programme.

The Working Group identified the sources and extent of pollution at Rum Jungle, as summarised in Tables 3.1 and 3.2.

Table 3.1

AREAS OF POLLUTION

Site	Area (ha)	Percentage of total area
Open Cuts	22	11%
Overburden Heaps	51	25%
Seepage from Heaps	12	6%
Old Tailings Dam	31	15%
Plant and Stockpile Area	45	22%
Riverbed and Banks	43	21%
TOTAL	204	100%

Table 3.2

SOURCES OF POLLUTION (1973/74 WET SEASON)

Source	Annual Release (%)		
	Cu	Mn	Zn
Whites Heap	32	16	55
Heap Leach Pile	32	-	-
Intermediate Heap	18	5	44
Whites Open Cut	8	40	-
Old Tailings Dam	5	6	-
Acid Dam	-	17	-
Dysons Open Cut	1	4	-
Dysons Heap	0.2	7	-
Intermediate Open Cut	3	4	1

The environmental problems at Rum Jungle were evaluated and a set of objectives by which alternative rehabilitation strategies could be compared was developed. The specific objectives formulated by the Working Group were:

(1) The mine area should be landscaped and treated for the establishment of a permanent vegetation cover, especially native plants, in order to merge it back into the local environment.

(2) Hazards to public health and safety in the area should be eliminated.

(3) Continuing pollution originating from the sources in the mine area should be reduced.

(4) Solutions should be permanent and maintenance should be minimal after the initial establishment period (e.g. vegetation establishment), unless follow-up monitoring determines an essential requirement.

(5) Solutions should be capable of achieving a high standard of rehabilitation and pollution control.

(6) Solutions should be cost effective having due regard to the above principal objectives.

(7) Solutions involving the removal or disposal of wastes or waste heaps are not to be adopted on an "out of site - out of mind" philosophy unless it is safe and beneficial to do so in accordance with objectives (2), (3) and (4).

(8) Having regard to the impending establishment of new uranium mines in the Alligator Rivers province, which will be subject to stringent environmental standards, the site should be rehabilitated to a degree consistent with the need to demonstrate that a high standard of environmental rehabilitation can be achieved in a monsoonal climate.

(9) Any proposed works to achieve rehabilitation should :

- be capable of immediate planning, design and execution, and allow subsequent stages of the project to be capable of being followed immediately;
- not be held up or delayed pending research or other than essential, short term immediate investigations; and finally,
- provide for essential field trials and pilot scale tests to be initiated immediately to avoid delaying implementation of ensuing stages of rehabilitation works.

In addition to describing the various environmental problems at Rum Jungle, the Working Group developed a range of possible rehabilitation measures based on the identified objectives of the proposed programme and seen as appropriate to the various problems identified on the site. The Working Group also developed estimates of the cost of these rehabilitation measures as well as the anticipated benefits of the proposed strategies.

3.1.1 The Rehabilitation Measures Considered by the Working Group

The various rehabilitation measures identified by the Working Group together with conclusions relating to them are outlined below.

1. The Heap Leach Pile and Area

The measures considered for the rehabilitation of the Heap Leach Pile and the associated polluted area around the pile were:

(i) recommission the heap leaching operation and remove the remaining copper from the heap -

regarded as not a viable proposition and disregarded;

(ii) transport the heap to a copper smelter - the heap contained only low grade ore, and the nearest copper smelter, at Tennant Creek, was closed down. This solution was disregarded;

(iii) seal the heap with an artificial membrane - disregarded on the basis that, given the harsh climatic conditions, the seal would break down in the long term and require considerable maintenance;

(iv) revegetation of the heap in situ - recontouring, drainage, covering and revegetation of the heap was regarded as a possible alternative rehabilitation strategy for the pile;

(v) removal of the heap to an open cut pit - the solution preferred by the Working Group and regarded as a permanent and viable solution which would enable the revegetation of the area previously occupied by the heap; and,

(vi) burial - not considered to be cost effective.

2. The Overburden Heaps

The overburden heaps were regarded together as the most serious source of pollution on the site, and the measures considered for their rehabilitation were:

(i) establishment of vegetation using simple techniques - would provide visual rehabilitation of the heaps but was not considered sufficient to reduce the infiltration of rainwater into the heaps and thus the generation and transport of the contaminants. Also the surface may be inhospitable to plant growth;

(ii) seal with clay, cover with rock and topsoil and establish vegetation - regarded as a viable rehabilitation strategy;

(iii) removal of the overburden to open cuts and revegetation of the areas occupied by the heaps - regarded as an alternative option for two of the overburden heaps; and,

(iv) collection and evaporation of seepage from the overburden heaps - not regarded as a permanent solution due to the requirement for permanent operation.

3. The Open Cuts

The rehabilitation measures for the three open cut pits were considered separately due to the varying extent of the pollution of the pits:

(a) Whites Open Cut

Whites Open Cut was the most seriously polluted open cut on the site and the alternative measures considered were:

(i) grout the aquifers around the open cut and reduce the possible flow of polluted groundwater from or into the open cut - not considered further because of the extremely low level of confidence in the likely achievement of objectives;

(ii) treat the water and re-open the open cut to the East Branch of the Finniss River - regarded as a possible solution although of uncertain effectiveness at that time; and,

(iii) treat the water and refill with waste rock - three options were considered under this scheme. Firstly seal active zones within the open cut and open the pit to the East Branch of the Finniss River. Secondly, dispose of waste rock from Intermediate Heap into the pit, in addition to the first option. Thirdly, completely refill the pit. All of which were considered viable options.

(b) Intermediate Open Cut
Options considered were:

(i) treat the water and divert the East Branch of the Finniss River through the open cut - regarded as a viable solution;

(ii) treat the water and refill the pit with waste rock - regarded as a practical solution; and,

(iii) use the pit as an environmental research model - regarded as a short term solution as rehabilitation would eventually be required.

(c) Dysons Open Cut
The only rehabilitation option considered for Dysons Open Cut was to improve drainage and revegetate.

4. The Old Tailings Dam

In addition to being a low level source of poorly contained radioactive waste the Tailings Dam contained heavy metals and acid. The rehabilitation measures considered by the Working Group were:

(i) remove the tailings to an open cut and revegetate the site - regarded as a feasible alternative providing satisfactory rehabilitation; and,

(ii) establish vegetation on the tailings in situ - whilst recognising the potential problems, the Working Group regarded this as a viable solution.

5. Acid and Sweetwater Dam Areas, Water Courses and Areas Affected by Seepage

The strategy considered by the Working Group for the rehabilitation of these areas was:

(i) clear obstructions from the river beds and form an even longitudinal grade;
(ii) remove dead trees; and,
(iii) cultivate, recontour the area and revegetate.

3.1.2 The Strategy

The Working Group reported in April 1978 (Reference 67).

From the above rehabilitation proposals for the various features of the site, the Working Group developed a range of strategies encompassing different degrees of the extent of rehabilitation of the site. Three of these strategies, which are outlined below, were further developed for engineering solutions and recommended to Government for consideration.

(i) Strategy D

Old Tailings Dam
- cover and establish vegetation
  Dysons Open Cut
- cover tailings and establish vegetation
  Acid and Sweetwater Dams, Water Courses etc.
- clear, grade streams and revegetate
  Intermediate Open Cut
- treat water and divert East Finniss River through open cut

Heap Leach
- dump into Whites Open Cut, cover with Dysons overburden

Overburden Heaps
- landscape, cover and establish vegetation

Whites Open Cut
- partly refill, treat water

Fence Site

(ii) Strategy F

Old Tailings Dam
- cover and establish vegetation
Dysons Open Cut
- cover tailings and establish vegetation
Acid and Sweetwater Dams, Water Courses etc.
- clear, grade streams and revegetate
Intermediate Open Cut
- treat water and divert East Finniss River through open cut
Heap Leach, Intermediate and Dysons Heaps
- dump into Whites Open Cut
Whites Overburden Heap
- landscape, cover and establish vegetation
Whites Open Cut
- treat water and refill
Fence Site

(iii) Strategy H
As for Strategy F but completely refilling Intermediate Open Cut

From these options, Strategy D was selected for implementation at an estimated cost of $12.14 million (in 1980 values). Strategy D was estimated by the Working Group to give notional benefits (pollution reduction plus aesthetic improvements) of 78%, of which the reductions of heavy metal pollution from the site were:

(i) 70% reduction in the copper levels in the East Branch of the Finniss River;
(ii) 56% reduction in the manganese levels in the East Branch of the Finniss River; and,
(iii) 70% reduction in the zinc levels in the East Branch of the Finniss River.

In its 1980/81 budget the Commonwealth Government appropriated $200,000 for the commencement of a rehabilitation programme for Rum Jungle. The programme was estimated to cost $12.14 million over four years.

3.2 The Final Engineering Report

During January 1981 the Chief Minister of the Northern Territory offered to carry out the rehabilitation programme on behalf of the Commonwealth, and in March 1981 the Prime Minister of Australia accepted the Northern Territory's offer to arrange the execution of the work as agent for the Commonwealth.

Further investigations were carried out by the Northern Territory Government and a detailed plan of execution for the rehabilitation of Rum Jungle was presented in August 1982 in the Final Engineering Report (Reference 119). This report included recommendations on the standards of rehabilitation, investigation programme, measures to be adopted, and the programme of work.

The standards of rehabilitation and the measures to be adopted which are described in the Final Engineering Report have been developed on the basis of being those standards and measures which, if implemented, would at least satisfy the rehabilitation objectives of:

(a) 70% reduction in copper pollution occuring in water courses;

(b) 70% reduction in zinc pollution occuring in the water courses;

(c) 56% reduction in manganese pollution occuring in the water courses;

(d) 78% notional benefits which includes pollution reduction, reduction of public health hazards, and aesthetic improvements to the mine site.

3.2.1 Engineering Design Targets

Utilising the reductions in the levels of pollution estimated by the Working Group, the Final Engineering Report established a set of design targets for the purpose of implementing the project. The project design targets are summarised below.

(i) Life of the Rehabilitation Works

The recommended design life of the rehabilitation measures was 100 years.

(ii) Water Quality Targets

The report recommended three sets of water quality targets for Rum Jungle, viz;

(a) The Finniss River
The quality of the water in the Finniss River downstream of its confluence with the East Branch during any release of water from the open cut pits at Rum Jungle should be at least to the criteria set out in page 2 of the National Health and Medical Research Council (NHMRC) publication "Desirable Quality for Drinking Water in Australia" (Reference 108) (Table 3.3).

Table 3.3

WATER QUALITY TARGETS FOR FINNISS RIVER

Parameter	Theoretical Release (based on Option D)	Design Target (NHMRC Desirable Drinking Water Criteria)
Physical		
Colour units		5Ø
Turbidity		25
Odour		Unobjectionable
Taste		Unobjectionable
pH Range		6.5 to 9.2
Chemical		
Total solids		15ØØ mg/L
Calcium	Not known	2ØØ mg/L
Chloride		6ØØ mg/L
Copper	Ø.53 mg/L	1.5 mg/L
Total Iron		1.Ø mg/L
Magnesium		15Ø mg/L
Manganese	Ø.83 mg/L	Ø.5 mg/L
Sulphate	Not known	4ØØ mg/L
Sodium	-	-
Zinc	Ø.19 mg/L	15 mg/L
Nitrate (as N)		1Ø mg/L
Fluoride		1.5 mg/L
Total hardness ($CaCO_3$)		6ØØ mg/L
Phenolics (as Phenol)		Ø.ØØ2mg/L
Methyl Blue active substances		1.Ø mg/L
Chromium (hexavalent)		Ø.Ø5 mg/L
Cadmium		Ø.Ø1 mg/L
Cyanide		Ø.Ø5 mg/L
Arsenic		Ø.Ø5 mg/L
Barium		1.Ø mg/L
Lead		Ø.Ø5 mg/L
Silver		Ø.Ø5 mg/L
Mercury		Ø.ØØ1mg/L
Selenium		Ø.Ø1 mg/L

(b) Treated Pit Water
The design targets for the quality of the water contained in Whites and Intermediate Open Cut pits are set out in Table 3.4.

Table 3.4

WATER QUALITY DESIGN TARGETS
FOR TREATED PIT WATER
(Reference 98, Table 2)

Parameter	Concentration (mg/L)
Copper	1.5
Iron	1.Ø
Manganese	1.Ø
Zinc	5.Ø
Chromium	Ø.1
Cadmium	Ø.1
Arsenic	Ø.Ø5
Barium	1.Ø
Lead	1.1
Silver	Ø.1
Mercury	Ø.ØØ5
Selenium	Ø.ØØ1
Nickel	1.Ø
Cobalt	1.Ø
Radioactivity	5.Ø pCi/L
pH	7.Ø units
Calcium	1ØØØ
Sulphate	2ØØØ

(c) General Water Quality
The general water quality targets for water in the Finniss River downstream of its confluence with the East Branch are to those criteria recommended in the NHMRC 198Ø publication for drinking water. Furthermore, the overall objective for pollutant reduction in the East Branch of the Finniss River gives rise to a set of flow related metal loads in that river.

(iii) Radiation Emission and Radon Emanation

The recommended criteria for radiological design targets were those put forward by the Northern Territory Department of Health and are summarised below.

(a) External Radiation
- Ø.8 uSv/hr

(b) Radon / Radon Daughters
- Ø.Ø37 Bq/L (1 pCi/L) radon
- Ø.Ø1 WL radon daughters
- Ø.14 Bq/m^2/s

(c) Radionuclide Contamination in Water
- Ra 226 Ø.37 Bq/L (1Ø pCi/L)
- Th 23Ø 74 Bq/L (2ØØØ pCi/L)
- Pb 21Ø 3.7 Bq/L (1ØØ pCi/L)

(d) Radionuclide Contamination in Soil
- Ra 226 Ø.37 Bq/g (1Ø pCi/g)
- Th 23Ø Ø.37 Bq/g (1Ø pCi/g)
- Pb 21Ø Ø.37 Bq/g (1Ø pCi/g)

(iv) Flora Revegetation

Design targets for flora revegetation, set by the Conservation Commission of the Northern Territory, are summarised below.

(a) Surface Stabilisation
All rehabilitated areas shall be designed to achieve long term surface stability for the expected life of the works and the design parameters shall be consistent with those reqired to satisfy the "Universal Soil Loss Equation" for an effective life of 1ØØ years.

(b) Plant Population
Where possible use should be made of plant populations similar to the surrounding areas, except where stability considerations dictate the use of species not native to the area.

(c) Weeds
Introduction of new weed species to the area is to be avoided.

(d) Borrow Pit Revegetation
Borrow pits to be graded to conform with adjacent areas and revegetated.

(v) Fauna Repopulation

The target for fauna was recommended to be the pre-existing fauna population at the Rum Jungle area (outside of the affected area), with the exception of feral buffalo, which were to be excluded from the site.

The standards of rehabilitation would allow the longer term prospect of a return to the river system of aquatic fauna which would be dependent on the re-establishment of aquatic flora.

(vi) Land Use

The recommended design target for land use was that the selected methods of rehabilitation should return the Rum Jungle area to a standard compatible with recreational use although it was recognised that some specific restrictions may have to be applied to certain areas of the site.

3.2.2 1982 Investigation Programme

In order to enable a more detailed evaluation of the rehabilitation programme, further investigation was required to confirm:

(a) the existence of suitable cover materials local to the site;
(b) a recommended cover system, constructed from locally occurring materials, which would reduce the infiltration of rainwater into the reshaped heaps; and,
(c) a suitable method of treating the water in Whites and Intermediate Open Cuts.

The investigation programme was carried out over an eight week period, commencing in March of 1982, and the results are summarised below (Reference 96).

(i) Cover Materials

Sufficient quantities of clay, gravel and broken rock to construct the required covers were located within a two kilometre radius of the mine site.

(ii) Cover System

A cover system and drainage details were developed for the overburden heaps and are illustrated in Figures 6.2 and 6.3.

(iii) Water Treatment

The preliminary design for an hydroxide precipitation water treatment plant was developed, as well as an operating strategy to enable the treatment of Whites and Intermediate Open Cuts by lime precipitation.

3.2.3 Measures To Be Adopted

Based on the results of the investigations described in Section 3.2.2 above, the Strategy D recommendations were evaluated, and a detailed rehabilitation strategy was proposed. These measures were incorporated in the Agreement.

The strategy for the rehabilitation project detailed in the Final Engineering Report proposed several significant variations from the Strategy D proposal endorsed by the Commonwealth Government. The main changes to the strategy were:

(i) Disposal of Old Tailings Dam

The Strategy D proposal recommended that the Old Tailings Dam be covered and revegetated in situ.

Investigations carried out in the preparation of the Final Engineering Report showed that the in situ covering of the tailings in the Old Tailings Dam would not achieve the desired design requirements due to the location of the water table under the western end of the dam and the potential problems of erosion of the soil covers. The relative costs of in situ covering compared to relocating the tailings to a safe disposal site did not support in situ covering.

It was therefore recommended that the tailings from the Old Tailings Dam be removed to a geomorphologically stable site for permanent containment as already considered by the Commonwealth. The alternative disposal sites considered were Whites and Dysons Open Cuts. Dysons Open Cut was selected as the preferable disposal site because of the probable adverse effects that the tailings would have on the treatment of the water in Whites Open Cut.

(ii) Disposal of the Copper Heap Leach Pile

The Strategy D recommendation for the disposal of the Copper Heap Leach Pile was to dump the material into Whites Open Cut and to cover it with material from Dysons Overburden Heap.

Disposal of the material into Whites Open Cut would introduce a large amount of sulphidic material into the open cut, below the groundwater level, and would have provided a further source of acid and of heavy metals. Furthermore, the disposal of the copper ore into the open cut would have the effect of increasing the amount of water from Whites Open Cut which would need to be released from the open cut to the river system. In addition, the viability of sealing with inert soil deposited underwater was considered difficult and of doubtful effectiveness.

It was therefore recommended to remove the low grade ore from the Heap Leach Pile to a safe containment site above any potential groundwater influence. Dysons Open Cut was selected for this purpose as it met the desired requirements.

The estimated cost of carrying out the rehabilitation programme defined above was $16.2 million in 1982 values, made up of the components set out in Table 3.5.

Table 3.5

ESTIMATED COST OF PROJECT IN 1982 VALUES

Description	Estimated Cost ($000)
Copper Heap Leach Pile	578
Tailings Dam	1,497
Dysons Open Cut	310
Whites Open Cut	77
Intermediate Open Cut	-
Dysons Overburden Heap	300
Whites Overburden Heap	696
Whites North Overburden Heap	328
Intermediate Overburden Heap	217
Acid/Sweetwater Dams	191
Other Areas	333
Water Treatment Plant	5,140
Protective Fence	24
Site Establishment	707
Site Services	415
Construction Camp	1,200
Monitoring	123
Engineering and Management	3,456
Sub Total	15,592
Contingency	600
TOTAL	16,192

The Final Engineering Report estimated that the rehabilitation programme would take four years to complete.

The Final Engineering Report also recommended a monitoring programme aimed at enabling the assessment of the effects of the Project and the comparison of the results of the rehabilitation programme with the objectives. The recommended monitoring programme was:

- Construct a total of 1Ø observation bores around the open cuts to enable observation of the groundwater system and any changes resulting from the rehabilitation programme;

- Monitor the water quality of the Finniss River and the East Branch of the Finniss River;

- Continue to monitor the meteorological station set up at the site;

- Examine the river bed sediments at arbitrary points and analyse for radionuclides;

- Monitor the water quality of Whites and Intermediate Open Cuts;

- Carry out spot checks of the site on a radiation survey grid;

- Carry out a flora check on the area to assess ground cover establishment and any possible erosion areas;

- Set up reference observation stations on the river courses to monitor changes in vegetation; and,

- Monitor the Finniss River aquatic life for any changes which may occur during the proposed water release programme.

The report also recommended that some aspects of the monitoring programme should be continued for a minimum period of six years after the completion of the rehabilitation programme, and noted that the success of the Project may only be known following a long period, such as ten years, after the completion of the works.

However, this monitoring programme was not adopted as part of the Commonwealth's agreement with the Northern Territory.

An agreement was concluded between the Commonwealth and Northern Territory Governments (Reference 125) establishing the Rum Jungle Rehabilitation Project incorporating the Measures to be Adopted as described in the Final Engineering Report. A memorandum of agreement was signed by respective Commonwealth and Northern Territory Ministers and dated on 4 March 1983 thereby enabling a major programme to commence at the former mine site in the "dry" season of that year.

The Agreement provided for scheduled works to be undertaken over a period of four years, together with a monitoring programme for a further period of two years, within an all up cost to the Commonwealth Government of $16.2 million (1982 values). The work has been undertaken by the Northern Territory Government. The Agreement provided for the management of the Project by a Commonwealth / Northern Territory Liaison Committee, established to monitor progress and advise Ministers on each stage of the programme.

The Agreement contained several important provisions:

4.1 Operation of the Agreement

Its provisions applied from 1 July 1982, when the programme officially commenced. The Agreement provides that the completion date for the Project, and the commencement of the two year monitoring period, is the date upon which the respective Ministers agree that the works to be undertaken have been completed.

The Agreement may be terminated after the completion of all requisite physical works to the Ministers' satisfaction, the completion of the two year monitoring and maintenance period, and after the project objectives (as set out in Clause 7 of the Agreement) have been achieved to a satisfactory degree.

4.2 Rehabilitation

The rehabilitation objectives, which were to be assessed against conditions existing prior to the commencement of the rehabilitation programme, taking into account the baseline studies carried out by the Commonwealth in the period 1969 to 1974, were defined as:

(a) a major reduction in pollution in the water courses feeding the East Branch of the Finniss River and in particular the reduction of the average annual releases of copper, zinc and manganese into the river by 70%, 70% and 56% respectively, as measured at the junction of the river with the Finniss River;

(b) a reduction in public health hazards and in particular reduction of radiation levels at the site at least to the standards set out in the Code of Practice on Radiation Protection in the Mining and Milling of Radioactive Ores published by the Australian Government Publishing Service in 1980 (Reference 15) (refer to the note below);

(c) a reduction of pollution in the water contained in the open pits known as Whites and Intermediate; and,

(d) aesthetic improvements including revegetation.

The Agreement required the Northern Territory to develop the rehabilitation programme, taking into account the design criteria and rehabilitation measures contained in the Final Engineering Report, and placed the responsibility for the achievement of the above objectives with the Commonwealth Government.

It is important to note that the Code of Practice on Radiation Protection in the Mining and Milling of Radioctive Ores applies to areas affected by mining and/or milling activity. In the case of Rum Jungle, this means it applies to areas of tailings, ore dumps and waste rock heaps. The Code of Practice does not apply to naturally occuring radiation which it is recognised occurs in the Rum Jungle area.

The measures which were to be adopted in order to achieve these objectives were incorporated in Schedule "A" of the Agreement and were:

(i) Copper Heap Leach Pile

- remove the Copper Heap Leach Pile to Dysons Open Cut and blend with tailings during the back filling of the pit

. remove affected subsoil from below the heap leach pile and dump into Dysons Open Cut
. treat the remaining area, reshape and revegetate surrounds

(ii) Tailings Dam

. remove tailings to Dysons Open Cut
. remove the affected subsoil from under the tailings and dump into Whites Open Cut
. reshape the tailings area to form water courses
. place rock and other protection bunds in the tailings area to control scouring and erosion
. spread topsoil after lime treatment of acidic areas
. revegetate tailings area
. remove tailings from tailings creek and dump into Dysons Open Cut
. clean up surrounds and repair erosion damage to the old treatment plant area

(iii) Dysons Open Cut

. drain Dysons Open Cut of water and release to local rivers
. construct haul roads around the lower perimeter of Dysons Open Cut and out to the tailings area
. fill Dysons Open Cut with tailings intermixed with Copper Heap Leach Pile material, once above the water table
. fill Dysons Open Cut with affected soils taken from below the Copper Heap Leach Pile
. shape the top of the transported materials to suit the surrounding contours
. construct impervious clay covers over the transported tailings and copper heap leach piles including scour resistant structures and drainage channels
. place soil/anti-scour cover over impervious covers
. revegetate Dysons Open Cut reshaped fill
. remove haul roads and revegetate temporary construction access roads

(iv) Whites Open Cut

. connect Whites to Intermediate Open Cut
. dump affected subsoils taken from the tailings dam area, once all tailings have been removed to Dysons Open Cut
. treat the water in Whites Open Cut by the addition of lime, introduced into an hydroxide precipitation treatment plant, constructed adjacent to Intermediate Open Cut
. dump crushed limestone into the pit to assist with long term water quality stability
. reshape and revegetate surrounds

- on completion of the treatment of both Whites and Intermediate Open Cuts, divert the East Branch of the Finniss River into Whites Open Cut leaving the connection channel between Whites and Intermediate Open Cuts as a permanent feature

(v) Intermediate Open Cut

- treat the pit water by the same method as for Whites Open Cut

(vi) Whites Overburden Heap

- reshape the heap to establish design slopes and construct erosion protection structures
- place impervious compacted clay covers over the reshaped heap
- construct erosion protection drains to control rainfall runoff from the reshaped heap
- place soil/anti-scour cover over the impervious covers
- vegetate the heap, remove acidic soils from surrounding area, treat and revegetate where necessary

(vii) Whites North Overburden Heap

- remove the overburden heap to Whites Overburden Heap before it is reshaped
- shape the surrounds to remove water collection ponds and to allow the rediversion of the East Branch of the Finniss River once water treatment has been completed
- treat soils and revegetate surrounds where necessary

(viii) Intermediate Overburden Heap

- reshape the heap to establish design slopes and construct erosion protection structures
- place impervious compacted clay covers over the reshaped heap
- construct erosion protection drains to control rainfall runoff from the reshaped heap
- place soil/anti-scour cover over the impervious covers
- vegetate the heap, remove acidic soils from surrounding area, treat and revegetate where necessary
- reshape the diversion channel adjacent to Whites and Intermediate Overburden Heaps to form a natural water course to allow passage of any excess water in high rainfall periods

(ix) Dysons Overburden Heap

- reshape the heap to establish design slopes and construct erosion protection structures
- place impervious compacted clay covers over the reshaped heap

. construct erosion protection drains to control rainfall runoff from the reshaped heap
. place soil/anti-scour cover over the impervious covers
. vegetate the heap, remove acidic soils from surrounding area, treat and revegetate where necessary

(x) Acid and Sweetwater Dams

. remove dam walls and clean out river beds
. rip all affected river banks, treat with lime and allow to revegetate naturally
. construct flood and erosion protection structures along the stream to control water during the wet season

(xi) Other Areas

. remove copper launders and evaporation ponds
. reshape Copper Creek
. remove small ore stockpiles from around the mine site
. clean up local creek beds, contaminated ponds, old roads and improve the general surrounds
. revegatate general areas as necessary

(xii) Protective Fence

. construct a stock-proof fence around the perimeter of the site before commencing revegetation

4.3 Liaison

The Agreement established a Liaison Committee comprised of two representatives of each of the Northern Territory and Commonwealth Governments whose functions were:

(a) to review the progress of the rehabilitation work at no more than twelve monthly intervals;

(b) to review, every six months, the implementation of the annual rehabilitation programmes;

(c) to consider any proposed development of, or amendment or variation to, the rehabilitation programme;

(d) to assess the effectiveness of the rehabilitation work in achieving the objectives defined in the Agreement; and

(e) to advise the appropriate Commonwealth and Territory Ministers accordingly.

4.4 Financial Provisions

The Agreement provided for financial assistance to be paid to the Northern Territory in the form of non-repayable, non-interest bearing grants to a limit of $16.2 million (escalated in accordance with an agreed formula). Assistance was to be paid quarterly to the Northern Territory against approved annual programmes of work.

The specific financial allocations provided in the Agreement were as below.

CATEGORY A. EARTHWORKS, ETC

Item 1	Copper Heap Leach Pile	$ 578,000
Item 2	Tailings Dam	$ 1,497,000
Item 3	Dysons Open Cut	$ 310,000
Item 4	Whites Open Cut	$ 77,000
Item 5	Intermediate Open Cut	$ -
Item 6	Dysons Overburden Heap	$ 300,000
Item 7	Whites Overburden Heap	$ 696,000
Item 8	Whites North Overburden Heap	$ 328,000
Item 9	Intermediate Overburden Heap	$ 217,000
Item 10	Acid / Sweetwater Dams	$ 191,000
Item 11	Other Areas	$ 333,000
Item 12	Site Establishment Including Protective Fence	$ 731,000
	Sub Total Category A	$ 5,258,000

CATEGORY B. CONSTRUCTION WORKS

Item 1	Water Treatment Plant	$ 2,020,000
Item 2	Discharge Pipeline To Whites Open Cut	$ 80,000
Item 3	Construction Camp	$ 280,000
	Sub Total Category B	$ 2,380,000

CATEGORY C. PROJECT MANAGEMENT, SITE SERVICING, MONITORING

Item 1	Camp Services - power, water sewerage	$ 140,000
Item 2	Camp Generator, Fuel and Maintenance	$ 220,000
Item 3	Camp Accommodation	$ 560,000
Item 4	Monitoring	$ 171,000
Item 5	Engineering and Management	$ 3,416,000
Item 6	Site Services	$ 415,000
	Sub Total Category C	$ 4,922,000

CATEGORY D.	SUPPLY OF CHEMICALS FOR WATER TREATMENT	$ 2,300,000
CATEGORY E.	OPERATION OF WATER TREATMENT PLANT	$ 740,000
CONTINGENCY		$ 600,000
GRAND TOTAL		$16,200,000

The Agreement made provision for the transfer of funds within a category of the programme subject to agreement between Ministers, and for variations to be made between the various categories of the rehabilitation programme.

5. PROJECT MANAGEMENT

The Rum Jungle Rehabilitation Project was funded by the Commonwealth Government by means of non-repayable annual grants under Northern Territory Government management, initially within the Water Division of the Department of Transport and Works and later, the Mines Division of the Department of Mines and Energy.

The Project team was established early in 1983. Its major objective was to implement the programme of rehabilitation within both the approved time and limit of grants provided. In doing so, the team sought to minimise the management costs of the Project by drawing on resources and expertise provided by other government authorities and private consultants where necessary. This was achieved by adopting an implementation strategy as follows:

- minimise the extent of the management team by selecting staff with a broad range of experience;
- maximise the use of consultants;
- utilise, where appropriate, lump sum and schedule of rates contracts to obtain works and services; and,
- utilise existing services and expertise within the Northern Territory Government.

Work on the Rum Jungle Rehabilitation Project commenced in January 1983 with the commissioning of consultants for the design of the water treatment plant and the design of Stages 1 and 2 of the Project, the initiation of a monitoring programme, the establishment of accommodation facilities in Batchelor and the establishment of a site office at Rum Jungle. With the exception of some relatively minor work, the rehabilitation works were completed by June 1986.

The constraints placed on the planning and execution of the Project were imposed by factors which included the climatic conditions of the area, in particular the effects of the monsoonal climate, budgetary considerations and the requirement to complete all of the rehabilitation works by June 1986. To overcome these constraints, project works

were divided into two streams which were progressed in parallel.

The first stream of work was the design and construction of the water treatment plant, and the subsequent treatment of the water contained in Whites and Intermediate Open Cuts. The second was the design and construction of the earthworks component of the rehabilitation programme. The earthworks were further divided into stages approximating the construction work which could reasonably and economically be completed during a single dry season. This work was then revegetated and established during the following wet season.

The earthworks phase of the Project was carried out in four stages, the broad scope of each of which is summarised below.

Stage 1

- Removal of Whites North Overburden Heap to the toe zone of Whites Overburden Heap.

Stage 2

- Rehabilitation of Whites Overburden Heap.

Stage 3

- Removal of the tailings from the Old Tailings Dam to Dysons Open Cut.
- Removal of the low grade copper ore from the Copper Heap Leach Pile to Dysons Open Cut.
- Removal of the tailings from Tailings Creek to Dysons Open Cut.
- Clean up of Copper Creek and the removal of the copper launders and the ponds associated with the heap leach pile.
- Covering and drainage of the landform created by the disposal of the tailings and the low grade copper ore.
- Rehabilitation of the areas previously occupied by the Old Tailings Dam and the Copper Heap Leach Pile.

Stage 4

- Rehabilitation of Dysons and Intermediate Overburden Heaps.
- Rehabilitation of the Treatment Plant and Stockpile Areas.
- Final covering of the Copper Heap Leach Pile Area.
- Rehabilitation of borrow pits.
- Rediversion of the East Branch of the Finniss River.
- Removal of the Acid and Sweetwater Dam walls.
- Covering of Whites North area.
- Other minor works.

In addition, other works were carried out separately from the major stages. These works included the construction of the washdown and ablution facilities for the handling of the tailings, the construction of a stockproof fence around the site, general clean up works, the supply of certain

materials required for the Project, the establishment of the site office and the Batchelor accommodation facilities, the establishment of the site water supply and general maintenance works.

Whilst every endeavour was made to follow the programme, there were instances where it was not possible. The most notable being the failure of the main contractor for Stage 2 of the Project, necessitating the deferral of part of the rehabilitation of Whites Overburden Heap until the following dry season.

The timeframe of the Project and the scope of the various stages are summarised in Table 5.1. With the exception of the water treatment plant, Table 5.1 does not include the design phase of each stage of the Project.

Table 5.1

PROJECT TIMEFRAME

Area/Stage	Activity	Timeframe
Site Fence		Dec'83
Water Treatment Plant		
	Design	Jan'83 - Apr'83
	Procurement	Jul'83 - Jun'84
	Construction	Dec'83 - Aug'84
	Operation - Whites	Aug'84 - Sep'85
	- Intermediate	Sep'85 - Dec'85
	Mothballing of Plant	Dec'85
	Cover Filter Cake	May'86 - Jun'86
Earthworks		
Stage 1	Whites North Heap - removal to Whites Heap	Apr'83 - Jun'83
Stage 2	Whites Heap - reshaping and cover top	Aug'83 - Jan'84
	- cover batters and revegetate	Apr'84 - Dec'84
Stage 3	The Old Tailings Dam	May'84 - Dec'84
	The Copper Heap Leach Pile	Jul'84 - Dec'84
	Dysons Open Cut	Jun'84 - Dec'84
Stage 4	Intermediate Heap	Aug'85 - Dec'85
	Dysons Heap	May'85 - Dec'85
	Treatment Plant Area	Jul'85 - Dec'85
	Stockpile Area	Jun'85 - Dec'85
	Acid/Sweetwater Dams	Jun'85 - Oct'85
	Copper Heap Leach Pile Area - covers	May'85 - Dec'85
	Rediversion of East Branch of the Finniss River	Oct'85 - Dec'85
	Whites North Heap - cover and revegetate	May'85 - Dec'85
Demobilisation		Feb'86 - Jun'86

5.1 Project Organisation

Initially the Project reported to the Director of the Water Division of the Northern Territory Department of Transport and Works. In December of 1984 the functions of the Rum Jungle Rehabilitation Project were transferred to the Mines Division of the Northern Territory Department of Mines and Energy where it reported to the Director of Mines.

The organisation of the Project Team is shown in Figure 5.1.

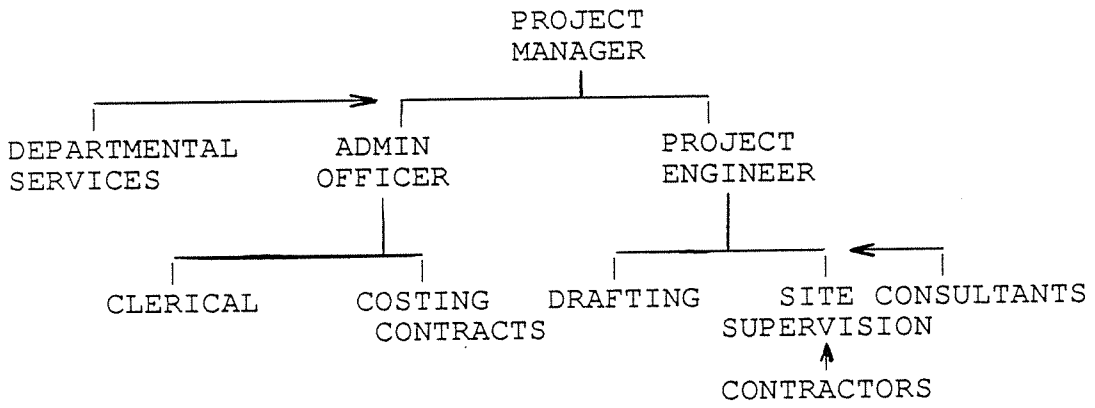


Figure 5.1

PROJECT ORGANISATION

The organisation consisted of two functional groups; an administrative group reporting to the Administration Officer and a technical group reporting to the Project Engineer, both reporting to the Project Manager.

The role of these functional groups is discussed in more detail below.

(i) The Technical Group

Reporting to the Project Manager, the technical group was responsible for the following areas of the administration of the Project:

- day to day management of the Rum Jungle and Batchelor facilities;
- assessment and award of consultant commissions, and of contracts for site works;
- administration and supervision of consultant commissions;

- administration and supervision of construction contracts;
- direction and supervision of works carried out by direct management;
- co-ordination of the monitoring programme;
- design and documentation of minor works;
- maintenance of video and photographic records of the Project; and,
- management of Project documentation.

(ii) Administration

Reporting to the Project Manager, the administration group was responsible for the following areas of the Project:

- cost control, recording and reporting;
- provision of administrative support;
- processing of payments for goods and services provided for the Project, including contractor's progress claims; and,
- maintenance of Project records.

Day to day services normally provided by the Northern Territory Government to its various departments were also provided to the Project by relevant departments, and included:

- Advertising of tenders for works and services and the award of subsequent orders and contracts;
- Maintenance of the Project trust account;
- Implementation of appropriate sections of monitoring programme;
- Payment of claims for goods and services; and,
- Provision of legal advice.

5.2 Consultants

Consultants were briefed by the Project to provide specialist professional and support services not available from within the Project and to supplement Project resources. Table 5.2 is a summary of the major consultant commissions which are described in more detail in Appendix C.

In selecting consultants for the performance of the various consultant commissions, preference was given to Northern Territory based organisations demonstrating adequate expertise in the requirements of the commission.

All consultant commissions were based on the Northern Territory Department of Transport and Works Standard Conditions of Engagement of Consultants (Reference 115) with the fee structures based on an upper limit or lump sum for time based fees and expenses reimbursed at cost. A major departure from this basis of consultant commission was the operating commission

for the Water Treatment Plant. This consultancy was considerably different from the other commissions not only in the significantly higher value of the commission but also in that it involved the consultant in the execution of work considerably different from that normally carried out by the other consultants for the Rum Jungle Project. Payment for this commission was structured on a reimbursible cost basis.

Table 5.2

CONSULTANT SUMMARY

Consultant	Commission
Mining and Process Engineering Services	Design and Construct Water Treatment Plant
Mining and Process Engineering Services	Operation of Water Treatment Plant
Dames and Moore (in conjunction with Cameron McNamara, Meehan, Burgess and Yeates)	Stages 1 and 2
Cameron McNamara (in conjunction with Dames and Moore, and Peter J Burgess and Assoc's)	Stages 3 and 4
Dames and Moore	On site Soils Technology
Unisearch Ltd	Design check of Water Treatment Plant
Cameron McNamara	Re-documentation of Whites Heap
Cameron McNamara	Final measure of Tailings Dam and Whites Heap

The total Project expenditure on consultants was approximately $2,500,000

5.3 Contracts

The majority of goods and services (excepting professional services) required to complete the Project were supplied under contracts tendered and awarded on behalf of the Project by the Northern Territory Department of Transport and Works and

administered by the Project. Other goods and services were supplied under orders raised by both the Department of Transport and Works and the Department of Mines and Energy. The major contracts are summarised in Table 5.3, and details of all contracts administered by the Project can be found in Appendix B.

Table 5.3

CONTRACT SUMMARY

Contract No	Contractor	Description of Contract
TW 1Ø2 of 82/83	Roadmakers (NT)	Rum Jungle Stage 1
TW 12 of 83/84	Hendrie Constructions	Rum Jungle Stage 2
TW 26 of 83/84	William Boby & Co	Supply Filter Press
TW 27 of 83/84	Larox Proprietary Ltd	Supply Secondary Clarifier
TW 28 of 83/84	Asoma	Supply of Hydrated Lime
TW 29 of 83/84	Thomas Robinson & Son	Supply of Lime Surge Bin
TW 34 of 83/84	William Boby & Co	Supply of Primary Clarifier
TW 43 of 83/84	Lightnin Mixers	Supply of Agitators
TW 49 of 83/84	Blakers & Thompson	Supply of Pumps
TW 8Ø of 83/84	Transcon	Supply of Flocculant System
TW 96 of 83/84	Elmec Pty Ltd	Supply and install Generator Sets
TW 1Ø1 of 83/84	Findlay Civil Cont's	W T P Foundations
TW 1Ø6 of 83/84	Transcon	W T P Steelworks
TW 1Ø8 of 83/84	Quarry Industries	Supply of Crushed Rock
TW 117 of 83/84	Kilpatrick Green	W T P Mechanicals
TW 126 of 83/84	Thiess Contractors	Rum Jungle Stage 3 and Completion of Stage 2
TW 127 of 83/84	John Holland Const's	W T P Electrics and Instrumentation
TW 33 of 84/85	CJ Property Maint	Disposal of Lime Bags
TW 117 of 84/85	Thiess Contractors	Rum Jungle Stage 4

All contracts administered by the Project utilised NPWC (Edition 3) general conditions of contract together with standard Northern Territory Department of Transport and Works specifications, conditions and format. They were either lump sum or schedule of rates contracts depending on the specific requirements of the contract. Tenders for contracts were advertised and opened by the Contracts Branch of the Northern Territory Department of Transport and Works and all contracts were awarded through the Capital Works Tender Board by the Department of Transport and Works.

Tenders for contracts were generally advertised throughout the Northern Territory and, in the case of some of the supply contracts for the specialised equipment required for the Water Treatment Plant, interstate. Tenders for the major earthworks stages of the Project were not advertised but were invited from contractors who had previously qualified for large value earthworks contracts in the Northern Territory.

In the assessment of tenders and the award of contracts, especially those involving interstate and overseas tenderers, the Northern Territory Government policy relating to preference for local contractors was applied in all cases.

Major assets were disposed of at the end of the Project through contracts arranged by the Northern Territory General Tender Board, with other assets being disposed of at public auction.

5.4 Committees

Three committees were involved in the oversight and co-ordination of various matters relating to the completion of the rehabilitation programme.

(i) The Liaison Committee

As noted in Section 4.3, the Rum Jungle Liaison Committee was a Commonwealth-Northern Territory Government committee established under the Rum Jungle Agreement to:

- review the progress and the implementation of the rehabilitation programme;
- to consider any proposed development of, amendment or variation to the rehabilitation programme;
- to assess the effectiveness of the rehabilitation works against the objectives defined in the agreement; and,
- to advise the appropriate Ministers accordingly.

The Liaison Committee met on a six monthly basis, with the first meeting held in Canberra on 23 March 1983. All subsequent committee meetings were held in Darwin in conjunction with Technical Committee meetings and site inspections. The Committee, chaired by the Commonwealth, consists of four members; two representatives from each of the Commonwealth and Northern Territory Governments. These representatives were assisted by appropriate technical advisers. Table 5.4 is a schedule of the meetings of the Rum Jungle Liaison Committee.

Table 5.4

LIAISON COMMITTEE MEETINGS

Meeting No	Timing	Location
1	23 March 1983	Canberra
2	27 September 1983	Darwin
3	22 March 1984	Darwin
4	24 October 1984	Darwin
5	6 March 1985	Darwin
6	12 September 1985	Darwin
7	1Ø April 1986	Darwin

(ii) The Monitoring Committee

The Monitoring Committee was established by the Liaison Committee to co-ordinate the implementation of the Rum Jungle monitoring programme. Chaired by the Project Manager, the Monitoring Committee comprises representatives of the various agencies who are involved in the environmental monitoring programme at Rum Jungle and a technical adviser nominated by the Commonwealth. This committee will continue to meet until the completion of the Monitoring Programme, currently planned for June 1988.

Agencies represented on the Monitoring Committee are:

- The Department of Housing and Construction
- The Australian Atomic Energy Commission
- The NT Department of Mines and Energy
- The NT Department of Health
- The Conservation Commission of the NT

The objectives and functions of the Monitoring Committee are:

(a) Objectives

1. To establish the extent to which the Project objectives as defined in the Agreement and any subsequent approved amendments have been achieved.
2. To keep under review the appropriateness of the design parameters during the construction phase.
3. To establish the extent to which public health requirements have been achieved.
4. To provide timely and quantitative data on the effectiveness of major portions of the rehabilitation works in order to provide a perspective on the rate of improvement in water quality.
5. To provide timely and quantatative information on any perceived shortcomings in

the rehabilitation work, design targets and the Monitoring Programme.

6. To establish arrangements, as approporiate, for providing information associated with monitoring activities for the public.

(b) Functions

1. Taking into account the objectives of the Monitoring Committee, provide technical advice and reports through the Project Manager, Rum Jungle Project, to the Liaison Committee associated with the Monitoring Programme established under the terms and conditions of the arrangements between the Commonwealth of Australia and the Northern Territory of Australia.
2. Plan and ensure the co-ordination of the Monitoring Programme.
3. Review the progress of the Monitoring Programme at no more than three monthly intervals.
4. To consider and recommend any development of, or amendment or variation to, the Monitoring Programme.
5. To implement or take into account the requirements of the Liaison Committee.
6. To provide, through the Project Manager, a progress report on the Monitoring Programme to each Liaison Committee meeting.
7. To critically and constructively review progress reports from individual agencies associated with monitoring.
8. Based on the results of the Monitoring Programme assess the effectiveness of the rehabilitation work towards achieving the objectives referred to in sub-Clause 7.2 of the Agreement dated 4 March 1983, or any approved amended objectives, and the design targets established in Section 2 of Final Engineering Report, subject to any amendments made under the terms of the above mentioned Agreement.
9. Subject to Item 1Ø below, in conjunction with the Project Team, provide Annual Reports detailing and evaluating the results of the monitoring to date. (No Annual Reports to be produced for those years when Consolidated Reports are produced.)
1Ø. In conjunction with the Project Team, provide Consolidated Reports based upon:
    a) monitoring undertaken up to that stage that the rehabilitation work, as defined in the Agreement dated 4 March 1983, has been completed;
    b) the monitoring undertaken up to the stage that all monitoring to be undertaken, persuant to the Agreement dated 4 March 1983, is completed.

    The Consolidated Reports are to detail, integrate and evaluate the results of all

the monitoring to date and to assess the effectiveness of the rehabilitation work to date towards achieving the objectives and design targets set out in Item 8 above.

11. In conjunction with the Project Team and monitoring agencies, establish a programme for producing a photographic record of monitoring activities.

12. Develop proposals and recommendations for ongoing Monitoring Programmes considered necessary beyond the time frame covered by the Agreement dated 4 March 1983.

The first consolidated report of the monitoring committee is included in Chapter 12 of this report.

Since the establishment of the Monitoring Committee in March 1984, there have been six meetings of the committee all of which have been held in Darwin. Table 5.5 is a schedule of those meetings.

Table 5.5

MONITORING COMMITTEE MEETINGS

Meeting No	Date
1	29 March 1984
2	21 August 1984
3	7 May 1985
4	1Ø September 1985
5	4 February 1986
6	8 April 1986

(iii) Technical Committee

The Technical Committee was a subcommittee of the Liaison Committee formed to advise the Liaison Committee on technical matters relating to the Project. The committee included the technical advisers to the representatives of each Government.

5.5 Project Facilities

The administration of the Project was based in Darwin, with site office facilities in Rum Jungle and contractor and Project accommodation in the town of Batchelor, approximately ten kilometres from the Rum Jungle mine site.

5.6 Planning

In planning the execution of the project, several major constraints had to be recognised.

Firstly, the impact of the weather and the Top End's monsoonal climate. The "wet season" in the Top End is characterised by high overall rainfall with extremes of precipitation rates during local thunderstorms and periods of little or no rainfall and high evaporation rates. The "dry season" is characterised by lower maximum temperatures, low humidity and very low average rainfall.

The implication of these seasonal patterns for the Project were:

- no major works could be carried out during the wet season;
- all newly constructed works had to be sufficiently stable prior to the onset of the wet season to withstand the anticipated extremes of precipitation;
- the growing season for vegetation was restricted to the period from November to May; and,
- the vegetation species selected had to be able to tolerate the long dry season and be resistant to moisture stress induced during the wet season.

Secondly, the measures to be undertaken to complete the rehabilitation works had to be completed prior to July 1986. With the first budget allocation to the Project in January 1983, the entire Project had to be carried out within a period of approximately three and a half years.

Another programming constraint was the availability of accommodation in the Rum Jungle area for use by the contractors' workforce. The Project had available the original single quarters in Batchelor, including accommodation and messing facilities. After extensive renovation, some thirty-six rooms were available for contractor accommodation. These limited facilities placed obvious constraints on the size of contract which the various stages of the Project could be incorporated into and was a major factor in the planning process.

The original and "as built" construction schedules are presented at Figures 5.2 and 5.3.

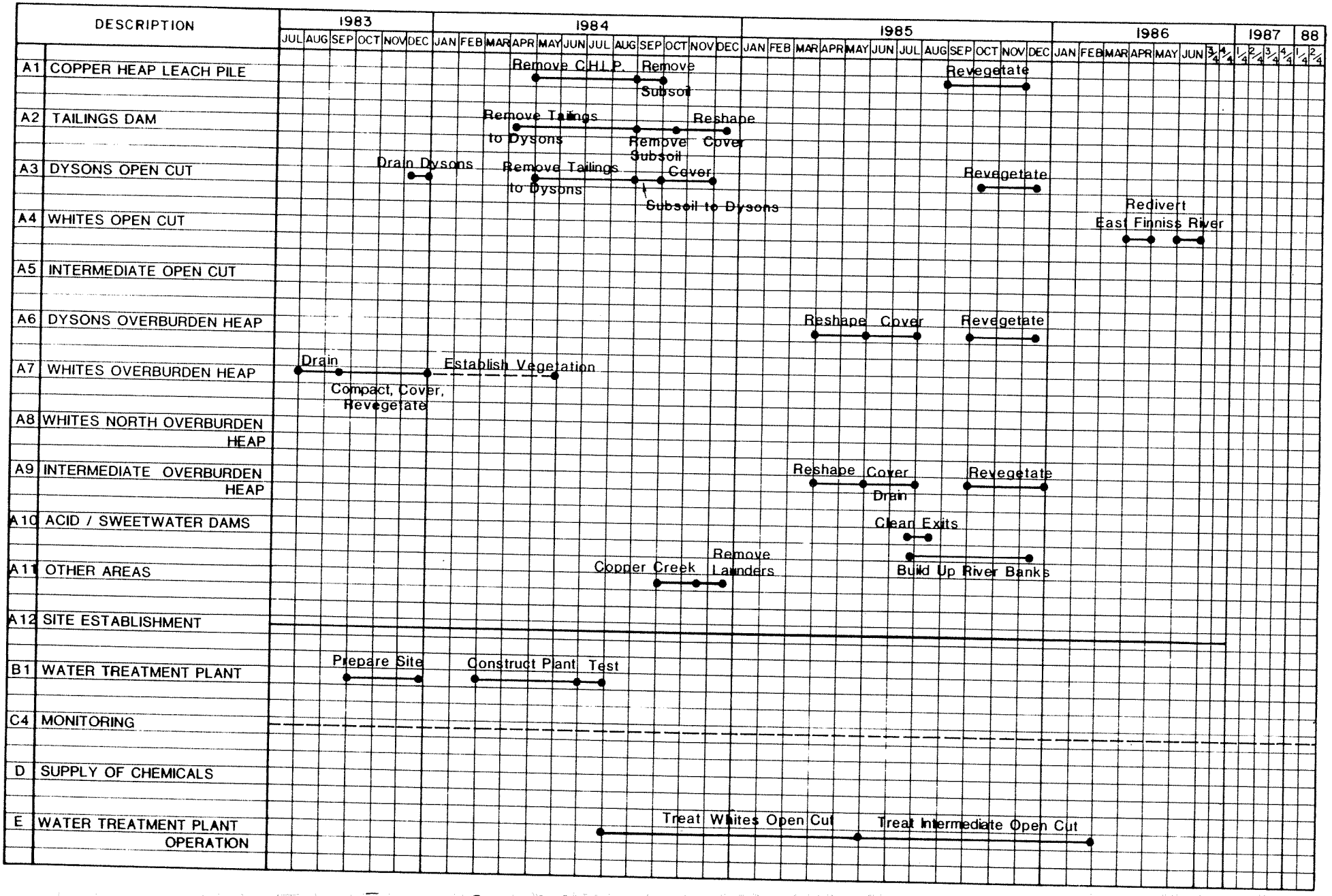


Figure 1.2 PROPOSED PROJECT SCHEDULE

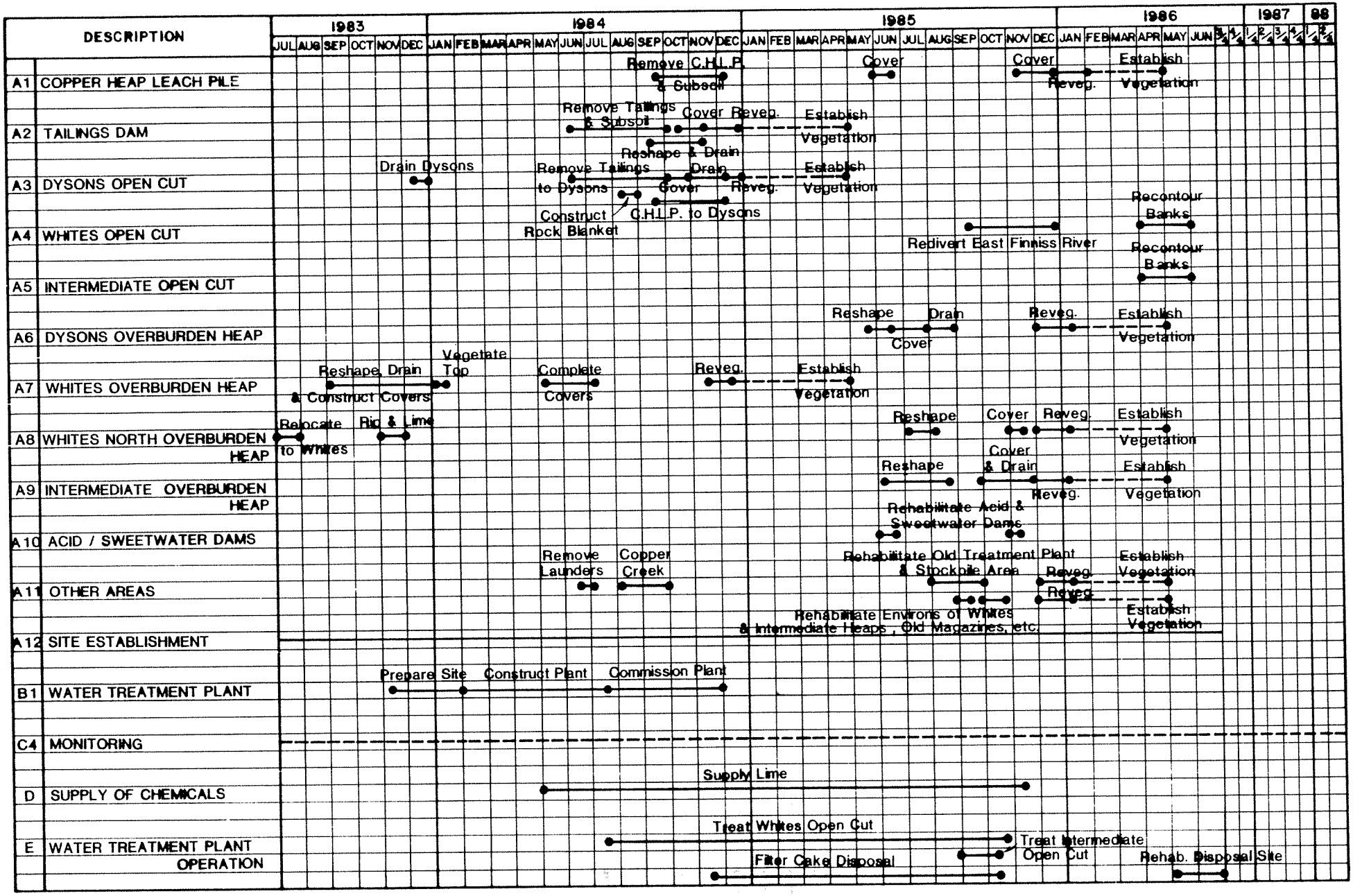


Figure 5.3 - ACTUAL PROJECT SCHEDULE

6. DESIGN CRITERIA AND APPROACH

The works carried out at Rum Jungle as part of the rehabilitation project can be categorised as:

- rehabilitation of overburden heaps;
- rehabilitation of the Tailings Dam, the Copper Heap Leach Pile and Dysons Open Cut;
- rehabilitation of Whites and Intermediate Open Cut pits;
- rediversion of the East Branch of the Finniss River; and,
- other works.

The approach to each of these aspects and the design philosophy adopted for their implementation is discussed in this chapter of the report.

A constraint in the establishment of the rehabilitation criteria for the Project is the climatic conditions at the site. Situated in the "Top End" of Australia, Rum Jungle is characterised by a typical monsoonal climate with an average annual rainfall of 1,400 mm which falls largely during the period from October to May. High intensity rainfall events occur during thunderstorm activity in the early wet season and steady falls occur during the latter part of the wet season (January to March). Even so, this season is marked by significant variability. Generally very little rain falls during the remainder of the year (the dry season). High average temperatures are experienced throughout the year as well as high evaporation rates.

A basic element of the design philosophy adopted at Rum Jungle was to utilise engineered solutions replicating as far as was appropriate systems natural to the area.

The design criteria discussed below are based on the agreed objectives upon which those criteria developed in the Final Engineering Report were based, and which are described in Chapter 3 of this report.

6.1 Rehabilitation of the Overburden Heaps

Studies carried out by the AAEC (References 62, 64, 71, 72 and 74) illustrate the effects that pyritic oxidation and the transport of the products of that

oxidation have had on the environment of the Rum Jungle area, as well as illustrating the mechanisms involved in the oxidation process.

Prior to the rehabilitation of Rum Jungle, rainwater entering the heaps by surface infiltration and oxygen entering the heaps via diffusion and convection support bacteriologically catalysed chemical oxidation of the pyritic overburden. This produces sulphuric acid and dissolved metals at levels toxic to aquatic flora and fauna. The acids and heavy metals are transported from the overburden heap by rainfall infiltration and runoff where they impact both surface water and groundwater. It was estimated (Reference 62) that in excess of 60% of incident rainfall infiltrated the heaps. A significant proportion of this infiltration contributed directly to aquifer recharge, carrying with it the products of the oxidation process. The remainder of the infiltration left the heaps either via evaporation or as acidic springs around the base of the heaps.

It was estimated that in the 1975 to 1977 wet seasons the average annual release from Whites Overburden Heap was of the order of 2500 tonnes of sulphate and 12 tonnes of copper, the vast majority of this being released to groundwater (Reference 74).

The overall effect on the environment was manifold and obvious.

Areas to the northeast and southwest of Whites Heap, to the south of Dysons Heap and the western toe of Intermediate Heap were denuded of vegetation due to the outward movement of toxic water from the heaps (Figure 6.1 and Plate 6.1). The chemistry of the material comprising a large proportion of the surface of the heaps was toxic to vegetation. Downstream, Fitch Creek and the East Branch of the Finniss River had significant areas which were similarly denuded of vegetation (Plate 6.12). The river system itself was largely devoid of aquatic fauna. It has also been speculated that the acid and heavy metal pollution leaving the heaps contributed substantially to the state of Whites and Intermediate Open Cut pits.

Design details for the overburden heaps, following the philosophy of the adopted strategy, were established during of the design of Stages 1 and 2 of the Project. These design criteria were developed for the rehabilitation of Whites Overburden Heap. These basic criteria and some standard design details were later applied to the rehabilitation of the other overburden heaps and to the general construction of cover systems on the site. Modifications were made to these details as dictated by the specific requirements of the areas being rehabilitated.

Some design features such as drainage channels are common to several areas of the rehabilitation works.

Greater detail of the various requirements is included in the specifications and drawings for the various works.

6.1.1 The Rehabilitation Strategy

The rehabilitation strategy for the overburden heaps was to minimise infiltration of rain water and hence reduce the transport of pollutants out of the heaps. Measures to reduce water infiltration might also reduce the infiltration rate of oxygen into the heaps. This was seen as a possible additional benefit as a reduction in oxygen supply reduces the rate at which acid and, possibly, other pollutants are produced.

Another important requirement for the design of the works was the minimisation of future maintenance of the rehabilitated heaps (and other rehabilitated areas). In order to achieve this, all drainage structures were engineered, and use was made where practical of naturally occuring materials.

The design life of the works was to be one hundred years. The effect of this criteria is described in Appendix A.

The design strategy detailed below was aimed at satisfying these rehabilitation criteria which had been developed from the rehabilitation objectives.

6.1.2 Chemical Treatment

Where investigation showed that excessively acidic heap surfaces could be beneficially treated to reduce that acidity, those surfaces were to be treated with lime at rates derived from an analysis of the acidity of the surface material.

Correction of this acidity was aimed at providing a neutral buffer against the possible rise into the cover system of toxic salts which would, if uncontrolled, be detrimental to the vegetation established on the heap.

6.1.3 Reshaping, Erosion Control and Drainage

(i) Reshaping

The overburden heaps were originally constructed during the development of mine open cuts by end dumping of spoil material from tipheads established along a centrally placed haul road. This resulted in heaps with precipitous external slopes at the angle of friction

of the dumped spoil, with the heap surface generally graded internally towards the original haulroads (Plate 6.1).

Reshaping of each heap was aimed at creating a landform with more stable external slopes (batters) on which surface erosion could readily be controlled and internal slopes (top surface) grading to a formal drainage system for control of runoff.

Separate criteria were developed for the reshaping of the batters and the top surfaces as below.

(a) The Batters

The reshaping of the batters had to satisfy the requirement that the grades were flat enough to enable draining without unnecessary risk of erosion damage and, at the same time, minimising the cost of construction. Additionally the grade selected had to be practical in that it was a requirement for construction traffic to safely traverse the batters during their construction.

A batter slope of one vertical to three horizontal was selected as satisfying these criteria.

In the case of Whites Overburden Heap, where the total vertical height of the batter varied from 12 to 19 metres, a berm was constructed around the reshaped heap at mid height to enable greater control of stormwater and to reduce the length of overland flow on the batter slope (Plate 6.2).

(b) The Top Surfaces

The top surfaces of the heaps had to be shaped such that erosion control and drainage could be effected at minimum cost and controlled runoff assured. A minimum surface gradient of 1% and a maximum gradient of 10% were selected as satisfying these requirements. The top surfaces of the heaps were graded inwards from the outer rim toward the drainage lines to limit overflow of the rim.

(ii) Erosion Control

In addition to the application of covers and vegetation to control erosion of heap surfaces which is discussed in Sections 6.1.4 and 6.1.5 below, graded banks were constructed on the near horizontal surfaces of the top of the heap to divide the surface into relatively small sub-catchments to enable the control of overland flow velocities thus reducing erosion.

Bank spacings were calculated using the horizontal interval concept as per the following formula:

$$HI = 0.3\ K\ S^{-1/2}$$

Where;

HI = Bank spacing (m)
K = Constant
S = Slope percentage (%)

The value of the constant "K" which is modified by soil erodibility, land use and annual rainfall was based on experience in northwest NSW and a figure of 500 was selected following discussions between the Conservation Commission and the design consultants.

Bank and channel dimensions were calculated using Manning's formula for open channel flow from runoff calculated using the Rational Method to establish peak discharge.

The formula for the Rational Method of calculating peak discharge is:

$$Q = \frac{CiA}{360}$$

Where;

Q = Peak discharge (m^3/s)
i = Rainfall intensity (mm/hr)
A = Catchment area (ha)
C = Runoff coefficient

Manning's formula was used to establish channel dimensions:

$$V = \frac{R^{2/3} S^{1/2}}{n}$$

Where

V = Velocity of flow (m/s)
R = Hydraulic radius (m)
S = Slope of drain (m/m)
n = Manning's "n"

The maximum velocity of flow in the grass lined channels of the erosion control drains was selected as 1.2 m/s to limit scour of the channel, and the maximum gradient for the erosion control drains was selected as 1% (being adequate to maintain flow in the channel), with the grade steepening to 2% at the outlet.

Erosion control drains on the overburden heaps discharged to the drainage system with outlets protected from erosion and scour with Reno mattresses and rip rap lining. The steeper end-section of the drain was protected with erosion control mesh.

The steep batters of the heap were covered with a uniformly graded rock mulch which was designed to carry water at low velocity through the voids and so reduce erosion of the underlying cover materials. The details of the rock mulch (zone 3A material) are discussed below.

(iii) Drainage

The design of the drainage on the heap is a key element in the rapid transport of the runoff away from the heap (see also Appendix A). This restricts infiltration and limits the amount of water available to infiltrate the heap below the cover system.

As for erosion control banks, peak discharge was calculated by the Rational Method for the various catchment areas on the heaps, using a runoff coefficient of Ø.75. Manning's formula was used to establish channel dimensions.

Channel protection of either rip rap or Reno mattress was selected. Selection depended on the calculated maximum flow velocity in the channel. Both rip rap and mattress channel protection were

underlain with geotextile fabric to prevent basement scour.

Table 6.1 details the criteria used for the selection of channel protection.

Table 6.1

SELECTION OF CHANNEL PROTECTION

Maximum Velocity	Channel Protection
1.2 m/s	Vegetation
3.5 m/s	Rip rap
5.Ø m/s	Reno Mattress

In the case of Whites Overburden Heap, there were additional elements in the drainage system - the drainage of the berm, subsoil drainage around the base of the heap and a drain around the perimeter of the heap at the toe of the heap. (Intermediate Heap also utilised a drain around part of the perimeter of the toe.)

(a) Berm Drainage

As noted in Section 6.1.3, Whites Overburden Heap was reshaped incorporating a berm at approximately mid height around the batter of the heap. The primary function of this berm was to break the batter slope into shorter downhill sections and thus enable greater control of overland flow. In order to render this control effective, a drainage system was incorporated in the berm. This drainage system comprised half round pipes along the berm draining to outlets and drop down drains to the toe drain, with energy dissipators at the outlet of the drop down drain. Refer to Figure 6.2 for details.

(b) Subsoil Drainage

Prior to the rehabilitation of Whites Overburden Heap, polluted groundwater was observed leaving the heap in the form of springs on the northeast and southwest sides. In order to control the groundwater flow, which could reasonably have been expected to continue for some time after the completion of the

rehabilitation works, a subsoil drainage system was constructed to intercept groundwater at the interface between the original ground surface and the underside of the overburden heap in the areas where the springs had been observed. Refer to Figure 6.3 for details of the subsoil drainage.

(c) Toe Drain

The stormwater runoff from, in the case of Whites Heap, the lower section of the batter and in the case of Intermediate, the entire batter slope, is collected and controlled in a toe drain running around the perimeter of the heap at its base. This drain is an open, rip rap lined channel outfalling to Wandering Creek, Fitch Creek and the East Finniss diversion channel. Refer to Figures 6.2, 6.4, and 6.8 for details.

6.1.4 Covers

Together with the drainage system, the cover system forms a major component of the rehabilitation strategy for the overburden heaps and is a key factor in the limitation of infiltration and the support of vegetation.

The criteria for the design of the cover system is comprised of a set of objectives, several of which are conflicting and which are summarised below.

(i) The cover system should possess low permeability to minimise infiltration.

(ii) The covers should be well drained and free from depressions and hollows which could contribute to the retention of water.

(iii) The cover system should support a vegetation cover to maximise the capacity of the upper soil zones to intercept, store and later evapotranspire rainfall and, to provide erosion resistance once the vegetation has developed.

(iv) The covers should be resistant to erosion at the slopes of the reshaped heaps before vegetation is fully established.

(v) The cover system should be of the minimum thickness compatible with the performance objectives to minimise costs of

construction and to economically use resources.

(vi) The construction of the cover system should be simple and should maximise the use of locally available materials without, where possible, the need for processing those materials.

The cover system designed on this set of criteria was a three zoned system, the construction of which differed between the upper surface of the heap and the batters.

(i) The Heap Surface

The top surface of the heaps, which, after reshaping were characterised by relatively flat uniform gradients, were covered with the following three zoned system.

Zone 1A - Moisture Barrier

The uppermost surface of the reshaped heap was rolled to form a thin crushed rock filter zone over which Zone 1A was placed.

The Zone 1A layer of the cover system is the infiltration resistant layer and is constructed from a compacted clayey material. Typical properties of the material and specifications for its placement are set out below.

(a) Material Characteristics

- Permeability after placement and compaction - in the range of 10^{-6} to 10^{-7} cm/s
- Compacted density - greater than 1.8 t/m^3
- Minimum thickness of compacted clay - 225 mm
- Material type - lateritic clay

(b) Material Specifications

- Grading of Zone 1A material:

Sieve Size (mm)	% Passing
75	100
19	90-100
2.36	75-100
0.425	50- 90
0.075	35- 80

- Liquid limit: not less than 40 and not greater than 65
- Plasticity Index: not less than 15
- Maximum particle dimension: 75 mm

(c) Placement Specifications

- Minimum total thickness of zone: 225 mm
- Maximum layer thickness: 150 mm compacted thickness
- Compaction: minimum of 98% of standard maximum dry density
- Moisture content: maximum of 1% above optimum moisture content and a minimum of 3% below optimum moisture content

Zone 1B - Moisture Retention Zone

The Zone 1B layer of the cover system constitutes the moisture retention zone. Moisture retained in this layer supports the vegetation during the dry season and provides a moisture source to assist in the prevention of desiccation of the Zone 1A layer.

(a) Material Characteristics

- Material type: sandy clay loam
- Compaction: material to be loosely compacted
- Minimum thickness: 250 mm

(b) Material Specifications

- Grading of Zone 1B material:

Sieve Size (mm)	% Passing
150	100
75	90-100
19	85-100
2.36	45- 80
0.425	30- 60
0.075	20- 45

- Liquid limit: not less than 30 and not greater than 60
- Plasticity Index: not less than 10
- Maximum particle dimension: 150 mm

(c) Placement Specifications

- Minimum total thickness of zone: 250 mm

. Maximum layer thickness: 150 mm compacted thickness
. Compaction: minimum of 90% of standard maximum dry density
. Moisture content: maximum of 2% above optimum moisture content and a minimum of 2% below optimum moisture content

Zone 2A - Erosion Resistant Zone

The Zone 2A material forms the upper layer of the three zoned cover system and, in addition to providing resistance to the erosive forces of rainfall and runoff, forms the seed bed for the vegetation and acts as a pore breaking zone to restrict moisture loss due to evaporation during the dry season.

(a) Material Characteristics

. Material type: well graded gavelly sand
. Compaction: placed in a loose state
. Permeability: greater than 10^{-5} cm/s

(b) Material Specifications

. Grading of Zone 2A material:

Sieve Size (mm)	% Passing
150	100
75	90-100
19	65- 95
2.36	25- 60
0.425	18- 40
0.075	10- 30

. Liquid limit: not greater than 40
. Plasticity Index: not less than 15
. Maximum particle dimension: 150 mm
. Sulphate soundness: weight loss of coarse fraction not less than 30% in 5 cycles

(c) Placement Specifications

. Minimum total thickness of zone: 150 mm

(ii) The Batters

The cover system adopted for the batters was, with the exceptions noted below, similar to covers applied to the tops of the heaps.

These exceptions were:

(a) Cover Thicknesses

The thicknesses of the batter cover materials were increased to take account of the higher potential for erosion on the batters and the potentially greater difficulty in placing covers on the batters. The thicknesses specified were:

Zone 1A	300 mm
Zone 1B	300 mm
Erosion layer	150 mm

(b) Erosion Barrier

With the maximum batter slope of one vertical to three horizontal, the erosion protection requirements for these areas of the heaps was considerably higher than for the relatively gentle slopes on the top surface of the heaps. Consequently the material required for this protection was considerably coarser than that specified for the top surface..

Material Characteristics

- Grading: uniformly graded with a low proportion of non-plastic fines
- Material type: competent crushed rock
- Minimum thickness: that thickness compatible with construction techniques

Material Specifications

- Grading:

Sieve Size (mm)	% Passing
150	100
75	50-100
19	0- 30
2.36	0- 10

- Maximum particle dimension: 150 mm
- Sulphate soundness: weight loss of coarse fraction not less than 30% in 5 cycles

General details of the cover system are illustrated on Figure 6.2.

6.1.5 Revegetation

The final phase of the rehabilitation of the overburden heaps is their revegetation. The prime requisite of the revegetation programme on the heaps is to stabilise the heap surfaces against the long term effects of erosion.

The essential criteria for the selection of species for vegetating the heaps included:

(i) ability to quickly establish and stabilise the heap surfaces;
(ii) ability to withstand the harsh climatic conditions of the Northern Territory;
(iii) ability to perenniate with little or no maintenance;
(iv) ability to establish on the particular cover systems used on the heaps;
(v) be readily available from commercial seed suppliers; and,
(vi) be shallow rooting so as not to penetrate the low permeability clay layer.

Based on these criteria, a "shotgun" mixture of species was selected. This was comprised of improved pasture grasses and legumes. The requirement for shallow rooting species precluded the use of trees on covered areas. Sowing rates and techniques varied depending on specific locations and conditions.

Table 6.2 details typical seed species and sowing rates for the various typical areas of heap rehabilitation. Seeding techniques are listed in Table 6.3.

The seed bed (Zone 2A and Zone 3A materials) were largely devoid of soil nutrients because of their sources and accordingly, application of fertiliser was required to assist in the establishment of vegetation. Heavy rates of fertilizer, up to 400 kg/ha, were applied. A compound N:P:K fertilizer such as 'Tropigro' 10:9:7 was used and the heavy rates compensate for the lack of vital elements present in the plant rooting medium.

During the first growing season maintenance dressings of nitrogenous fertilizer at 100 kg/ha were scheduled at four and eight weeks after germination. In addition, the vegetation was monitored closely for signs of nutrient deficiency. Should this occur, the deficient element was applied as an additional maintenance dressing.

Table 6.2

SEED SPECIES SOWN ON TOP SURFACE, BATTERS, SURROUNDS AND CHANNELS OF OVERBURDEN HEAPS

Species Name	Common Name	Sowing Rate kg/ha
Top Surface: Seed Mix t		
Sorghum bicolor	Hybrid dwarf sorghum	4
Chloris gayana	Rhodes grass	3
Brachiaria decumbens	Signal grass	4
Cynodom dactylon	Speedy green couch	1
Paspalum notatum	Pensacola Bahia grass	4
[1]Styosanthes guianensis cv Graham	Graham stylo	6
[1]Styosanthes hamata cv Verano	Verano stylo	4
		26
Digitaria decumbens	Pangola grass	Runners at Ø.5 metre centers
Batters: Seed Mix b		
Chloris gayanaa	Rhodes grass	6
Brachiaria decumbens	Signal grass	6
Cynodom dactylon	Speedy green couch	2
[1]Stylosanthes scabra cv. Seca	Seca stylo	4
[1]Macroptilium atropurpureum	Siratro	2
[1]Calopogonium mucunoids	Calopo	4
		24
Surrounds: Seed Mix s		
Sorghum bicolor	Hybrid dwarf sorghum	4
Chloris gayana	Rhodes grass	5
Paspalum notatum	Pensacola Bahia grass	4
[1]Stylosanthes hamata cv. Verano	Verano stylo	5
		18
Channels: Seed Mix c		
Chloris gayana	Rhode grass	5
Brachiaria mutica	Para grass	1Ø
Paspalum plicatulum cv. Bryan	Bryan Plicatulum	1Ø
		25

[1] Legumes

TABLE 6.3

SEEDING TECHNIQUES FOR OVERBURDEN HEAPS

Code	Technique	Application
B	Broadcast by blower or spreader	.Rock mulch batters .Straw mulched areas
D	Contour drill seeding	.Flat to gently undulating slopes .Straw mulched areas
M	Bituminous straw mulching	.Slopes between 5% and 20% .Erosion control banks .Slopes leading to drainage lines
MN	Straw mulching and netting	.Slopes with overland flow
F	Erosion control fabric pinned over seeded surface	.Vegetated channels with moderate water flows
P	Propagation of Pangola runners	.Narrow strip around outer edge of top surface

In the second, third and fourth seasons reduced maintenance dressings of nitrogen and phosphorous were applied to maintain a balanced pasture sward, but not at a rate that prevented native grasses from colonising the surfaces.

Steeper areas of the surface were protected against surface erosion and scour by the use of bituminous hay mulching and erosion control mesh on slopes greater than 10%.

The result of reshaping, erosion control and drainage on Whites, Dysons and Intermediate Overburden Heaps is shown in Figures 6.4 to 6.8. Plates 6.1 and 6.4 show the results for Whites and Intermediate Overburden Heaps.

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6.2 Tailings Dam, Copper Heap Leach Pile and Dysons Open Cut

Although the problems associated with the Old Tailings Dam, the Copper Heap Leach Pile and Dysons Open Cut were significantly different, they are treated together because of the inter-relationship of their rehabilitation.

Tailings Dam

During the period from the commencement of uranium treatment in 1954, to the redirection of the tailings to Dysons Open Cut in 1961, unneutralised tailings from the plant were discharged to an area to the east of the treatment plant (the Old Tailings Dam).

The tailings were partially contained in sub-impoundments. A wall was constructed across the downstream end of the dam and the supernatent liquor was discharged over the wall to the Tailings Creek where it entered the Finniss River System. This liquor contained entrained tailing. The dam wall was frequently breached by the wet season rains, allowing significant amounts of tailings to pass down Tailings Creek (see Figure 6.9)

As the waste product of uranium milling, the tailings contained the daughter products of the uranium decay series and were a low level source of radioactivity. The tailings were also acidic and contained a significant amount of heavy metals, particularly copper.

After the abandonment of the Tailings Dam, the wall at the downstream end breached, and erosion and transport of tailings continued unchecked to the extent that a significant amount of tailings has now been deposited in the river system. The toxic nature of the tailings had resulted in the entire area of the dam (some 35 ha) and Tailings Creek being denuded of vegetation (Plates 6.5 and 6.12).

Copper Heap Leach Pile

During the mining of Intermediate Open Cut, the low grade (below mill grade) copper ore was stockpiled in an area between Whites and Intermediate Open Cuts for heap leaching. The leach pile was constructed on an "impervious" base prepared by grading the area and placing a layer of polythene, malthoid and/or bitumen coated hessian. Ancillary to the experiment were a series of ponds adjacent to the original bed of the East Branch of the Finniss River (now known as Copper Creek) and a concrete launder (see Figure 6.11). The experiment was never particularly successful and was abandonded in 1971. An estimated 3,5ØØ tonnes of copper remained, in the form of oxide and sulphide ore.

The copper ore continued to leach and the original "impervious" base has broken down allowing direct infiltration of the products of that leaching process to the shallow groundwater system. The original drainage structures and ponds failed through neglect resulting in uncontrolled contamination of the area with acid and toxic metals.

This process resulted in the area between the two open cuts becoming devoid of vegetation (Plate 6.8). Groundwater and Copper Creek became acidic and polluted with heavy metals.

Dysons Open Cut

Dysons Open Cut was the smallest of the open cut pits on the Rum Jungle mine site (discounting Whites Extended mine) and was excavated during the period from 1957 to 1958.

After the Old Tailings Dam was abandoned in 1961 (and until 1965 when the available capacity was fully utilised) Dysons Open Cut was used to dispose of tailings from the uranium treatment plant (Plate 6.1Ø).

In the investigation programme carried out for the preparation of the Final Engineering Report, Dysons Open Cut was identified as a suitable disposal site for the tailings from the Old Tailings Dam on the basis that:

- it already contained a significant volume of tailings;
- it was a geomorphologically stable site; and,
- once filled, the resulting landform could readily be shaped to shed water, thus minimising infiltration.

6.2.1 The Rehabilitation Strategy

The rehabilitation strategy for the Old Tailings Dam and the Copper Heap Leach Pile was directed at the complete removal of the contaminant source and the disposal of those contaminants (the tailings, the low grade copper ore and the associated contaminated soils) in a safe and permanant site (Dysons Open Cut). The areas previously occupied were then rehabilitated.

The disposal strategy for the tailings in the Old Tailings Dam outlined in the Final Engineering Report called for the disposal of the subsoil from the Old Tailings Dam into Whites Open Cut. Investigations carried out during the detailed design for this phase of the works showed that, contrary to previous expectations, there was sufficient room within Dysons Open Cut to accommodate this subsoil

with the other materials. The placement of the subsoil within Whites Open Cut was not regarded as a viable solution for the disposal of the subsoil due to:

- The requirement to double handle the subsoil (treatment of Whites Open Cut was not scheduled for completion until after the completion of the rehabilitation of the Old Tailings Dam); and,

- The undesirable aspects of adding solids to the open cut after treatment.

When all material was disposed of, Dysons Open Cut was covered, drained and revegetated.

This strategy, and the relevant design criteria are discussed in more detail below.

6.2.2 The Old Tailings Dam

(i) Earthworks

As noted above, the underlying strategy for the rehabilitation of the Old Tailings Dam was the removal of the tailings, together with any contaminated subsoil and their disposal in Dysons Open Cut in accordance with:

(a) Code requirements: all earthworks on the Old Tailings Dam to be carried out strictly in accordance with the requirement of the Code of Practice on Radiation Protection in the Mining and Milling of Radioactive Ores published by the Australian Government Publishing Service in 198Ø.

(b) Material to be removed: all tailings, as identified by the colour change from the grey tailings to the red-brown subsoil to be removed and subsoil to be removed to a depth where the external gamma radiation, measured one metre above the ground surface was less than Ø.6 uGy/hr.

(c) Reshaping: once all tailings and contaminated subsoil had been removed the area was reshaped to control drainage, falling evenly to a central drainage line (see Figure 6.1Ø).

(ii) Chemical Treatment

The soil profile remaining after the contaminated material had been removed was still acidic and toxic to plant

growth. Accordingly, the area was treated with hydrated lime as follows:

(a) Sampling: sampling to be based on a 50m grid, with 4 samples to a depth of 150 mm at each intersection point.

(b) Testing: each set of 4 samples to be bulked and the saturation paste analysed for pH, EC and lime requirement.

(c) Incorporation: lime to be spread and mixed into the top 150 mm of the soil profile.

(iii) Erosion Control and Drainage

Erosion control contour drains and open lined drains to be constructed on the reshaped surface as described below. Relevant requirements for the design of drainage systems are similar to those adopted as discussed in Section 6.1.3 with the exception of the erosion control drain spacing. This is to be determine zd by the application of the horizontal interval formula in Section 6.1.3 (ii) but with a maximum catchment area of 2 ha.

(iv) Covers

The primary purpose of covers on the Old Tailings Dam area is to provide a suitable medium for the establishment of vegetation on the surface. A single layer cover comprising a minimum thickness of 300 mm of Zone 1B material (as defined in Section 6.1.4) was selected for this area.

(v) Revegetation

The criteria for the selection of revegetation species for the Old Tailings Dam was similar to that outlined in Section 6.1.5 with the modified requirement that the presence of deep rooting species was not detrimental to the performance of the cover system. The species selected for the overburden heaps were supplemented with native tree and shrub seed stock as per Table 6.4.

Table 6.4

SUPPLEMENTARY SEED SPECIES
SOWN ON TAILINGS DAM

Species Name	Common Name	Sowing Rate g/ha
Seed Mix n		
Acacia dimidiata	Wattle	150
A. auriculiformis	Wattle	200
A. difficilis	Wattle	100
A. holosericea	Wattle	150
A. Montfordiae	Wattle	100
Eucalyptus bleeseri	Cabbage gum	50
E. miniata	Woolly butt	50
E. papuana	Ghost gum	50
E. polycarpa	Bloodwood	50
G. pteridiifolia		50
Melaleuca viridiflora	Paperbark	50
		1000

The striking effects of these rehabilitation measures on the Old Tailings Dam is shown in Plates 6.5, 6.6 and 6.7. The effect of rehabilitation of Tailings Creek is shown in Plates 6.12 and 6.13.

6.2.3 Copper Heap Leach Pile

The rehabilitation strategy for the Copper Heap Leach Pile area consisted essentially of the complete removal of the pollutant source. This source consisted of the the low grade copper ore which made up the heap leach pile, the surrounding structures and a significant amount of contaminated soils. The detailed strategy is:

(i) Earthworks

(a) Material to be removed: all low grade ore from the Copper Heap Leach Pile, together with contaminated subsoil to a depth of 450 mm under the Copper Heap Leach Pile and 300 mm elsewhere to be removed and placed in Dysons Open Cut.

(b) Structures to be removed: the copper launders, the evaporation ponds, holding ponds and associated concrete pads and footings to be removed and placed in Dysons Open Cut.

(c) Reshaping: after removal of the Copper Heap Leach Pile, associated subsoil and structures, the remaining area to be reshaped (and filled if required) to form even grades and to fall towards Copper Creek (see Figure 6.12).

(d) Subsoil Drainage: subsoil drainage system to be designed to encourage leaching of the contaminated subsoil.

(ii) Erosion Control and Drainage

Erosion control drains to be designed as per Section 6.1.3.

Due to the gently sloping nature of the finished surface, no other drainage measures were required.

(iii) Covers

The cover system for the Copper Heap Leach Pile had to be designed to take account of the highly mobile and toxic metals in the near surface zones under the pile and in the area surrounding the heap. The cover system also had to allow for the potential of these metals to be brought to the surface by capillary action if a one layer cover were used. The system specified for this area was a four layer zoned system comprising:

(a) Zone 3B - Anti-capillary layer

Material Characteristics
- Relatively permeable material with low fines content
- Chemically sound so as not to break down in the acidic groundwater conditions
- Minimum thickness of 250 mm

Material Specifications
- Particle sizes: ranging between 50 mm and 200 mm
- Maximum of 5% retained on a 0.075 mm sieve
- Maximum particle size: that size which can be incorporated within a layer 250 mm thick

Placement Specifications
- Minimum total thickness of zone: 250 mm
- Compaction: by passage of construction plant

(b) Zone 1A - Moisture Barrier
Zone 1B - Moisture Retention Zone
Zone 2A - Erosion Resistant Zone

The specifications for these zones are detailed in Section 6.1.4.

(iv) Revegetation

The revegetation requirements for the Copper Heap Leach Pile area were similar to those for the zoned cover systems on the overburden heaps and are detailed in Section 6.1.5.

The effect of these rehabilitation measures on the Copper Heap Leach Pile and surrounds is shown in Plates 6.8 and 6.9.

6.2.4 Dysons Open Cut

Dysons Open Cut was selected as the disposal site for the materials from the Old Tailings Dam and the Copper Heap Leach Pile area.

Detailed criteria for the disposal of these materials were:

- to ensure that the tailings are isolated from the environment;
- to ensure that any porewater released from the contained materials is controlled;
- to reduce as far as is practical, ongoing oxidation of the low grade ore from the Copper Heap Leach Pile; and,
- if such oxidation does occur, to prevent the transport of the products of that oxidation to the environment.

Strategies adopted to meet these detailed criteria are shown in Figure 6.13 and described below:

(i) Earthworks

The earthworks for Dysons Open Cut comprised the filling of the open cut with the material from the Old Tailings Dam, the Copper Heap Leach Pile area, together with the tailings removed from Tailings Creek and material removed during the cleanup of Copper Creek.

(a) Tailings disposal

Tailings from the Old Tailings Dam and from Tailings Creek to be placed in Dysons Open Cut directly above the existing tailings and contained

within the lower portion of the open cut.

(b) Copper Launders

The copper launders from the Copper Heap Leach Pile area to be demolished and placed in Dysons Open Cut with the tailings.

(c) Rock Blanket

A rock blanket of one metre nominal thickness constructed on a geotextile fabric layer over the placed tailings provided a drainage path for any porewater released from the tailings during consolidation under the surcharge loading. This rock blanket was connected to the subsoil drainage system and also provided a construction platform for placing and compaction of material above the level of the tailings.

In order to intercept any groundwater entering the fill material from the high side of the open cut (northern and western sides), the rock blanket was extended up the face of the original open cut above the level of the tailings.

The specifications for the rock blanket were as below.

- Geotextile fabric: a single layer of high strength woven polypropylene geotextile fabric on the finished surface of the tailings, minimum lap of 300 mm.

- Rock blanket:minimum layer 1000 mm thick of dolomitic rock, sized between 100 mm and 750 mm, recovered from Intermediate Overburden Heap.

(d) Copper Heap Leach Pile Material and all Soils

The Copper Heap Leach Pile material and all soils to be placed in alternating layers and compacted on top of the rock blanket in Dysons Open Cut in accordance with the following.

- Layer thicknesses: maximum compacted thickness of layers of Copper Heap Leach Pile material to

be 1000 mm and soils to be maximum of 300 mm compacted thickness.

- Compaction requirements

  0 to 2 metres above rock blanket: 90% of standard maximum dry density.

  2 metres above rock blanket to surface of fill: 95% of standard maximum dry density.

- Shaping: the finished surface shall be shaped such that batter slopes comply with the requirements as set out in Section 6.1.3.

(ii) Erosion Control and Drainage

The completed landform (see Figure 6.14 and Plate 6.11) was designed to slope inward from the rim and with an overall grade to the eastern end. The overall grade of the surface was expected to approach 5% and erosion control banks were incorporated in the design to control overland flow. The design criteria for these banks are discussed in Section 6.1.3 above.

Two drainage systems were specified; an open, lined drain collecting surface runoff and a subsoil drainage system to control released porewater and infiltrating water.

Drainage on the top of the fill had the additional requirement that grades should be adequate to maintain the function of the drains in the event of substantial settlement of the central area of the landform.

In order to prevent surface runoff from the higher area to the northwest of Dysons Open Cut from flowing onto the filled area, a cutoff drain was specified around the western and northern sides of the open cut, outfalling to the east of the open cut together with the main drain from the fill.

The design criteria for the surface drains on Dysons Open Cut were the same as those for the overburden heaps and are described in Section 6.1.3.

The subsoil drainage, which was provided to control infiltrating water and released porewater, was specified along the downslope side of the landform. The criteria for this drain were as below.

(a) General

- Location of drain: commencing on the western most corner of the open cut and extending along the south-western and south-eastern (downslope) sides of the open cut at the toe of the batter slope.
- Depth of drain: invert level a minimum of 5ØØ mm below the original natural surface level, with the granular fill extending to the underside of the cover system.
- Minimum grade: one vertical to 3ØØ horizontal.
- Pipe: 15Ø mm diameter UPVC slotted, corrugated pipe.

(b) Filter drain

- Minimum dimensions: 65Ø mm deep and 45Ø mm wide fully encased in geotextile fabric.
- Material characteristics: to consist of hard durable stone having a Los Angeles Abrasion Loss of not greater than 35%.
- Filter material grading:

Sieve Size (mm)	% Passing
37.5	1ØØ
19.Ø	9Ø - 1ØØ
9.5	65 - 85
4.75	45 - 65
Ø.6Ø	Ø - 5

(iii) Covers

The cover system for Dysons Open Cut was similar in concept to that adopted for the overburden heaps with the notable exceptions of the thickness of the zones and the incorporation of a filter zone on the underside of the covers of the batters (see Figure 6.13).

(a) Thickness of Zones

The thicknesses of the zones comprising the covers for the fill material of Dysons Open Cut were increased over those of the overburden heaps to take account of the possibility of settlement of the fill material and to provide an increased degree of infiltration resistance desirable because of the nature of the materials confined in the open cut.

. Cover thicknesses

Cover thicknesses adopted for Dysons Open Cut were:

Top surface -	Zone 1A	300 mm
	Zone 1B	300 mm
	Zone 2A	150 mm
Batter slope -	Zone 1A	450 mm
	Zone 1B	300 mm
	Zone 3A	250 mm

(b) Filter Layer

In order to control any infiltration through the batter cover system, a filter zone was included on the underside of the covers. The filter zone transports any collected water to the subsoil drain. The specifications for the filter zone were.

. Filter material: non pyritic crushed rock.

. Grading:

Sieve Size (mm)	% Passing
75	100
19.0	70 - 96
2.36	30 - 60
0.425	10 - 40
0.075	5 - 20

. Plasticity index: 2 - 6
. Compaction: minimum of two passes of an approved track type dozer.
. Thickness: minimum thickness of 250 mm.

(iv) Revegetation

The revegetation requirements for the area were similar to those for the heaps.

6.3 Whites and Intermediate Open Cuts and the Water Treatment Plant

On completion of the removal of all of the economically recoverable ore from the open cuts, the dewatering was discontinued and the pits were allowed to fill with groundwater and, in the case of Whites Open Cut, surface water from the East Branch of the Finniss River.

During the period from 1965 until the close of the plant in 1971, Whites Open Cut was used for the disposal of tailings from the treatment plant as well as, towards the end of the life of the mine, an integral part of the containment policy for plant wastes.

As a result of these practises and of polluted water entering the open cuts, both Whites and Intermediate Open Cuts were acidic and contained significant concentrations of heavy metals. The pollution status of the open cuts is described in several of the reports referenced in Chapter 16 and is summarised in Table 6.5.

The pollution from Whites and Intermediate Open Cuts was entering the East Branch of the Finniss River by seepage through the pit walls into the groundwater system. As noted in Table 3.2, both Whites and Intermediate Open Cuts contributed significantly to the pollution of the river system.

The rehabilitation strategy identified in the Final Engineering Report as being appropriate to the open cuts included the construction of a water treatment plant and the treatment of the water contained in the open cuts with lime to neutralise and precipitate heavy metals to design targets. The removal of the solids so produced was achieved by filtration. The target water quality for this treatment is set out in Table 3.3 of this report. It was estimated that water of this quality would have a density of approximately 1001 kg/m^3, compared with the density of the contaminated water which ranged from 1004 to 1012 kg/m^3 in Whites Open Cut and approximately 1002 kg/m^3 in Intermediate Open Cut.

Detailed sampling and analysis of both open cuts revealed significant differences in the chemical composition of their vertical profiles.

Whites Open Cut

The analysis showed that Whites Open Cut was vertically stratified to the extent that the density difference between the upper and lower levels of the pit was of the order of 6 to 8 kg/m^3, with the heavier and more polluted water in the lower levels of the pit (below 15 metres from the surface)

Intermediate Open Cut

The analysis of Intermediate Open Cut revealed that there was very little density change from the top to the bottom of the pit and that the chemical composition of the vertical profile was approximately constant.

This Final Engineering Report strategy was further developed by the project consultants, and the following criteria were selected.

Table 6.5

COMPARISON OF PIT WATER QUALITY BEFORE TREATMENT WITH TARGET PIT WATER QUALITY

Pollutant	Concentration (mg/L) Before (see note) Whites	Intermediate	Target Both
Copper	55	6Ø	1.5
Iron	44Ø	Ø.9	1.Ø
Manganese	23Ø	53	1.Ø
Zinc	8	6.5	5.Ø
Chromium	Ø.55	Ø.Ø8	Ø.1
Cadmium	Ø.21	Ø.Ø4	Ø.1
Arsenic	Ø.45	Ø.ØØ3	Ø.Ø5
Barium	< Ø.ØØ2	< Ø.Ø2	1.Ø
Lead	Ø.6	Ø.Ø38	1.1
Silver	Ø.11	Ø.13Ø	Ø.1
Mercury	< Ø.ØØ1	< Ø.ØØØ	Ø.ØØ5
Selenium	< Ø.ØØ5	< Ø.ØØ5	Ø.ØØ1
Nickel	15	12	1.Ø
Cobalt	15	13.6	1.Ø
Radioactivity (pCi/L)	2363	865	5.Ø
pH	2.6	3.7	7.Ø
Calcium	445	2ØØ	1ØØØ
Sulphate	84ØØ	28ØØ	2ØØØ

Note : Chemical analysis of the water contained in the open cut pits is based on information in the report by Alcock and Connolly (Reference 5), with the chemical content of the water at 15 metres below the surface being selected as representative.

6.3.1 Process Engineering

Following the development of the Final Engineering Report further testwork was carried out to fully define the treatment parameters for the design of the treatment plant.

(i) Water Quality

Table 6.5 is a comparison of pit water quality before treatment with the target water quality, and shows the significant improvement in water quality expected as the criteria for the design of the water treatment plant.

(ii) Treated Water Throughput

In order to achieve the completion of the treatment of all of the water contained in both Whites and Intermediate pits, a treated water throughput of 1Ø,ØØØ cubic metres per 24 hour day was selected. Operating on a 6 day per week basis it was then estimated that it would take 47 operating weeks to treat the water in both open cuts.

(iii) Process Flow Diagram

Figure 6.15 shows the general arrangement of the water treatment plant, and Figure 6.16 is a schematic representation of the process design. The location of the plant is shown in Plate 6.9.

(iv) Neutralisation of Raw Water

Table 6.6 indicates the pH at which the various critical heavy metal ions will precipitate from solution.

Table 6.6

APPROXIMATE pH AT WHICH METALS WILL PRECIPITATE FROM SOLUTION

Metal	pH for Precipitation START	COMPLETION
Iron (Ferric)	3.2	4.1
Aluminium	5.Ø	5.5
Copper (Cupric)	6.1	6.9
Zinc	7.2	7.5
Manganese	9.Ø	9.1

Thus the pH of the raw water would have to be raised to 9.5, to give an adequate margin over the estimated level required to complete the precipitation of all of the manganese in solution and thus achieve the target level of 1.Ø mg/L.

In order to achieve this pH the lime dosing levels (for 100% available CaO) were as set out in Table 6.7.

Table 6.7

LIME DOSE RATES
(100% CaO)

Source of Raw Water	Dose Rate (kg/m^3)
Whites (top 10m)	2.89
Whites (lower)	3.51
Intermediate	0.76

(v) Thickening

The neutralised liquor was thickened in primary and secondary clarifiers to achieve a pulp density sufficient to enable economic filtration and final dewatering. The target solids content of the thickened liquor was 6%.

(vi) Filtration

The thickened liquor was passed to a filter press to further separate the precipitated solids from the treated water. The target solids content of the cake formed by filtration was in the range of 30% to 35%.

6.3.2 Water Management Strategy

(i) Whites Open Cut

The strategy for the management of Whites Open Cut utilised the density difference between the treated water and the raw water brought about by the removal of the contaminants from the raw water. It was estimated that the magnitude of this difference would be of the order of 6 kg/m^3. Raw water was to be drawn from well below the surface of the pit and treated water returned via a low velocity discharge structure at the surface. As treatment progressed, the raw water suction line was lowered to the floor of the pit at a rate consistent with the treatment rate until all of the water body had been treated.

Because this pit had been used for tailings and raffinate disposal during the operating life of the mine, an untreated buffer layer was to be left in the bottom of the pit. This buffer layer would ensure that neither

tailings nor raffinate would be drawn into the treatment plant with the raw water.

Because of the very stable stratification achieved (resulting from the large density differential) the energy required to mix treated and untreated water was much higher than the energy available from external sources such as wind, thermal influences and incoming water. The treated water thus forms a layer floating on the untreated water with the potential for mixing by diffusion being very slight (Prof. J. Imberger, University of Western Australia).

(ii) Intermediate Open Cut

The analysis of the polluted water in Intermediate Open Cut showed that the strategy to be adopted to treat the water in the pit would require significant modification before it could be applied to this pit.

Studies had shown that:

- The estimated density difference between the raw water and the treated water would be insufficient to enable the establishment of stratification to separate the raw and treated waters;

- The amount of contaminant in the pit was of such a low level as to render use of the water treatment plant uneconomic; and

- Due to the low level of the contaminant in the pit, the water could be satisfactorily treated in situ.

Accordingly, a strategy of in situ treatment of Intermediate Open Cut was adopted, as shown in Figure 6.17.

The strategy was characterised by:

(a) The water in the open cut was to be overturned and mixed by the energy produced from aeration using a manifold anchored at the floor of the pit;

(b) Once the entire water body was moving, lime was to be added by direct addition of lime slurry introduced into the rising air plume used to provide the energy to destratify the water body;

(c) The pH of the pit water was to be raised to 9.7; and,

(d) After allowing the solids to settle to the floor of the pit, they would be pumped out and dewatered in the water treatment plant.

6.3.3 Filter Cake Disposal

The filter cake, which is the final residue of the treatment process, was to be disposed of as landfill in one of the exhausted borrow pits on the site. The disposal site would be sealed against the ingress of surface water by covering in a similar manner to the overburden heaps and ingress of groundwater would be prevented by a combination of low permeability cutoff walls and rubble drains.

6.4 Rediversion of the East Branch of the Finniss River

The original course of the East Branch of the Finniss River was north of the diversion channel, running over the sites of both Whites and Intermediate ore bodies. In order to develop the ore bodies by open cut methods, the river was diverted in two stages.

During the excavation of Whites Open Cut, the river bed was diverted to the south of its original course, this diversion was later extended to the south and west to allow the mining of Intermediate Open Cut, resulting in the diversion channel as it existed at the start of the Project.

The rediversion of the East Branch of the Finniss River to as near as possible to its original bed, as shown in Figure 6.18, was judged necessary in order to:

- Provide a secure and adequate source of fresh water on a regular basis to ensure the continuing, long term recreational standard water quality in both Whites and Intermediate Open Cuts by annual flushing of the open cuts;
- Provide a source of fresh water for the regular flushing of Copper Creek; and,
- Restore, as far as is reasonably practical, the East Branch of the Finniss River to its original course.

The requirements for the rediversion of the East Branch of the Finniss River were aimed at providing the above flushing effects and satisfying the set of criteria below:

(i) Design Recurrence Interval

As with the remainder of the rehabilitation works, the criteria for the nominal design life of the rediversion works is 100 years. A design recurrence interval of 100 years was selected as appropriate for these works.

(ii) Flushing Effects

One of the main reasons for rediverting the East Branch of the Finniss River was to ensure annual flushing of the open cuts. Recognising that it would be undesirable (and unnecessary) to flush the full depth of Whites Open Cut, it was established that the flushing should be sufficient to ensure that at least the top four metres of each of the open cuts was adequately flushed on an annual basis.

(iii) Early Seasonal Flows

The first flows during any wet season carry a significantly higher proportion of the total annual pollution load than the later flows and are characterised by low flow events. It is obviously undesirable to introduce these flows to the open cuts and provision is made for low river flows to pass via the diversion channel and Copper Creek.

(iv) Peak Flows

To avoid the requirement to design hydraulic structures that would withstand flood flow conditions, the works were designed such that peak flows were routed through the diversion channel.

6.5 Other Works

In addition to the major works addressed above, the following areas are included in other works:

- The rehabilitation of the treatment plant area;
- The rehabilitation of the stockpile area;
- The construction of a fence around the site;
- The rehabilitation of the Acid and Sweetwater dams;
- The removal of small ore stockpiles from around the site; and,
- The general cleanup of the site.

6.5.1 The Treatment Plant Area

The Treatment Plant Area, that is, the area formerly occupied by the uranium treatment plant and located to the north of Whites Open Cut, was partially rehabilitated in 1977 during an earlier cleanup carried out after the closure of the mine. In that cleanup , lead ore and below ore grade uranium ore (Bogum) which had been stockpiled but not treated was used as fill material over the area which had been occupied by the plant in order to make the area conform approximately to the original topography. Subsequently a layer of topsoil was placed over area and then revegetated.

These measures achieved a level of site safety but were insufficient to arrest pollution sources. The area remained toxic and the vegetation did not establish sufficiently to prevent erosion of the topsoil. As a result the area was characterised by a lack of established vegetation and severely scoured slopes, in some areas exposing the previously placed fill materials and necessitating further rehabilitation.

The rehabilitation measures adopted for this area were conceptually similar to the rehabilitation of the Copper Heap Leach Pile (after removal of the low grade ore) and employed a zoned cover system with a porebreaking layer to prevent the rise of toxic salts.

(i) Earthworks

Earthworks required for this area were limited to reshaping and trimming to achieve grades in the range of 1% to 10% and to facilitate drainage.

(ii) Chemical Treatment

The surface material, as well as the underlying fill material in the area, was toxic to vegetation and was consequently treated with lime to condition the top 150 mm of the surface as set out in Section 6.2.2.

(iii) Erosion Control and Drainage

Erosion control banks were specified for the area as set out in Section 6.1.3.

The erosion control drains discharged to an open, rip rap lined drain designed in accordance with the criteria set out in Section 6.1.3.

(iv) Covers

Due to the presence of underlying toxic material, the cover system specified for this area was a low permeability cover system incorporating a porebreaking zone under the infiltration resistant layer. The cover system was identical to that used for the Copper Heap Leach Pile and is described in Section 6.2.3.

(v) Revegetation

The revegetation of this area was identical to that used on the heap surfaces and is described in Section 6.1.5.

6.5.2 The Stockpile Area

The Stockpile Area is that area to the north, east and southeast of the Treatment Plant Area which was previously occupied by stockpiles of untreated ore. As noted above, these stockpiles were removed in 1977 and used to fill the Treatment Plant Area.

The area was characterised by a lack of established vegetation generally caused by a lack of topsoil and some areas of toxicity, especially to the north of the Treatment Plant.

The rehabilitation of this area involved the minor reshaping of the area, its covering with a dual zoned cover system, drainage and revegetation.

(i) Earthworks

Due largely to the lack of existing soil cover on this area, reshaping was confined to minor trimming required to effect satisfactory drainage control.

(ii) Chemical Treatment

Some of the surface material, as well as the underlying material in the northern area, was toxic to vegetation and was treated with lime to condition the top 150 mm of the surface as set out in Section 6.2.2.

(iii) Erosion Control and Drainage

Erosion control banks were specified for the area as set out in Section 6.1.3. Erosion control drains discharging to the natural watercourse to the southeast of the area did not incorporate mattress protected outlets.

The remaining erosion control drains discharged to an open, rip rap lined drain designed in accordance with the criteria set out in Section 6.1.3.

(iv) Covers

Because of the less toxic nature of the Stockpile Area, the covers did not need to resist infiltration but had to provide a growth medium for the vegetation. To cater for this, a two layer cover system comprised of 250 mm of zone 1B material and 150 mm of zone 2A material was specified for this area. Details of zone 1B and 2A materials are described in Section 6.1.4.

(v) Revegetation

The revegetation of this area used a mixture of improved pasture grasses and native species similar to those used on the Old Tailings Dam, refer to Section 6.2.4 for details.

6.5.3 Site Fence

The Rum Jungle area, in common with large areas of the Northern Territory, is populated by feral buffalo. The detrimental effects of buffalo on the northern environment is quite well established and it was recognised that it would be undesirable to allow grazing on newly vegetated areas of the sites. Accordingly, a stockproof fence was specified to be constructed around the site.

The removal of feral buffalo from within the fence and the on-going management of the buffalo population was also specified.

6.5.4 Acid and Sweetwater Dams

The Acid and Sweetwater Dams were constructed on the East Branch of the Finniss River and on Fitch Creek during the operating period of the mine as a part of the water containment policy (Plate 6.1).

The Acid Dam, which had been used to store process water from the plant during the dry season prior to its release to the river system during the wet season, had been denuded of vegetation. Remanents of the old dam wall were adversely affecting the river system.

Sweetwater Dam and Fitch Creek upstream had been adversely affected by acidic outwash from Whites Overburden Heap and the stream bed was constricted by the remanents of the dam wall.

The rehabilitation of these areas was restricted to the removal of the old dam walls and some minor revegetation with native species. The success of this rehabilitation is shown in Plate 6.14.

6.5.5 Removal of Small Ore Stockpiles Around the Site

Scattered around the minesite of Rum Jungle were numerous small stockpiles of various pyritic ores, the majority left over from exploration activities carried out during the mining period. These stockpiles were to be removed and buried in some of the equally numerous costeans around the site.

6.5.6 General Cleanup of the Site

Some of the worst of the denuded areas around the site such as the acid outwash area between Whites and Intermediate Overburden Heaps were specified to be covered with a single layer of topsoil and revegetated.

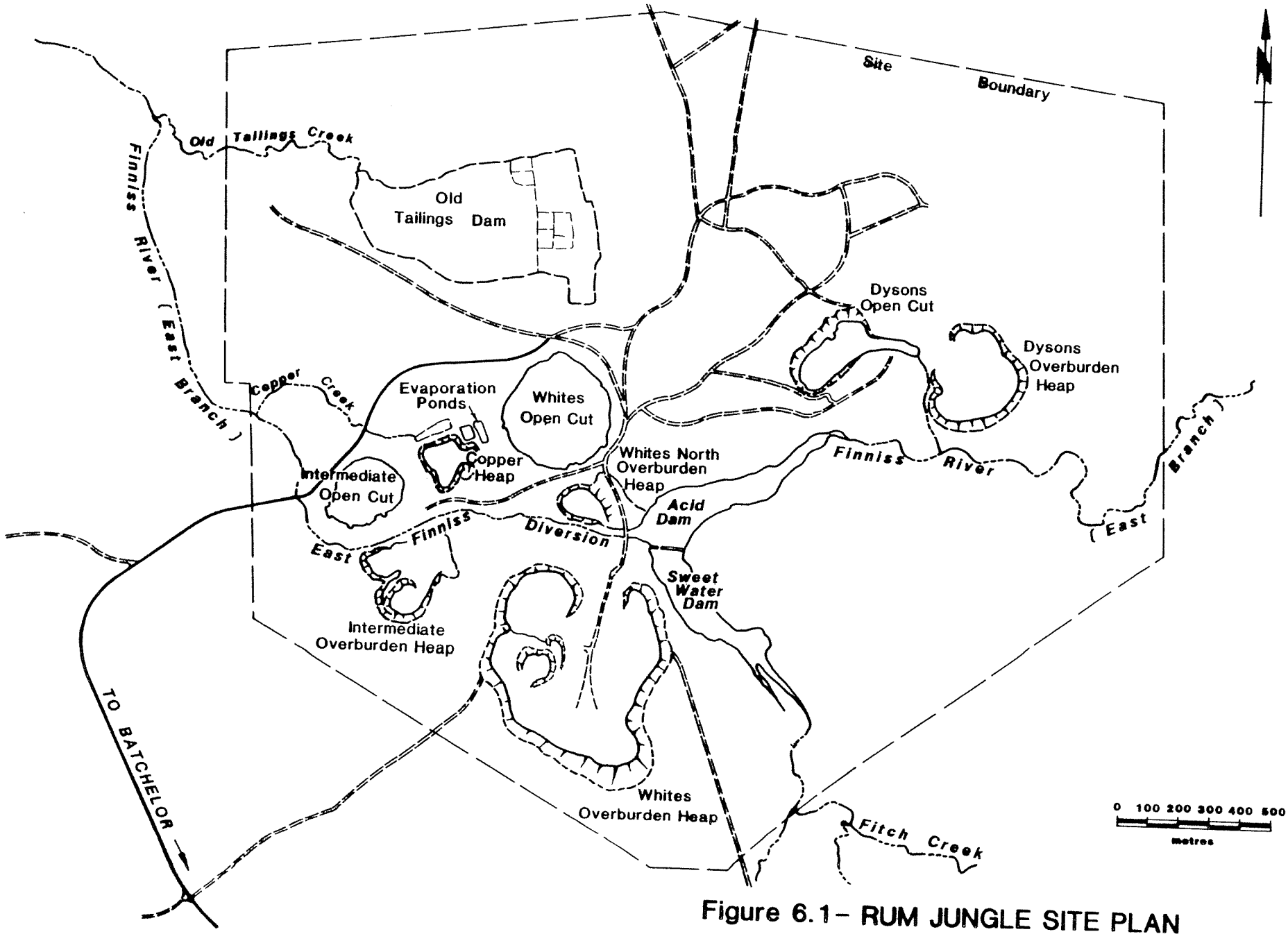


Figure 6.1- RUM JUNGLE SITE PLAN PRIOR TO REHABILITATION

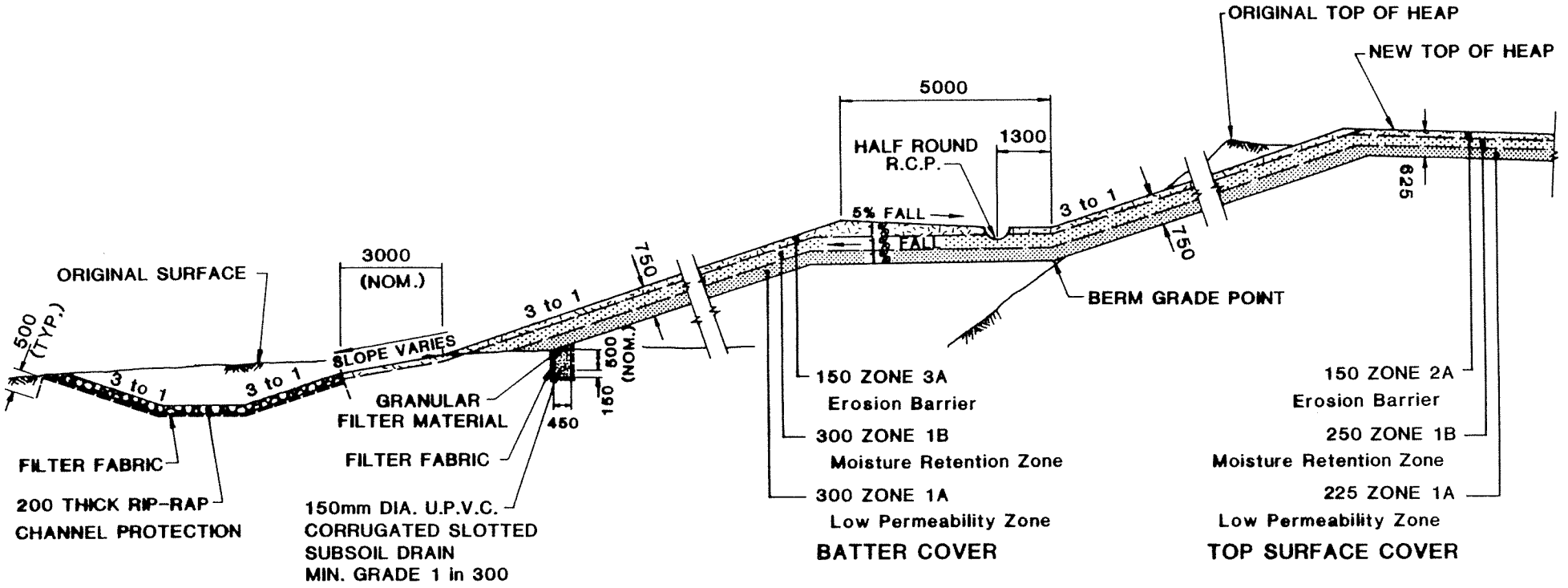
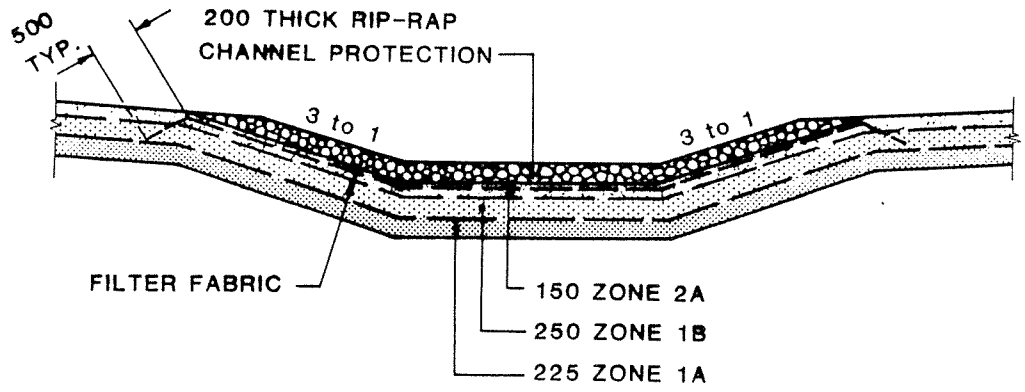
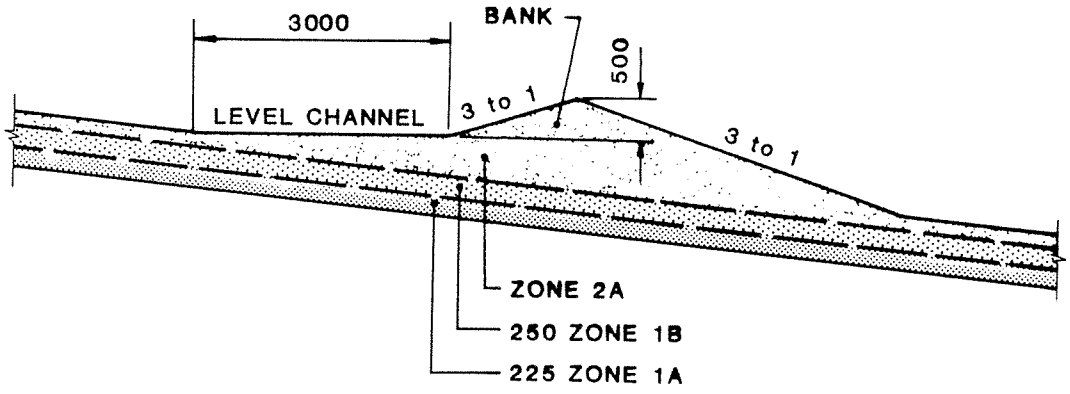


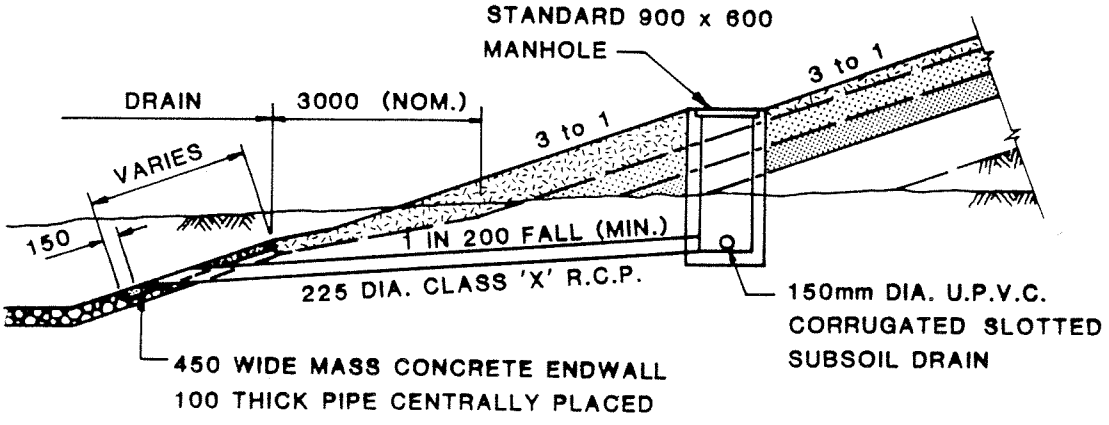
Figure – 6.2 TYPICAL CROSS SECTION OF REHABILITATED HEAP



TYPICAL CROSS SECTION RIP-RAP LINED DRAIN



TYPICAL CONTOUR DRAIN



SUBSOIL DRAIN OUTLET

Figure 6.3 – TYPICAL OVERBURDEN HEAP DRAIN CROSS SECTIONS

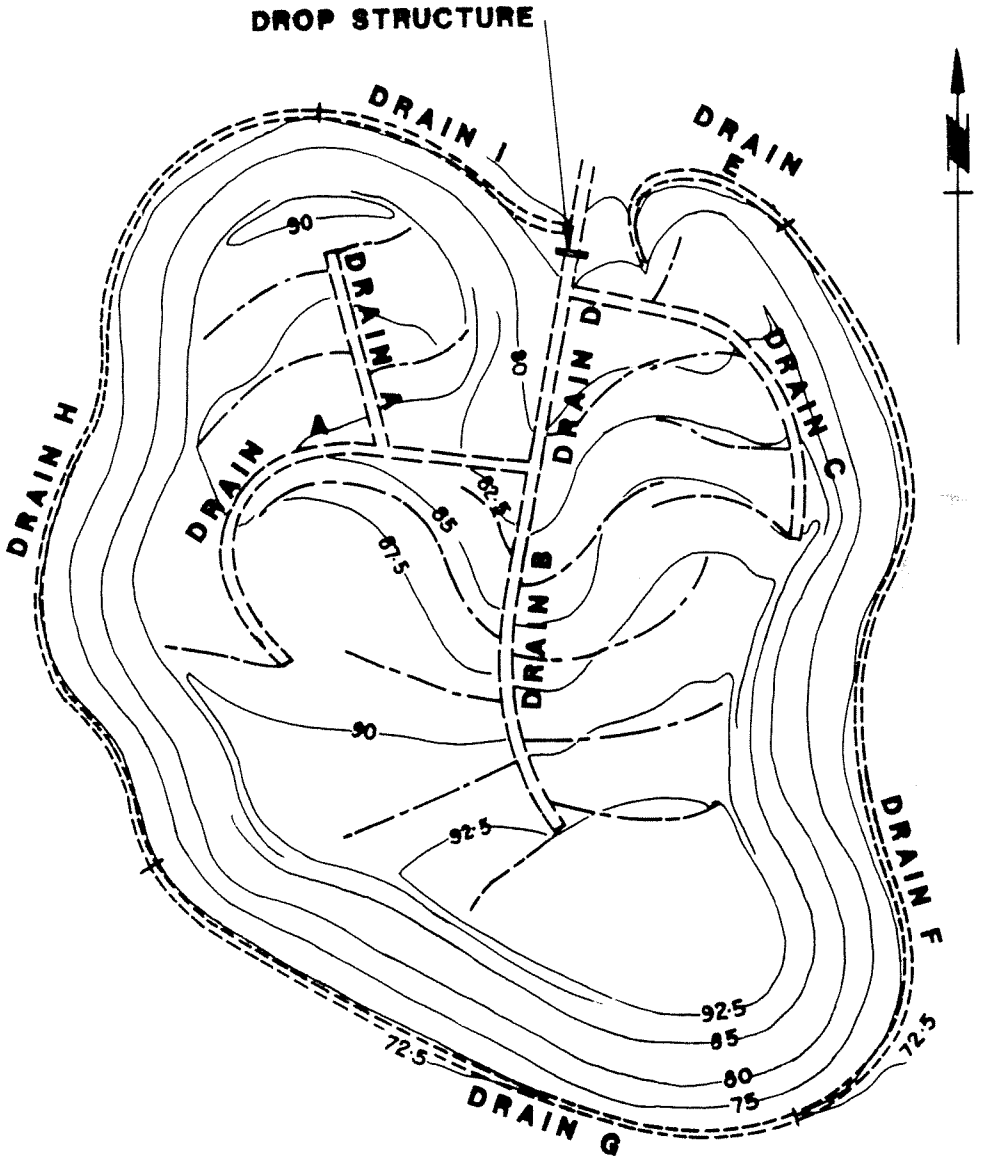


Figure 6.4 – WHITES OVERBURDEN HEAP
AFTER COMPLETION OF REHABILITATION

metres 1000 0 1000 2000 metres

Scale – 1 : 50,000 (Approx.)

CONTOUR DRAINS ———————

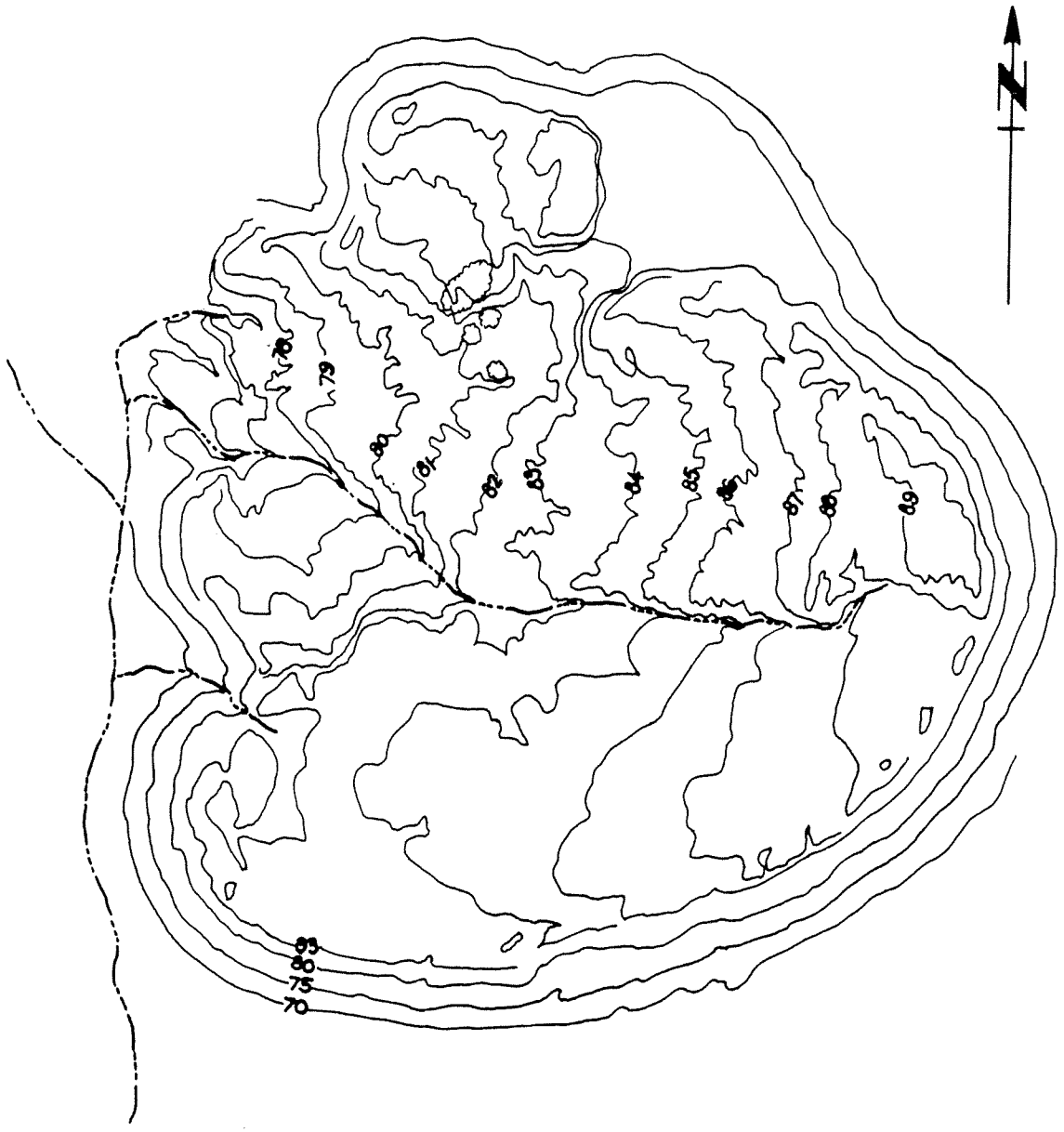


Figure 6.5 – DYSONS OVERBURDEN HEAP PRIOR TO REHABILITION

metres 50 0 50 100 metres

Scale – 1 : 2500 (Approx.)

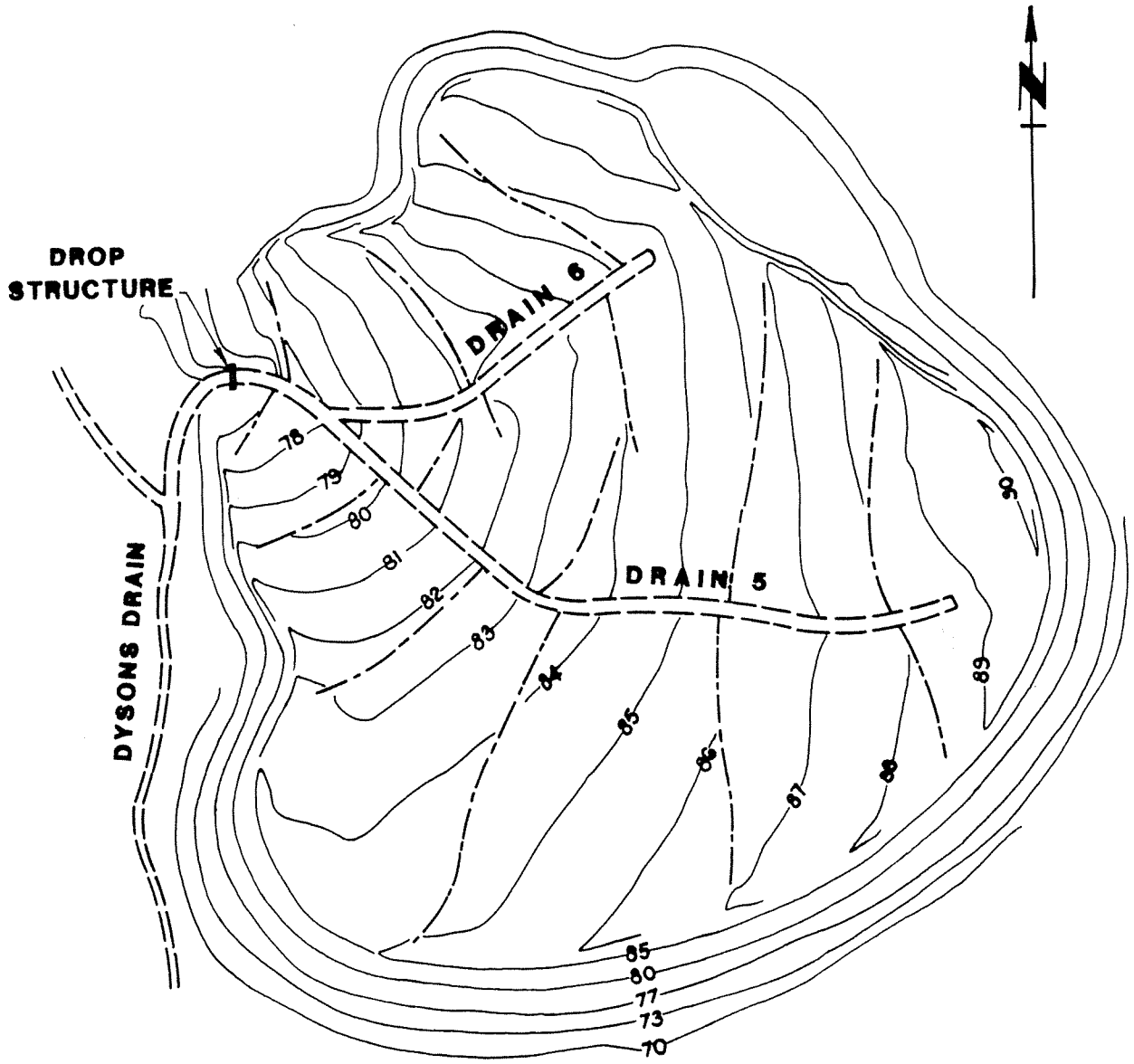


Figure 6.6 – DYSONS OVERBURDEN HEAP
AFTER COMPLETION OF REHABILITATION

metres 50 0 50 100 metres

Scale – 1 : 2500 (Approx.)

CONTOUR DRAINS - —— - ——

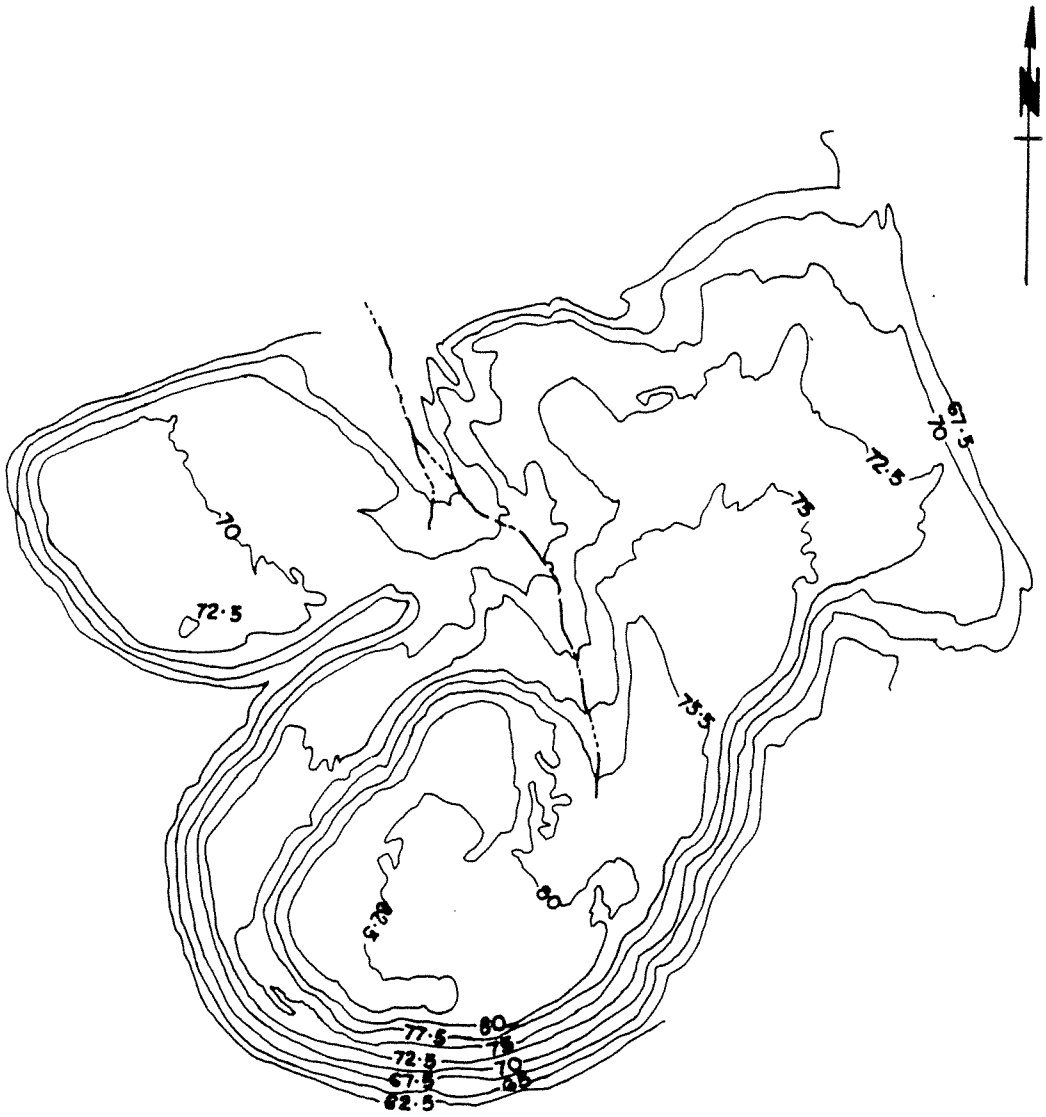


Figure 6.7 – INTERMEDIATE OVERBURDEN HEAP PRIOR TO REHABILITATION

metres 50 0 50 100 metres

Scale – 1 : 2500 (Approx.)

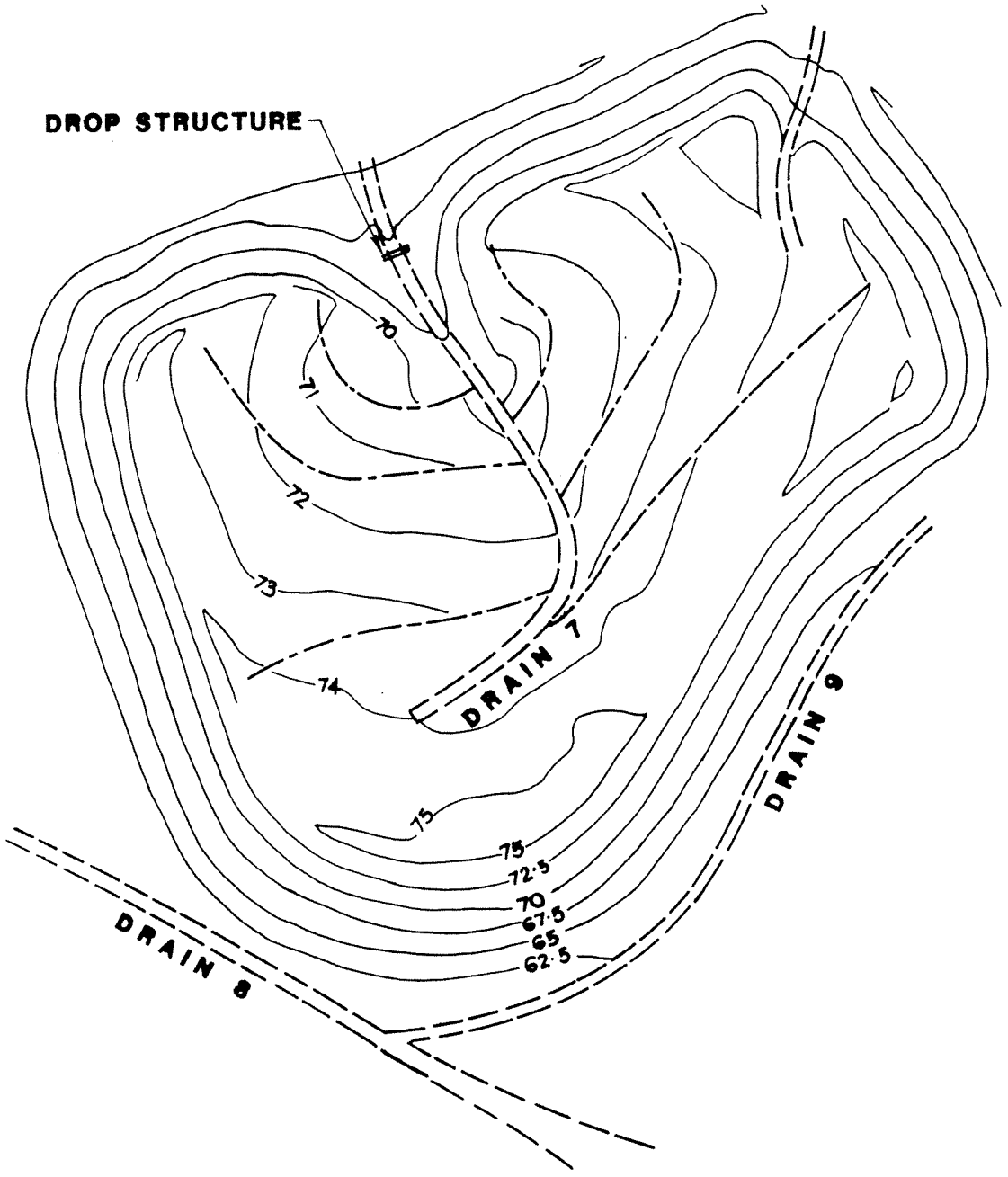


Figure 6.8 – INTERMEDIATE OVERBURDEN HEAP AFTER COMPLETION OF REHABILITATION

metres 50 0 50 100 metres

Scale – 1 : 2500 (Approx.)

CONTOUR DRAINS ----——----

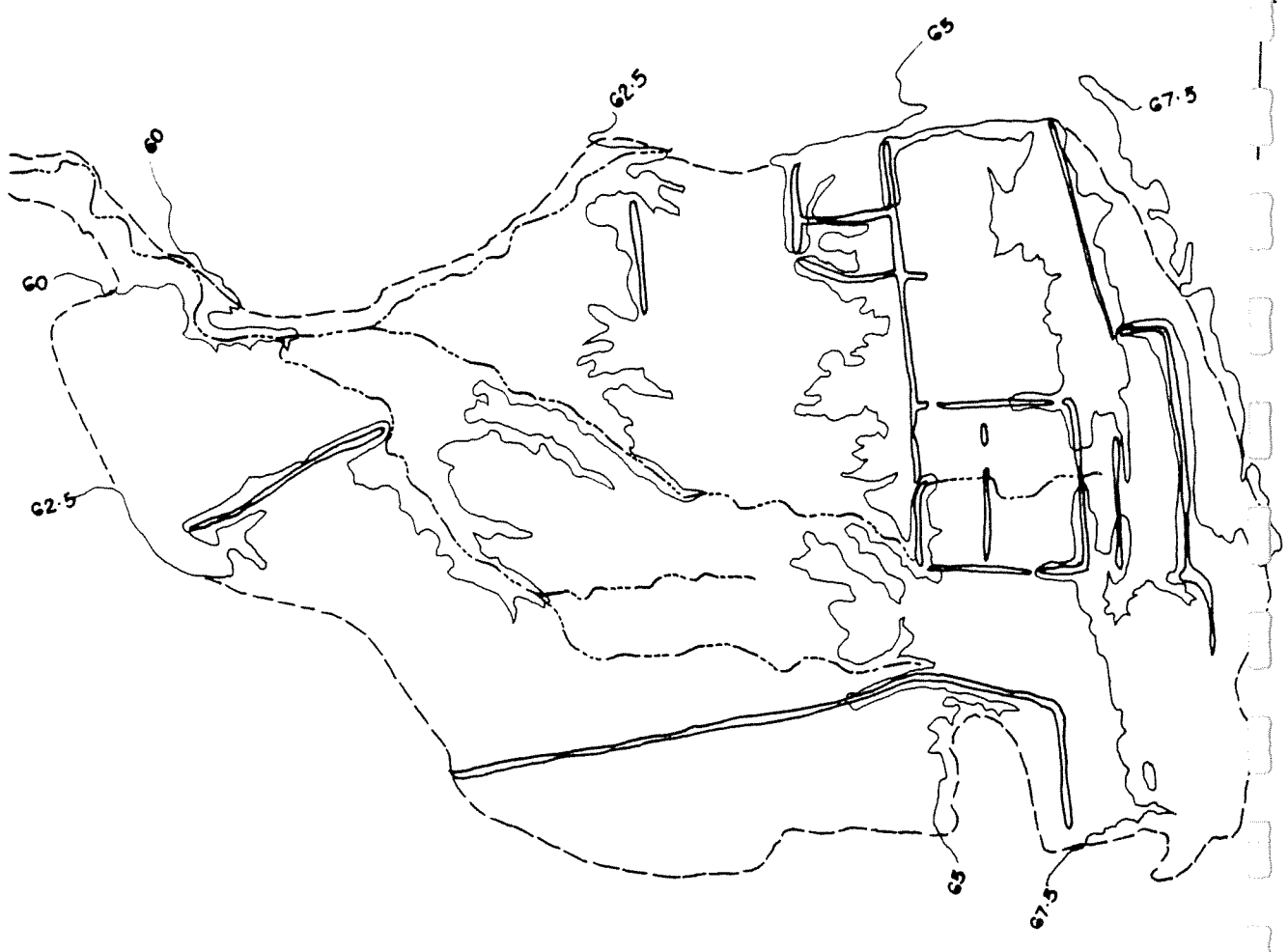


Figure 6.9 – OLD TAILINGS DAM
PRIOR TO REHABILITATION

metres 100 0 100 200 metres

Scale – 1 : 5000

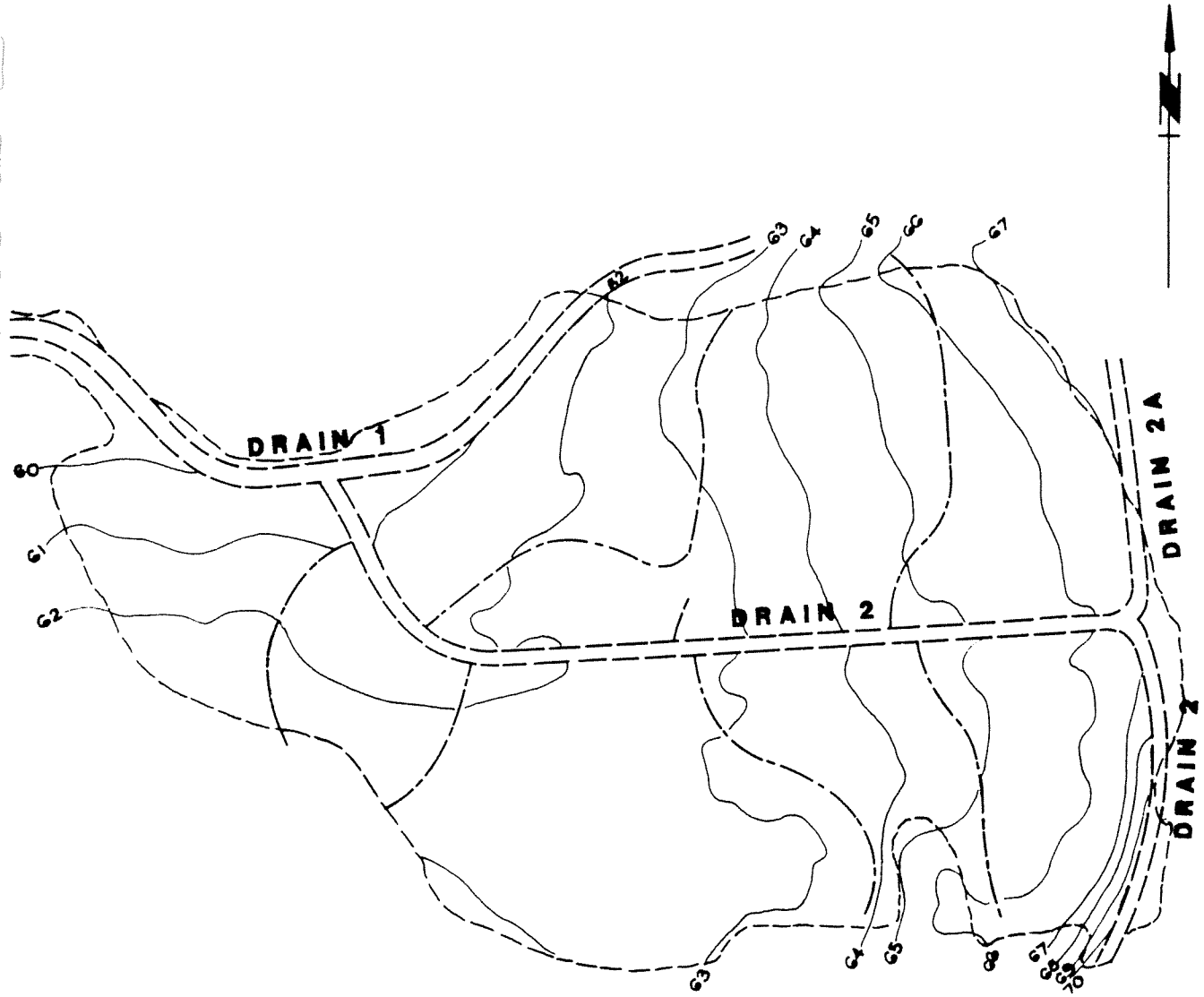


Figure 6.10 - OLD TAILINGS DAM
AFTER COMPLETION OF REHABILITATION

metres 100 0 100 200 metres

Scale - 1 : 5000 (Approx.)

CONTOUR DRAINS ——-——-

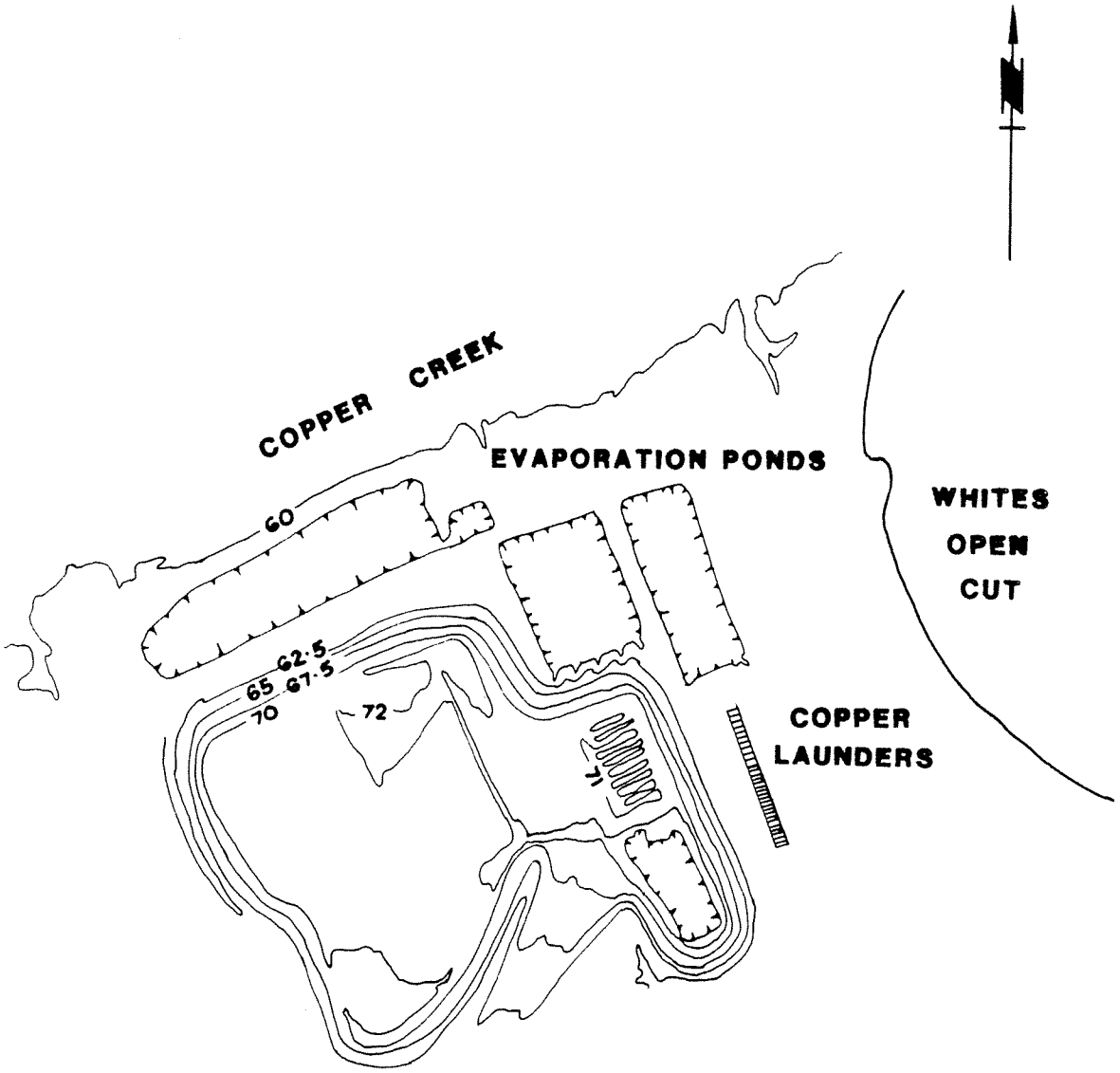


Figure 6.11 – COPPER HEAP LEACH PILE AREA PRIOR TO REHABILITATION

metres 50 0 50 100 metres

Scale – 1 : 3000 (Approx.)

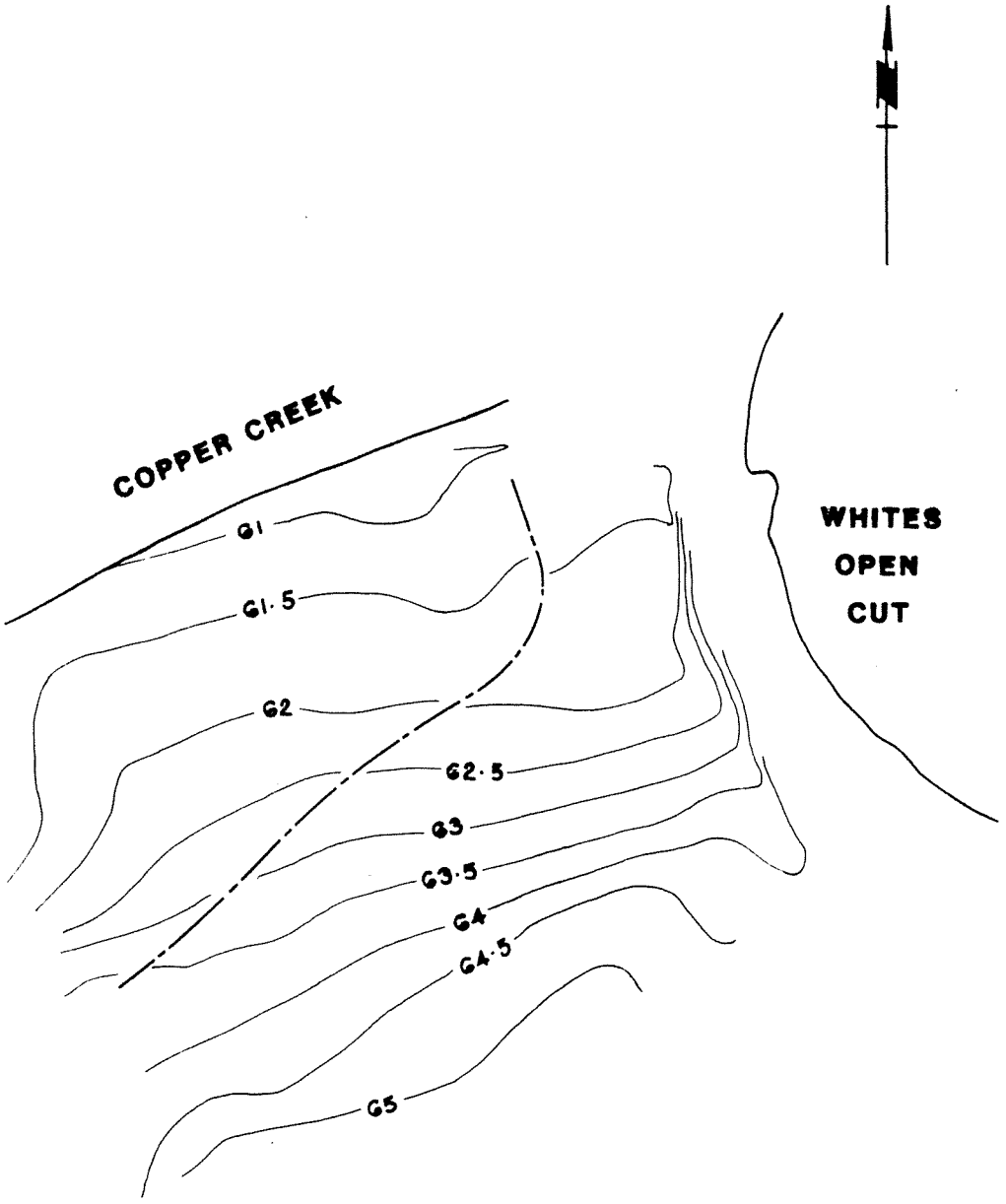
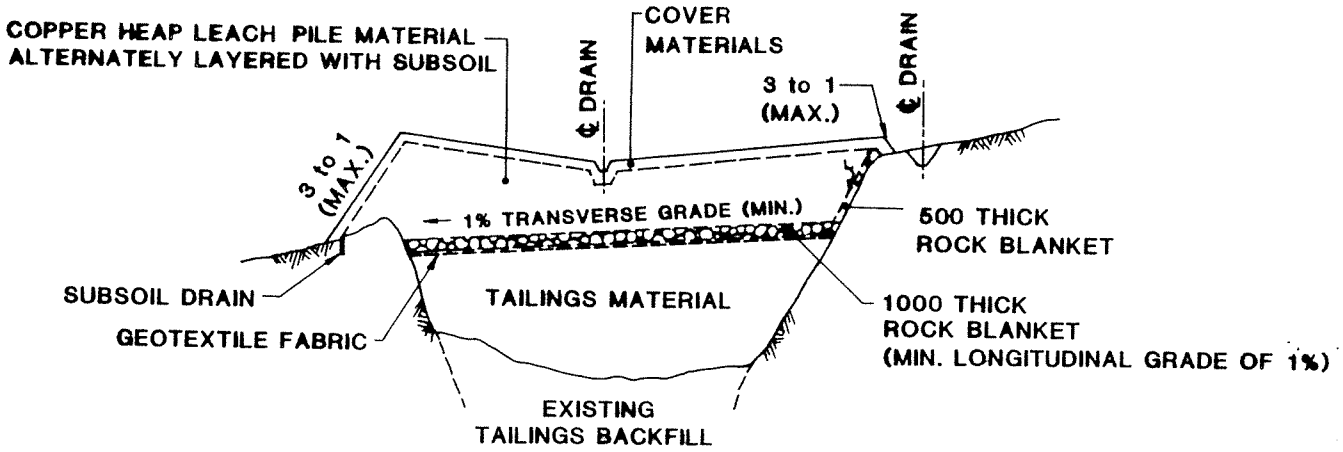


Figure 6.12 – COPPER HEAP LEACH PILE AREA AFTER COMPLETION OF REHABILITATION

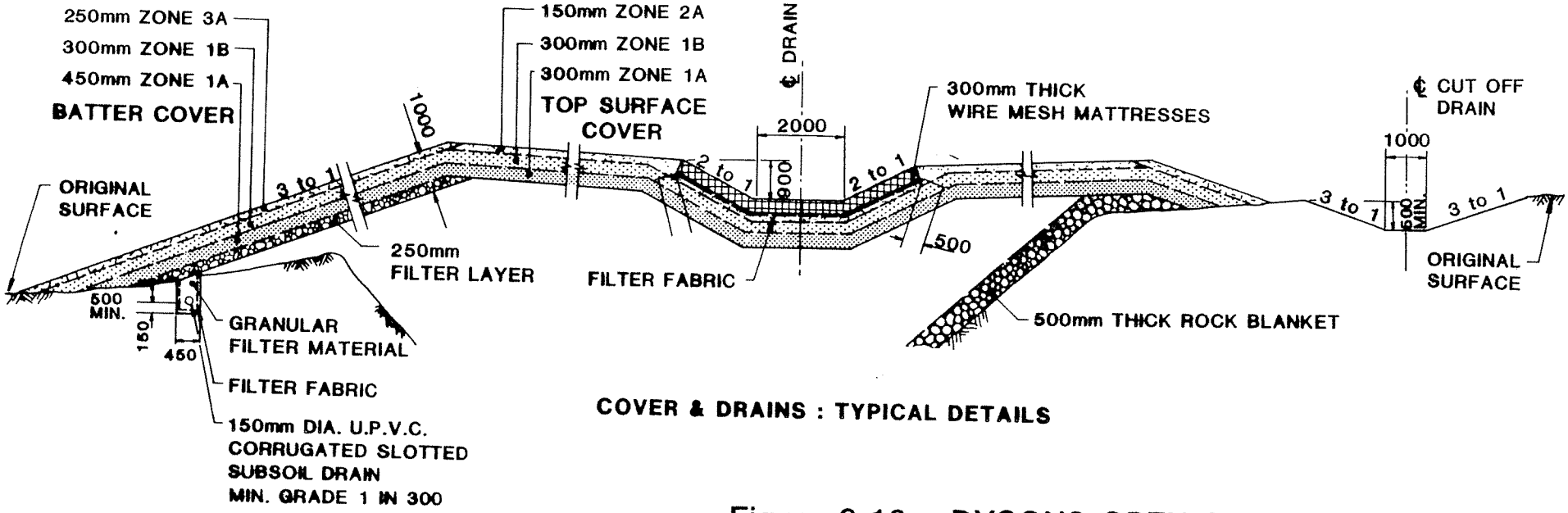
metres 50 0 50 100 metres

Scale – 1 : 3000 (Approx.)

CONTOUR DRAIN -——-——-——



TYPICAL CROSS SECTION



COVER & DRAINS : TYPICAL DETAILS

Figure 6.13 – DYSONS OPEN CUT TYPICAL CROSS SECTION

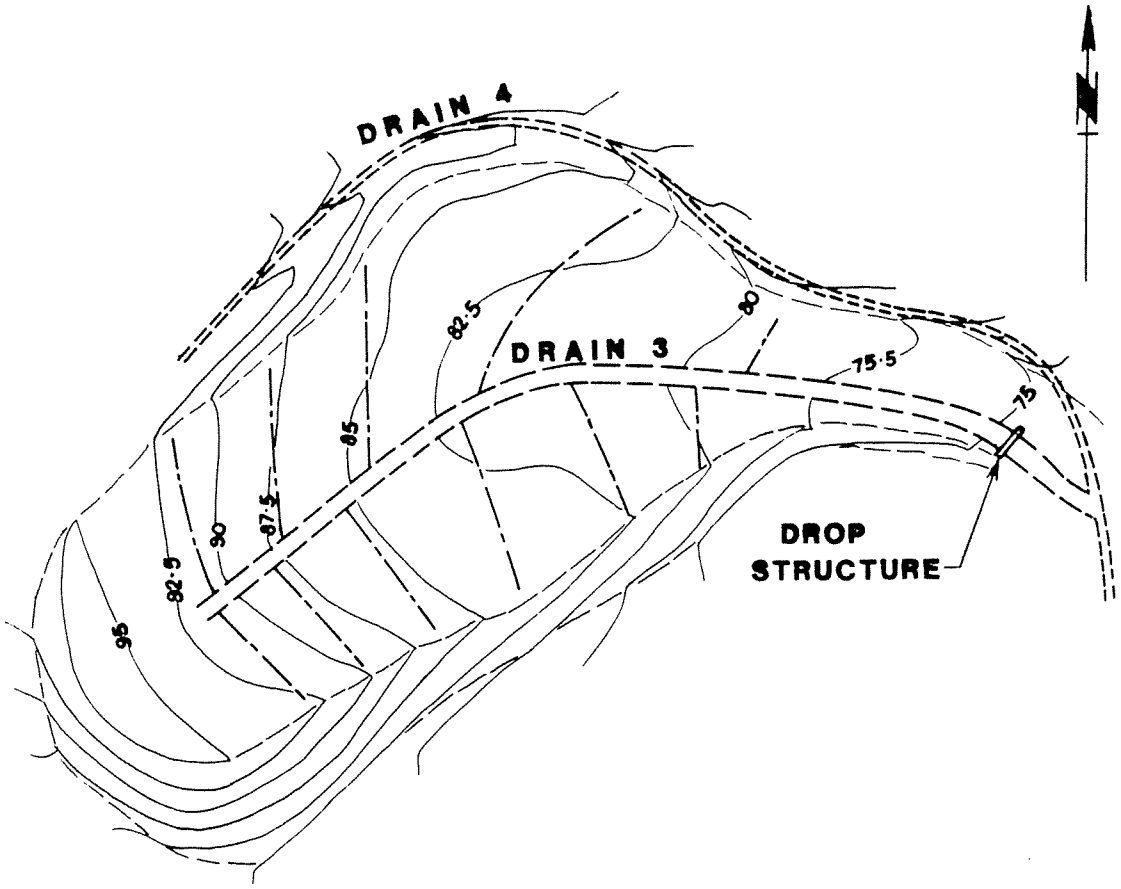


Figure 6.14 – DYSONS OPEN CUT
AFTER COMPLETION OF REHABILITATION

metres 50 0 50 100 metres

Scale – 1 : 3000 (Approx.)

CONTOUR DRAINS ——·——·——

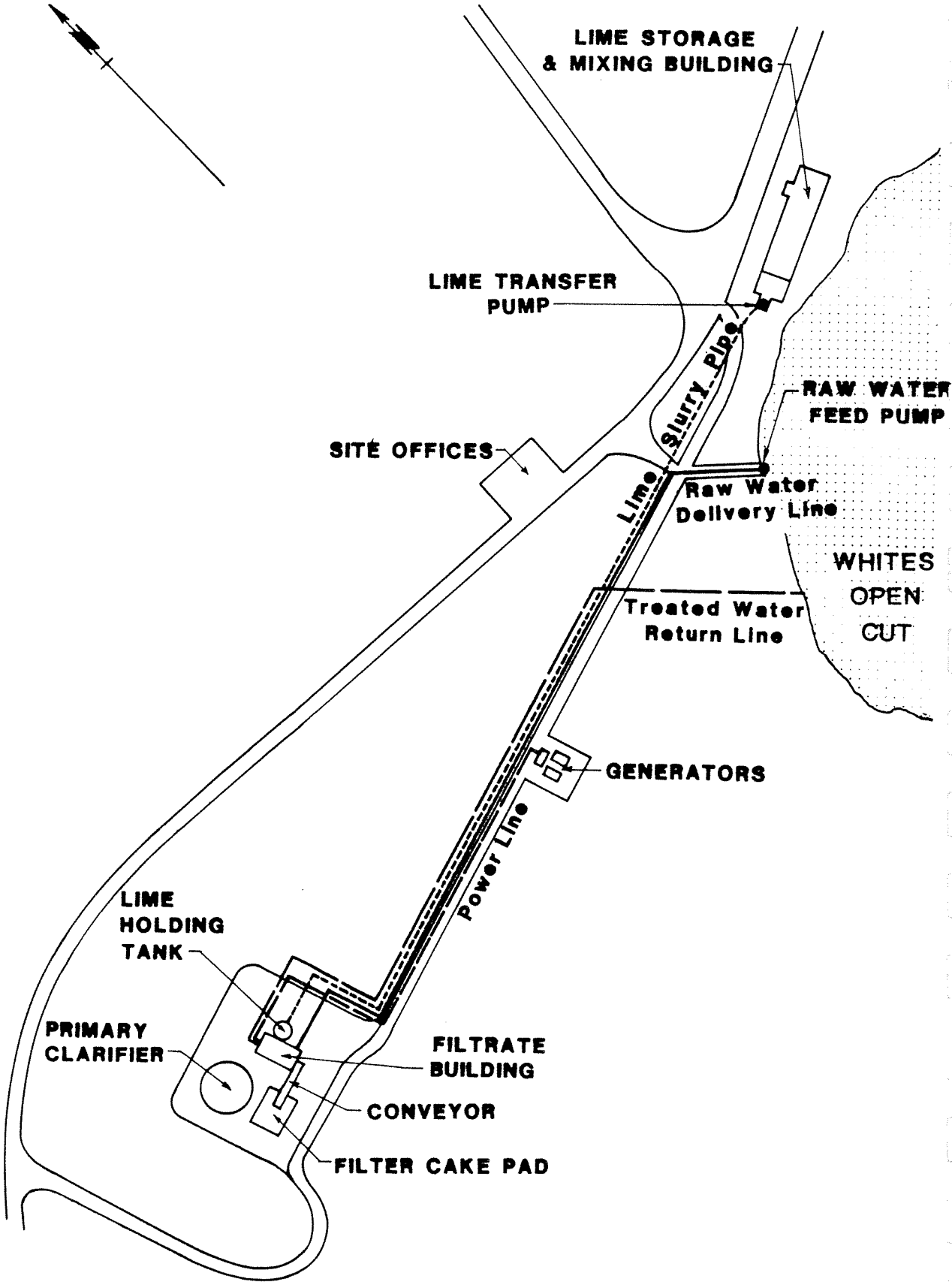


Figure 6.15 – WATER TREATMENT
PLANT GENERAL ARRANGEMENT

metres 50 0 50 100 metres

Scale – 1 : 2500 (Approx.)

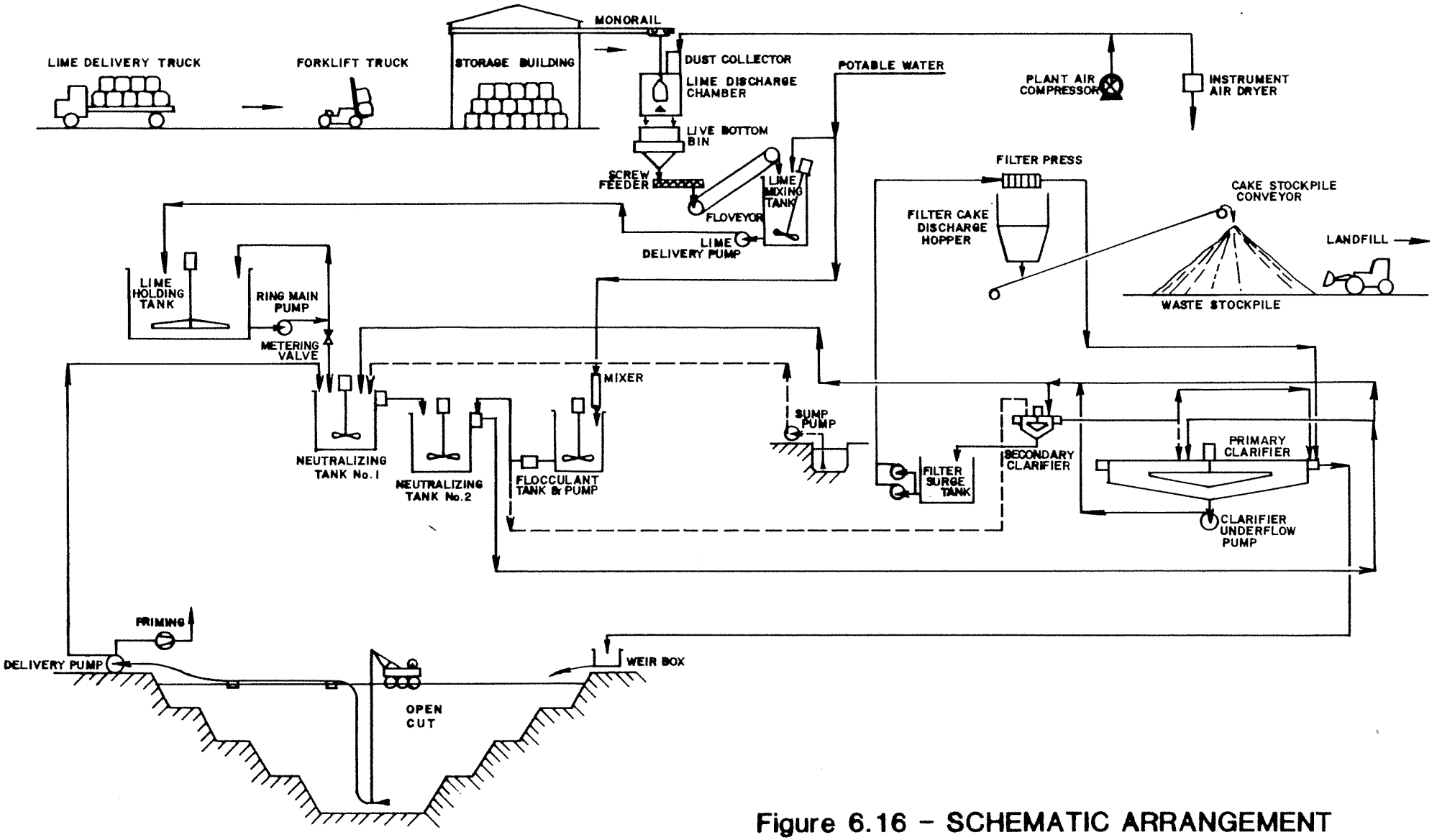
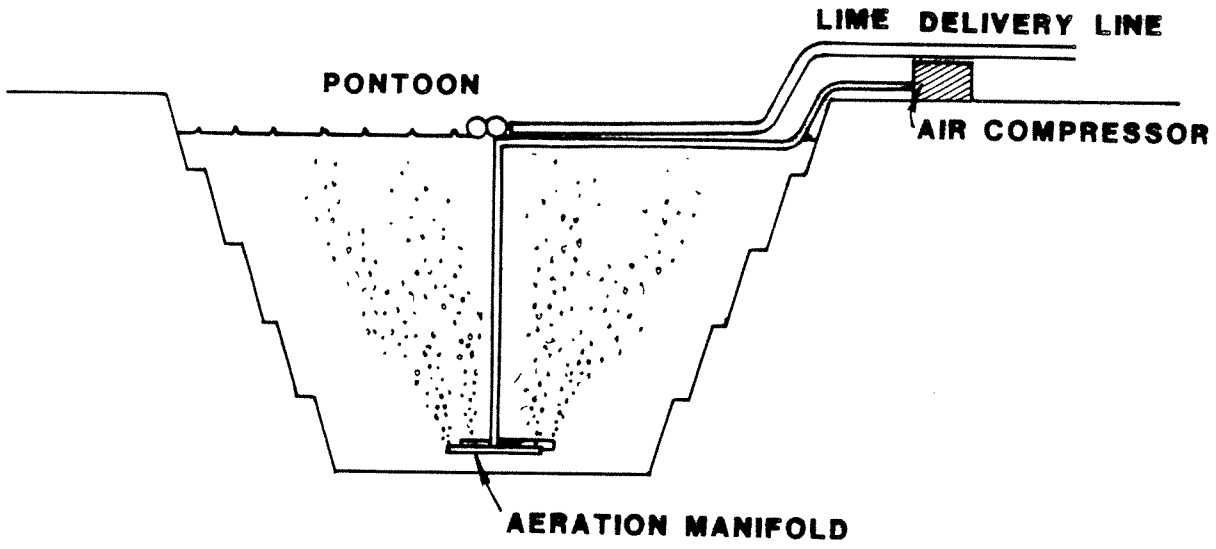


Figure 6.16 – SCHEMATIC ARRANGEMENT WITH THE WATER TREATMENT PLANT

AERATION AND LIME ADDITION



WITHDRAWAL OF PRECIPITATES

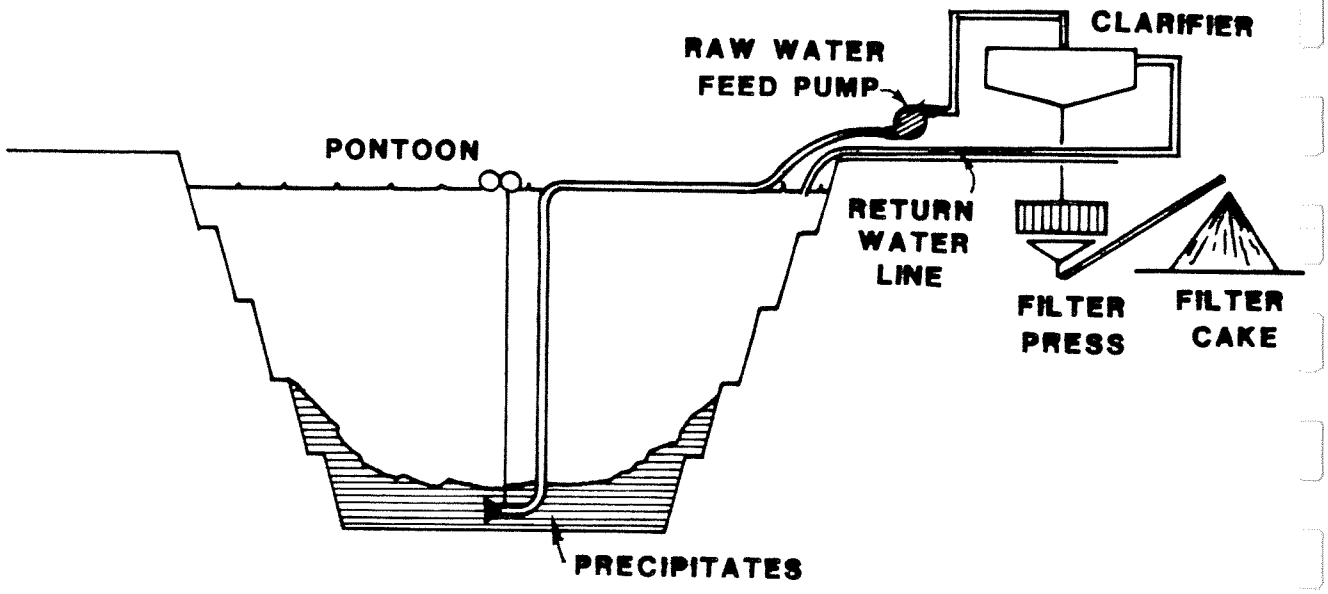


Figure 6.17 – TREATMENT OF
INTERMEDIATE OPEN CUT

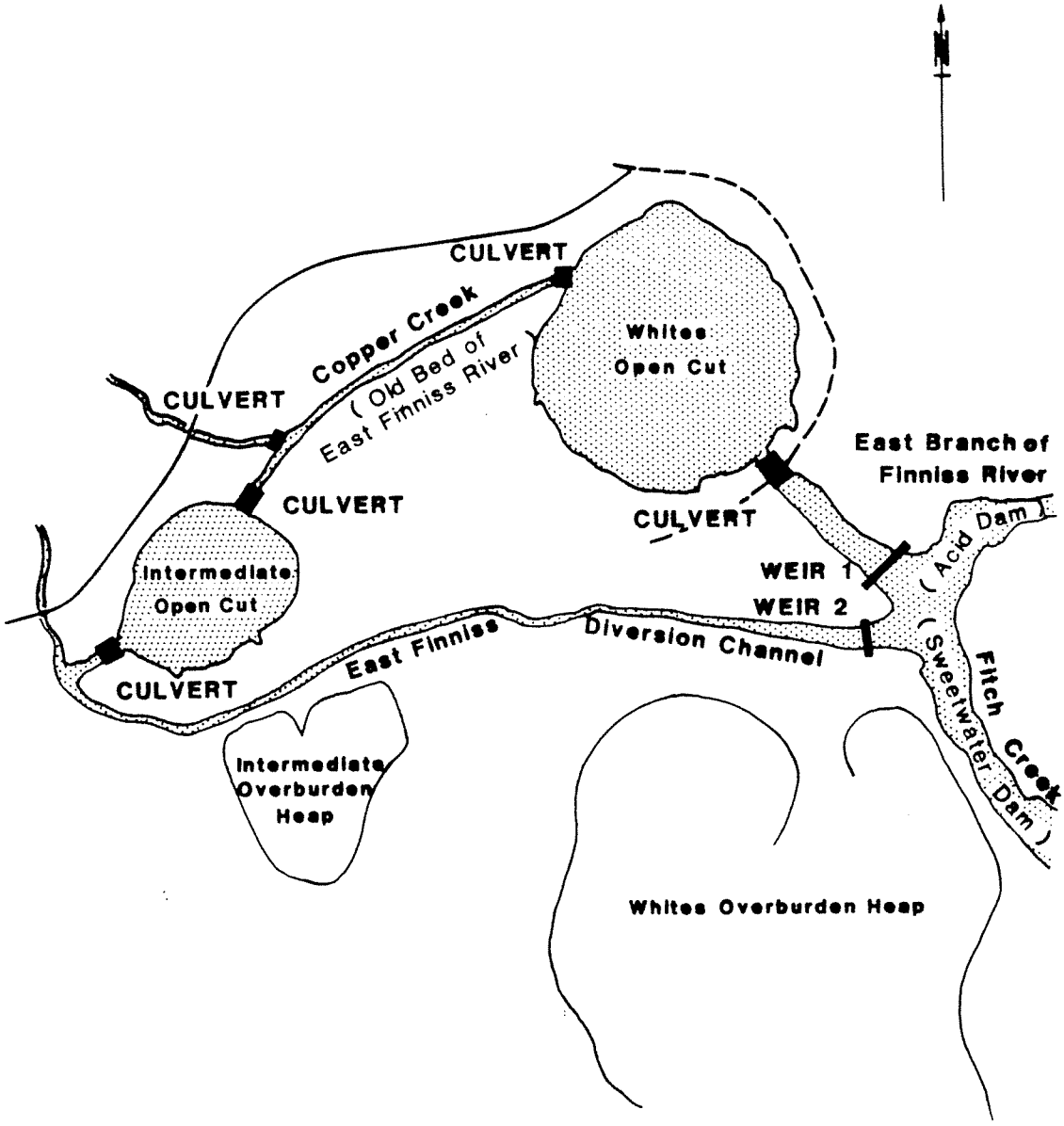


Figure 6.18 – REDIVERSION OF THE EAST BRANCH OF THE FINNISS RIVER



Plate 6.1 WHITES OVERBURDEN HEAP BEFORE REHABILITATION. JUNE 1983.



Plate 6.2 WHITES OVERBURDEN HEAP AFTER REHABILITATION. MAY 1985.

Illustrates reshaping, drainage (top, berm and toe) and vegetation works as described in Section 6.1.



Plate 6.3 INTERMEDIATE OVERBURDEN HEAP BEFORE REHABILITATION. JANUARY 1985.



Plate 6.4 INTERMEDIATE OVERBURDEN HEAP AFTER REHABILITATION. MAY 1986.

Considerable reshaping, capping, new drainage lines and vegetation have stabilised the heap.



Plate 6.5 OLD TAILINGS DAM BEFORE REHABILITATION.
JUNE 1983.

An active erosion area and pollution source.



Plate 6.6 OLD TAILINGS DAM AFTER REHABILITATION.
MAY 1986.

The same view as in Plate 6.5. Works included removal of tailings and subsoil, land treatment, construction of drainage, and vegetation as described in Section 6.2.



Plate 6.7 AERIAL VIEW OF OLD TAILINGS DAM AFTER REHABILITATION. MAY 1986.

The drainage lines lead to Tailings Creek in the foreground. Whites Open Cut is in the background.



Plate 6.8 COPPER HEAP LEACH PILE AND SURROUNDS BEFORE REHABILITATION. AUGUST 1984.

Illustrates various pollution sources including the heap, copper launders and evaporation ponds. The area is sited between Whites Open Cut (upper picture) and Intermediate Open Cut (foreground).



Plate 6.9 COPPER HEAP LEACH PILE AND SURROUNDS AFTER REHABILITATION. MAY 1986.

The heap, copper launders and ponds have been removed, and the ground contoured, drained, treated and vegetated. The water treatment plant is in the foreground.



Plate 6.10 DYSONS OPEN CUT BEFORE REHABILITATION.
MAY 1984.



Plate 6.11 DYSONS OPEN CUT AFTER REHABILITATION.
MAY 1986.

The pit was drained, infilled with material from the tailings dam and copper heap leach areas, capped, shaped and revegetated.



Plate 6.12 TAILINGS CREEK BEFORE REHABILITATION.
AUGUST 1984.



Plate 6.13 TAILINGS CREEK DURING REHABILITATION.
SEPTEMBER 1984.



Plate 6.14 ACID DAM AFTER REHABILITATION.

The strategy for the treatment of the water contained in Whites and Intermediate Open Cuts was to utilise the natural density stratification of the pit water and draw the denser, polluted, acidic raw water from the lower regions of the pit, treat that water by hydroxide precipitation in a treatment plant to remove the heavy metals, and to return the treated, less dense, water to the surface of the pit. The density difference between the raw and treated waters was sufficient to enable the treated water to float on the raw water with stable stratification which would not mix even during wind and surface layer movements. This strategy, it was estimated, would enable the entire contents of the pits to be treated by passing the water once only through the plant, rather than multiple treatment which would be required if raw and treated waters were mixed.

7.1 The Water Treatment Plant

The treatment plant was designed specifically for the Project, utilising proprietary components, with the selection of those components to meet operational requirements based on the results of testwork. As noted in Section 3.2, the hydroxide precipitation method of water treatment had been selected, and a preliminary design developed, in the Final Engineering report. Equipment selection criteria are summarised in Table 7.1. Transfer rates between the various items of plant and the overall capacity of those items of plant were dictated by the design plant throughput rate of 10,000 cubic metres per 24 hour day and the internal circulating loads within the treatment plant.

With the exception of the filter press which was fully automatic, plant control was manual, with adequate instrumentation to enable the operators to make the necessary adjustments to the various operating parameters and to provide the necessary information to monitor the operation of the plant.

TABLE 7.1

WATER TREATMENT PLANT EQUIPMENT SELECTION CRITERIA

Item	Selection Criteria
Treated Water Throughput	10,000 m^3/d 116 L/s
Neutralising Tanks	
lime addition rate	5 t/hr
pH raw water	2.4 - 3.5
pH neutralised liquor	8.7 - 9.0
liquor throughput	418 m^3/hr
Lime Plant	
average lime requirement	5 t/hr
lime slurry % solids	30%
slurry transfer rate	15.94 m^3/hr
Primary Clarifier	
feed rate	418 - 484 m^3/hr
feed % solids	0.95 - 1.23 %
underflow % solids	3%
overflow rate	287.65 m^3/hr
underflow rate	131 - 196 m^3/hr
Secondary Clarifier	
feed rate	130.74 m^3/hr
feed % solids	3%
underflow % solids	6 - 12%
overflow rate	67 - 100 m^3/hr
underflow rate	31 - 64 m^3/hr
Filter Press	
average feed rate	64 m^3/hr
feed % solids	6 - 12%
filtrate % solids	nil
filter cake % solids	30 - 35%
average filtrate discharge rate	40 - 53 m^3/hr
average filter cake discharge rate	13 - 27 t/hr
Power Supply	
rating	415 V, 3 phase
average demand	320 kW
peak demand	400kW

Tenders were called for the supply and delivery to Rum Jungle of the plant and equipment as shown on Figures 6.15 and 6.16. The plant selected from these tenders is listed in Table 7.2. Details of the resulting contracts and orders can be found in Appendices B and D; those major contracts pertinent to the water treatment plant are summarised in Table 7.3.

Table 7.2

WATER TREATMENT PLANT EQUIPMENT LIST

Item Ref	Description	Manufacturer	Model
Ø1-PP-1	P.C. Feed Pump	SPP Aquastream	AM 3Ø A
Ø1-PP-2	Sump Pump	Ebara	1ØØ DV 57.5
Ø1-PP-3	Floc T'fer Pump	Mono	
Ø1-PP-4	Floc Metering Pump	Mono	
Ø1-PP-5	Filter Press Wash	Uraca	RS613 E/1ØØ
Ø1-AG-1	Neut 1 - Agitator	Lightnin	NLDG - 3ØØ
Ø1-AG-2	Neut 2 - Agitator	Lightnin	NLDG - 3ØØ
Ø1-AG-3	Floc Mixing Tank Agitator	Lightnin	
Ø1-AG-4	Floc Holding Tank Agitator	Lightnin	
Ø1-CV-1	Filter Cake Transfer Conveyor		1.2m wide x35m
Ø1-CP-1	Air Compressor	Cash Eng'ing	E series
Ø1-FP-1	Filter Press	Netzch	1.5m sq plates
Ø2-PP-6	Lime T'fer Pump	Seepex	17-6 LBN
Ø2-AG-5	Lime Mixing Tank Agitator	Lightnin	NLDG - 3ØØ
Ø2-CV-2	Lime Metering Screw	Thos Robinson	Type SD A
Ø2-CV-3	Lime T'fer Elevator	Flowveyor	BR4325622BCE
Ø2-AT-1	Lime Bin Activator	Thos Robinson	PD A 21ØØ L
Ø2-FL-1	Lime Bin Dust Filter	Dalamatic	DLM V15/15
Ø2-HT-2	Lime Charge Hoist	Hitachi	1FH - 1ET
Ø3-PP-7	F/Press Charge Pump	Netzch-Mohno	2NE - 12ØA
Ø3-PP-8	F/Press Press Pump	Netzch-Mohno	4NE - 8ØA
Ø3-PP-9	PC U/flow Pump	Ebara	125 DVB 515
Ø3-PP-1Ø	T/Water Return Pump	SPP Aquastream	AM 25A
Ø3-PP-11	Lime Slurry Ringmain Pump	Seepex	17-6 LBN
Ø3-CV-4	Filter Cake Stack Conveyor		Ø.6m widex62m
Ø3-CL-1	Primary Clarifier	William Boby	2Ømdia
Ø3-CL-2	Secondary Clarifier	Larox	5.5m dia, FB
Ø3-AG-6	Lime Holding Tank Agitator	Lightnin	LQ - 15ØØ
Ø4-PP-12	Raw Water Feed Pump	Goulds	3196 XLT
	Generator Sets	Powerlite	2ØØ kVA

The water treatment plant was constructed under a project management agreement with the design consultant as an extension to the design commission. The plant was built using the following main contracts:

(i) Earthworks contract for the construction of the earthworks pad and associated roadworks for the water treatment plant.

(ii) Footings and concrete works contract for the construction of concrete footings and floor slabs for the plant.

(iii) Steelworks contract for the construction of steelworks, including fabrication and

installation of tanks and the fabrication and erection of structures.

(iv) Mechanical works contract for the supply and installation of pipeworks and the installation of pumps and motors.

(v) Electrical equipment installation contract for the installation of electrical equipment and instrumentation.

(vi) Electrical reticulation contract for the supply and installation of electrical reticulation.

Table 7.3

WATER TREATMENT PLANT MAJOR SUPPLY CONTRACTS

Contract No	Contractor	Description of Contract
TW 26 of 83/84	William Boby & Co	Supply Filter Press
TW 27 of 83/84	Larox Proprietary Ltd	Supply Secondary Clarifier
TW 28 of 83/84	Asoma	Supply of Hydrated Lime
TW 29 of 83/84	Thomas Robinson & Son	Supply of Lime Surge Bin
TW 34 of 83/84	William Boby & Co	Supply of Primary Clarifier
TW 43 of 83/84	Lightnin Mixers	Supply of Agitators
TW 49 of 83/84	Blakers & Thompson	Supply of Pumps
TW 8Ø of 83/84	Transcon	Supply of Flocculant System
TW 96 of 83/84	Elmec Pty Ltd	Supply and install Generator Sets
SD 5419	Elmec Pty Ltd	Supply Electrical Distribution Boards

The construction of the water treatment plant was completed in August 1984 and the plant was commissioned during August and September 1984.

Control systems on the plant were simple, being designed to keep the supervisory staff on the plant to a minimum, consistent with safe and effective operation. The plant was designed to operate 24 hours per day for 6 days per week, using two operators per shift under the direction of a day shift supervisor.

The treatment of the water contained in both Whites and Intermediate Open Cut pits was completed in December 1985 and the plant was mothballed pending final disposal.

7.2 Treatment of Whites Open Cut

The treatment of Whites Open Cut commmenced on 25 August 1984 and continued until the treated water

layer reached a depth of 22 metres on 28 September 1985. During this period, 2,112,420 cubic metres of pit water were treated in the plant, 6,672 tonnes of hydrated lime were added to the pit water and approximately 75,600 tonnes of filter cake extracted in the treatment plant. This filter cake was 30% solid and included 355 tonnes Manganese, 166 tonnes Copper, 22 tonnes Zinc and 4,200 tonnes Calcium sulphate.

The treatment of Whites Open Cut can be considered in three stages:

- the period from start of treatment to December 1984 and the modifications carried out in the Christmas 1984 shutdown;
- the period from 15 January 1985 to September 1985; and,
- the direct addition of lime slurry to the open cut carried out over the period from May 1985 to October 1985.

(i) September 1984 to December 1984

The water treatment plant was commissioned and the treatment of Whites Open Cut commenced in September 1984.

Previous investigations had shown that the significant density gradient which existed over the top twelve metres of the pit water may have led to problems when water drawn from around three metres below the surface of the pit was treated and returned to the surface of the pit. As the density of the treated water would have been marginally higher than that of the untreated surface water, this treated water would have mixed with the surface water and the density stratification required to separate the treated and untreated water would not have formed.

In order to remove the density gradient and ensure that this mixing would not take place, the top twelve metres of the water in the pit was mixed at the start of operations. This was done using aeration from a manifold anchored approximately fourteen metres below the surface of the pit. Compressed air (approximately five cubic metres per second at 100 kPa) was pumped through the manifold and the energy of the rising plume used to rotate the water body over a period of twelve days. This resulted in an even density profile in the upper levels of the pit. The mixing was carried out over the period from 28 September 1984 to 10 October 1984.

During operation of the plant in this period approximately 468,000 cubic metres of raw water were treated in the plant but stratification had not developed to any noticeable degree. In addition, severe problems were being experienced

with the build up of gypsum in the pipework, pump impellers, on the walls of tanks and on structures within the plant.

The problems identified and the solutions adopted are discussed below. With the exception of modifications to the raw water intake nozzle undertaken during October 1985, the solutions were implemented during an extended plant shutdown from 23 November 1984 until 14 January 1985.

(a) Lack of stratification

After treatment of 468,ØØØ cubic metres of water from the open cut it was estimated that stratification should have been established to the extent that the treated water layer should have been in excess of five metres deep. Monitoring of the open cut, carried out during the operation of the plant, had shown that stratification was not being established and that the treated water was mixing with the pit water. Tests had shown this to be essentially due to the lack of differential in the densities of the raw and treated waters.

In order to improve the density differential between the raw and treated water, the pit was again mixed, this time to a depth of twenty metres. On completion of this mixing, the top twenty metres of the pit had an average density of the order of 1ØØ6 kg/cubic metre.

(b) Gypsum buildup

A major product of the treatment of the pit water was gypsum ($CaSO_4.2H_2O$) resulting from the reaction between the calcium cations of the added lime and the sulphate anions contained in the acid raw pit water. Between 5Ø and 8Ø tonnes of gypsum was produced daily in the treatment of Whites Open Cut, of which approximately 35 tonnes was contained in filter cake, 3 to 5 tonnes precipitated within the plant and the remainder pumped to the open cut. The 3 to 5 tonnes precipitating daily within the treatment plant caused considerable problems, building up as hard scale in pipes and pumps and as precipitate within tanks (on the walls and floors) and on all structures within tanks. This reduced the capacity of the plant and design capacity was not reached. The problem was never fully overcome during the operating life of the plant, however several measures were implemented to reduce the impact of the

problem and to enable the plant to continue to operate.

- A regular plant descaling programme was implemented to control the build up of gypsum.

- Where possible, all below ground pipework was raised above ground to improve access for pipe descaling. Steel pipe in some areas was replaced with PVC pipe to enable simple replacement and descaling.

- Access hatches were installed on all tanks to enable regular removal of accumulated gypsum during regular maintenance shuts.

- Pig launchers were installed on several pipelines to enable descaling with pigs.

- Process modifications were implemented to recirculate treated water to the neutralising tanks and to increase the pH of the treated water and thus seed the gypsum from solution. This increased the proportion reporting to filter cake.

At the same time, plant throughput was improved by re-routing the overflow and underflow lines from the secondary clarifiers to enable the primary and secondary clarifiers to operate in parallel.

(ii) January 1985 to November 1985

The treatment plant was recommissioned on 15 January 1985 and quickly reached throughput rates approaching the original design criteria.

By 16 March 1985, a two metre deep treated water layer was evident, growing to in excess of twenty metres deep by September 1985. On 6 October 1985, the treatment of Whites Open Cut by the water treatment plant was completed at the predetermined level of 22 metres below the surface.

(iii) Direct Addition of Lime

In establishing the treated water layer in January and February 1985, approximately two metres depth of untreated water was mixed with the treated water to create the treated water layer. Due to the low buffering capacity of the treated water, the pH of the treated water layer was controlled by this untreated water and was approximately 3.5.

In order to remedy this situation, lime slurry (containing 30% hydrated lime) was added to the treated water layer via the return water from the treatment plant. This direct addition of lime was commenced in April 1985 and continued until September 1985 when the pH of the treated water layer was 7.0.

The final aspect of the treatment of Whites Open Cut was the question of when to stop the treatment process.

Considerations influencing the depth of treatment of the open cut included:

- the Project objectives;
- the economics of water treatment;
- the pre-existing density stratification of the open cut;
- the presence of tailings in the base of the open cut and the need to leave a buffer layer;
- the possibility of the pit reverting to its previously polluted state at some time in the future; and,
- possible future utilisation of the pit.

After taking into account the above considerations, a decision was made to treat to a depth of 22 metres below the surface.

7.3 Treatment of Intermediate Open Cut

As can be seen from Table 6.5, the water contained in Intermediate Open Cut was considerably different to that contained in Whites Open Cut. Intermediate Open Cut contained significantly less pollution than Whites Open Cut, and was largely free from stratification.

Due primarily to the low overall heavy metal content of the water contained in Intermediate Open Cut, and the economics of the operation of a treatment plant designed to cater for heavily polluted water treating significantly lower levels of pollutants, alternative methods of treatment of the open cut were investigated.
These included:

- Release of the untreated pit water to the East Branch of the Finniss River during wet season flows;

- In situ treatment of the water in the open cut by direct addition of lime slurry;

- Flush the surface layers of the open cut with the East Branch of the Finniss River during the wet season, releasing the water to the river system;

- Treat (using the water treatment plant) a limited depth of the open cut; and,

- Treat the water in the open cut as previously planned but release the treated water to the river system rather than return to the open cut.

Based on environmental and economic considerations of the alternative treatment strategies, the water contained in Intermediate Open Cut was treated in situ by the direct addition of hydrated lime. The scheme adopted included:

- Induce complete mixing of the open cut by aeration from a compressed air manifold anchored at the floor of the pit;

- Add lime slurry to the surface of the pit and induce mixing with the pit water using the rising air plume from the manifold;

- Once the pH of the water contained in the open cut had reached 9.Ø, shut down the lime addition and aeration, and allow the precipitates of the heavy metals to settle to the floor of the pit; and,

- Once the precipitates had settled, the accumulated "sludge" was removed and dewatered in the water treatment plant, returning the clarified water to the open cut.

The above strategy was implemented, commencing during October 1985, and the removal and dewatering of the accumulated precipitates was completed on 6 December 1986.

7.4 Disposal of Filter Cake

The filter cake produced by the water treatment plant contained the residue of the hydroxide precipitation process. A typical assay of the material extracted from Whites Open Cut is presented in Table 7.4. The solids content of the material averaged approximately 3Ø%.

Table 7.4

CHEMICAL COMPOSITION OF FILTER CAKE

Component	Chemical Composition
Na_2O	Ø.Ø5 %
MgO	15.Ø %
Al_2O_3	8.1Ø %
CaO	9.7 %
Mn	2.22 %
Fe	3.7Ø %
Co	Ø.25 %
Cu	1.Ø4 %
Zn	Ø.14 %
SO_3	16.5 %
As	6 g/t
Hg	Ø.Ø1 g/t
Th	1Ø g/t
U	Ø.14 %
$Th^{23Ø}$	7.4 Bq/g
Ra^{226}	Ø.Ø21Bq/g
$Pb^{21Ø}$	Ø.37 Bq/g
$Po^{21Ø}$	Ø.Ø52Bq/g

The filter cake was disposed of as landfill in one of the borrow areas at the mine site.

Borrow area 5 on the northern side of the mine site was selected as a suitable disposal site on the basis that:

- it had a low permeability clay floor;
- the area had a water table which was below the floor of the borrow area; and,
- the rehabilitated site could be readily drained.

On completion of the removal of the filter cake from the water treatment plant, and placement in the borrow area, the filled area was rehabilitated by:

(i) grading the area to drain evenly away from the surface of the fill;

(ii) construction of a three layered low permeability zoned cover system over the filter cake; and,

(iii) construction of a groundwater cutoff system comprising a combination of low permeability cutoff walls and rubble drains.

The area was then revegetated and a stockproof fence constructed around the disposal site.

The total amount of filter cake produced in the water treatment plant was 81,2ØØ tonnes, with 75,6ØØ tonnes being extracted from Whites Open Cut and the balance from Intermediate Open Cut. Covering of the filter

cake disposal site was carried out during the 1986 dry season.

7.5 Rediversion of The East Branch of the Finniss River

Model studies established that a sustained inlet flow of 2 cubic metres per second for a period of two and a half days would induce adequate mixing within the open cuts and ensure that at least the top four metres of the open cut would be flushed with fresh river water on an annual basis.

Hydrologic studies of the catchment for the East Branch of the Finniss River above the mine site and analysis of the stream gauging data gathered as part of the monitoring programme yielded the data required to design the system. The more important of these are summarised in Table 7.5, with further detail presented in Appendix A.

Table 7.5

REDIVERSION OF THE EAST BRANCH OF THE FINNISS RIVER.
DESIGN PARAMETERS

Parameter	Value
Average annual flow	29×10^6 m^3
1 in 10 year (high) flow	48×10^6 m^3
1 in 10 year (low) flow	14×10^6 m^3
1 in 100 year peak discharge	360 m^3/s
Whites Open Cut	
1 in 100 year inflow	5 m^3/s
1 in 100 year water level	62.5 m RL
Intermediate Open Cut	
1 in 100 year inflow	6 m^3/s
1 in 100 year water level	61.0 m RL
Copper Creek Culvert	
1 in 100 year discharge	0.7 m^3/s

(i) Scope of Work

The scope of work required for the rediversion of the East Branch of the Finniss River was as described below (see Figure 6.18).

- Reshape the confluence of the East Branch of the Finniss River and Fitch Creek and construct flow control structures in the diversion channel and in the East Branch of the Finniss River. (A baffle wall in the diversion channel with a 0.3 m diameter opening together with a weir in the bed of the East Branch, upstream of Whites Open Cut.)

- Construct a channel from the southern end of Copper Creek (adjacent to the water treatment plant) to Intermediate Open Cut.

- Construct inlet and outlet structures to Whites and Intermediate Open cuts.

- Construct a levee bank at the inlet to Whites Open cut.

- Construct a levee bank over Copper Creek adjacent to the water treatment plant and install a culvert through the levee bank.

- Excavate an outlet channel from the outlet structure from Intermediate Open Cut to the East Branch of the Finniss River.

- Install channel protection at the outlet structures and the downstream end of the culvert under the levee bank on Copper Creek.

The general arrangement of the rediversion works is illustrated on Figure 6.18, and further details are included at Appendix G.

(ii) Principle of Operation of Rediversion

In general terms, the rediversion works were designed to split the flow between the open cuts and the diversion channel, as described below.

- Initial wet season flows containing the "first flush" pollutants from the upstream areas of the site and low flows from the confluence of the East Branch of the Finniss River and Fitch Creek, are prevented from entering the open cuts by the relative levels of the baffle wall in the diversion channel and the weir in the East Branch above Whites Open Cut and pass down the diversion channel through a Ø.3 m diameter opening in the baffle wall, thus bypassing the open cuts. A similar control system, built into the levee bank on Copper Creek, prevents low flows from the Copper Creek area from entering Intermediate Open Cut by diverting these via Copper Creek to the East Branch of the Finniss River, downstream of the mine site.

- When the backwater level in the region of the confluence reaches the crest level of the weir in the East Branch, the weir overflows, and the majority of the flow in the river is directed via the open cuts.

- When the backwater level rises to the crest level of the baffle wall in the diversion channel, the higher flow is split between the open cuts and the diversion channel.

- As the flow in the river increases, flow through the open cuts becomes restricted by

the capacity of the culvert entry structure to Whites Open Cut. As flow through the opencuts is then essentially constant, the excess flow is directed more towards the diversion channel.

. An embankment constructed above the entry culvert to Whites Open Cut ensures that, when the river flow reaches its estimated 1 in 100 year peak level, the floodwaters pass via the diversion channel and approximately one metre of freeboard exists to prevent overtopping of the banks of the open cuts and the consequent uncontrolled flooding of the pits.

. The water leaving the open cuts is drawn from a level of approximately three metres below the surface level of the pit which is controlled by a weir built into the downstream end of the outlet stucture.

The estimated annual flows through the open cuts are summarised in Table 7.6

Table 7.6

ANNUAL FLOWS THROUGH THE OPEN CUTS

	Whites	Intermediate (cubic metres)
Average Annual Flow	19×10^6	18×10^6
1 in 10 year dry	9×10^6	8×10^6
1 in 10 year wet	32×10^6	30×10^6

(iii) Construction

The rediversion works were constructed between October and December 1985 as part of the contract for the earthworks for Stage 4 of the Project (Contract No TW 117 of 84/85). Details of these works are included on Drawing W85/4049 sheets 6, 8, 9, 15 and 16 (Appendix G). Changes from the original design which arose during the construction phase included:

. The level of the crest of the outlet weir from Whites Open Cut was constructed 100 mm above the design level.

. The weir in the East Branch of the Finniss River and the baffle wall in the diversion channel were modified such that:
  - top of weir was at RL 62.00 AHD;
  - top of baffle wall was at RL 62.25 AHD;

- end sections of weir were modified to suit profile of river bed.

The rediversion works were completed prior to any significant river flows during the 1985/1986 wet season.

(iv) Performance of the Rediversion Works

The rediversion works were completed during December 1985 and their performance was monitored during the 1985/86 wet season. The works performed in accordance with the design requirements and the following specific observations were noted:

- mixing occured in both Whites and Intermediate Open Cuts to a depth of fifteen metres;
- debris carried by river flows did not result in any significant detrimental effects on the operation of the rediversion works; and,
- construction defects exposed by wet season storms did not significantly detract from the operation of the system. Defects were remedied.

7.6 Expenditure

The total direct cost expenditure on the construction of the water treatment plant and the treatment of the water contained in the open cut pits was $6,673,000. This was made up of:

Construction of plant	$2,017,000
Treatment of water	$1,791,000
Supply of Lime	$2,865,000

The direct cost of the rediversion of the East Branch of the Finniss River was $299,000.

Stage 1 of the Project was limited to the design, documentation and removal of Whites North Overburden Heap and its placement around the base of Whites Overburden Heap.

This stage of the Project was intended to include the complete removal of the overburden material comprising Whites North Overburden Heap and its placement around the base of Whites Overburden Heap. On completion of the works under the contract, overburden material still remained at the site of Whites North. Investigations revealed that this material contained significant amounts of pyrites and had the potential to oxidise, producing acid mine drainage. This remaining material was covered as part of Stage 4 of the Project. For details of timing refer to Section 5.6, Figure 5.3.

8.1 Scope of Stage 1

The detailed scope of the works is included in Specification No R83-2134:

- Clear and grub the area around the base of Whites Heap to be occupied by the material from Whites North Heap;
- Remove the material from Whites North Overburden Heap and spread, grade and compact the material around the base of Whites Overburden Heap; and,
- Trim the base area of Whites North Heap.

8.2 Implementation

Contract number TW 1Ø2 of 82/83 was awarded to Roadmakers Pty. Ltd. on 15 April 1983, a lump sum contract for the complete removal of the material comprising Whites North Overburden Heap and its placement around the base of Whites Overburden Heap.

The certificate of practical completion for the work under this contract was issued on 1Ø June 1983.

8.3 Expenditure

The cost of Stage 1 of the Project was $236,432.

Stage 2 of the Project included the complete rehabilitation of Whites Overburden Heap, shown prior to rehabilitation in Plate 6.1.

This stage was carried out in two phases; in 1983 the first contract (TW 12 of 83/84) was awarded to Hendrie Contractors Pty Ltd. Unfortunately this contractor failed in January 1984, and the contract was terminated due to the contractor's inability to complete the works. The completion of the rehabilitation of the heap was awarded to Thiess Contractors Pty Ltd as a variation to the contract for the removal of the Old Tailings Dam and the Copper Heap Leach Pile (contract TW 126 of 83/84).

9.1 Scope of Stage 2

Stage 2 of the Project, the design details of which were developed from the criteria set out in Chapter 6, comprised the detailed design, documentation and construction works required to rehabilitate Whites Overburden Heap. This included:

- Reshape Whites Overburden Heap to provide stable external and internal slopes which can be drained and revegetated;
- Cover the heap with a low permeability, erosion resistant cover system consisting of three zones;
- Construct a formalised drainage system on the heap; and,
- Revegetate the heap surfaces.

9.2 Design of Stage 2

The works were designed by a consultant group (Appendix C) during the period from October 1982 to July 1983. Construction commenced in August 1983.

As with the development of the design criteria, where appropriate, design details developed for Stage 2 of

the Project were replicated in later stages of the Project.

(i) Reshaping

The reshaping of the overburden heap was designed according to the criteria set out in Chapter 6, incorporating a five metre wide berm constructed at mid height on the heap batter. The general arrangement of the resulting landform is illustrated in Figure 6.4 and Plate 6.2, and the details are included on Drawing W83/4ØØ4, sheets 3, 4 (Appendix G) and 8 to 21.

(ii) Erosion Control

(a) Surface Protection

The surfaces of the cover system (top surface and batter surface of the heaps) were protected from erosion by the selection of suitably graded materials, with the material selected for the batter being coarser than that for the top surface. These materials are discussed in Section (iv) below.

(b) Erosion Control Banks

- Bank Spacing

The spacing of the erosion control banks for the varying gradients on the heap is as summarised in Table 9.1.

Table 9.1

SPACING OF EROSION CONTROL BANKS ON WHITES OVERBURDEN HEAP

Surface Grade	Bank Spacing *
1% - 4%	61 metres
5% - 6%	49 metres
7% - 1Ø%	4Ø metres

* Based on Horizontal Interval formula, Section 6.1.3.

- Bank Discharge

The estimated 1 in 1ØØ year flow rate from the erosion control drains is Ø.75 m^3/s.

The details of the erosion control drains are shown on Drawings numbered W83/4ØØ4, sheets 3 (location), 4 (typical cross sections), 6 (typical junction details), 22

and 23 (vegetation and erosion control details). See Appendix G.

(iii) Drainage

The design details of the drainage system for the heap were considered in two parts; the top surface of the heap and the batters. Each is discussed separately below. The layout of the drainage of Whites Overburden Heap is illustrated in Figure 6.4.

(a) The Top Surface of the Heap

The drainage system for the top surface of the heap consisted of lateral drains, collecting runoff from the erosion control banks and overland flow and directing that runoff to a main drainage line (drain D). The details of these lateral drains, all of which are lined with rip rap and have geotextile fabric basement protection, are as shown in Table 9.2.

Table 9.2

DETAILS OF LATERAL DRAINS ON WHITES OVERBURDEN HEAP

Drain	Catchment Area (ha)	Peak Discharge (m^3/s)	Base Width	Batter Slope	Depth of Flow	Vel (m/s)
A	6.4	2.3	3 m	3:1	Ø.4 m	3.29
B	7.4	4.Ø	4 m	3:1	Ø.35m	2.45
C	3.3	2.1	3 m	3:1	Ø.35m	2.12

The main drainage line on the top surface of Whites Overburden Heap (drain D), collected the runoff from the lateral drains, discharging it to the East Branch diversion channel. The details are:

Catchment Area	19.Ø ha
Peak Discharge	8.3 m^3/s
Base Width	4.Ø m
Batter Slope	2:1
Depth of Flow	Ø.42m
Flow Velocity	4.Ø m/s

The main drain was lined with 3ØØ mm thick Reno mattresses filled with rock spalls and the drain basement was protected with geotextile fabric.

To reduce the overall grade, three rock filled Gabion drop structures were included in the main drain.

Details of the top surface drainage are included in Drawing W83/4ØØ4, sheets 3, 4 and 7, in Appendix G.

(b) The Heap Batters

The heap batters are covered with a uniformly graded rock mulch designed to drain the batters at low energy, by throughflow to lower levels.

The formal drainage system for the batters of Whites Overburden Heap consists of a berm drain, discharging via cross berm drains to drop down drains. These carry the runoff from the berms and the upper section of the batters (above the berm) to a drain around the toe of the overburden heap.

Possible water flow along the interface between the overburden heap and the original ground surface is intercepted by a subsoil drain at the base of the northeastern and southwestern sides of the heap. The subsoil drain discharges to the heap toe drain.

- Drainage Along the Berm

The berm constructed on the batter of Whites Heap was specified as parallel with the ground surface at the toe of the heap. The berm was divided into a number of small catchments whose grade averaged that of the ground surface, with each catchment draining via the berm drain to a cross drain. In designing the berm drainage the heap was considered in two sections, the eastern batter and the southern and western batters. The layout of the berm drain is shown on Drawing W83/4ØØ4, sheet 3, the longitudinal section is on sheet 6 and the details are included on sheet 5 (see Appendix G). The relevant flow data is summarised in Table 9.3. All berm drains were specified as half round reinforced concrete pipe.

Table 9.3

DETAILS OF BERM DRAINS ON WHITES OVERBURDEN HEAP

Berm Length	Grade (%)	Peak Flow (m^3/s)	Pipe Size (mm)
15Ø m	1.5	Ø.44	45Ø/6ØØ
5Ø m	1.Ø	Ø.17	45Ø
15Ø m	2.8	Ø.45	45Ø/6ØØ
5Ø m	2.8	Ø.17	45Ø

- Drainage Across the Cross Berm

  The cross berm drains have a peak discharge of Ø.6 m^3/s, and were specified as 6ØØ mm diameter corrugated steel pipes. The details of the cross berm drains are included on Drawing W83/4ØØ4, sheet 5 (Appendix G).

- Drop Down Drains

  The drop down drains carry the batter runoff to the toe drains and have a gradient of 33%, that is, the slope of the batter. The peak flow in the drop down drains is Ø.6 m^3/s, and 6ØØ mm diameter half round corrugated steel pipe was specified. The outlets of the drop down drains are protected with energy dissipators.

  Details of the drop down drains are included on Drawing W83/4ØØ4, sheets 3 and 5 (Appendix G).

- Toe Drains

  The toe drains carry the runoff from the lower half of the batter slopes and from the drop down drains, and discharge variously to the Main Drain (drain D), to Wandering Creek and to Fitch Creek. The toe drain also collects the water discharged from the subsoil drains on the northeastern and southwestern sides of the base of the heap. Details of the toe drains are summarised in Table 9.4.

Table 9.4

DETAILS OF TOE DRAINS FOR WHITES OVERBURDEN HEAP

Drain	Catchment Area (ha)	Peak Discharge (m^3/s)	Base Width	Batter Slope	Depth of Flow	Vel (m/s)
E	1.51	1.32	1.Øm	3:1	Ø.35m	1.44
F	3.52	2.82	2.Øm	3:1	Ø.5 m	1.59
G	2.65	2.12	2.Øm	3:1	Ø.75m	1.49
H	3.52	2.92	2.5m	3:1	Ø.5 m	1.52
I	1.3	1.17	1.Øm	3:1	Ø.35m	1.44

The toe drains are lined with rip rap and their foundations are protected with geotextile fabric.

- Subsoil Drains

Prior to rehabilitation, acid groundwater issued from the heap at various locations. This caused a large area adjacent to the heap, otherwise untouched, to be denuded of vegetation.

A subsoil drain was specified for the northeast and southwest sides of the heap to intercept and control any possible residual polluted groundwater flow from those sections of the heap after infiltration had minimised by covering the reshaped heap.

The details of the subsoil drain are included on Drawing W83/4ØØ4, sheets 3 and 4 (Appendix G) and are summarised below.

Drain size - 45Ømm x 65Ø mm deep
Pipe size - 16Ømm dia
Outlet pipe - 225mm dia RCP,class X
Outlet spacing - 1ØØm (max)

(iv) Covers

The detailed specification of the cover system is dicussed in Section 6.1.4 of this report and is illustrated on Drawing number W83/4ØØ4, sheet 4 (Appendix G).

(v) Revegetation

(a) Seed Species

The seed species specified for Whites Overburden Heap are as shown in Section 6.1.5 Table 6.2.

(b) Fertilisation

Three applications of fertiliser were specified for all revegetated pastures, with the applications as set out below.

At seed sowing - 4ØØ kg/ha, 'Tropigro'
4 weeks after germination - 1ØØ kg/ha, 'Agran'
8 weeks after germination - 1ØØ kg/ha, 'Agran'

(c) Seeding Techniques

The specified seeding techniques are those as specified in Table 6.3.

(d) Watering

Areas specified to be seeded prior to the onset of reliable rains (vegetated channels) were specified to be watered as set out below.

Pre-sowing (24 hrs before sowing)	- 25 mm
Immediately after sowing	- 25 mm
1st week (every day)	- 25 mm
2nd week (every 2nd day)	- 25 mm
Next 3 weeks, or until sufficient natural rainfall (twice weekly)	- 25 mm

(e) Scheduling of Vegetation

In order to provide a reasonable chance of the successful establishment of vegetation and to minimise the potential for erosion damage, a schedule for seeding was specified, as shown in Table 9.5.

Table 9.5

SEEDING SCHEDULE FOR WHITES OVERBURDEN HEAP

Sowing Code	Location	Timing
F	Along vegetated channel	Mid November
M & MN	Slopes greater than 1 in 2Ø	Late October
D	Slopes less than 1 in 2Ø	Early November
B	Batters	Jan - Feb

(f) Maintenance

Short term maintenance of the vegetation was limited to mowing of established pastures, reseeding of failed areas, removal of tree seedlings and noxious weeds and the application of fertiliser.

The effect of rehabilitation is shown by comparing Plates 6.1 and 6.2.

9.3 Documentation

The above works were incorporated in specifications numbered R83-2293 and W84-29Ø7.

9.4 Tender and Award

Tenders for the works described in specification R83-2293 were initially invited by the Northern Territory Department of Transport and Works from previously qualified contractors, closing on 4 August 1983, and the tender from Hendrie Constructions Pty Ltd was accepted on 17 August 1983. The lowest tender, received from Thiess Contractors Pty Ltd, was unacceptably qualified and the tender was withdrawn by the tenderer.

After the failure of the contractor and the determination of the contract, the remaining works were re-documented and included in specification W84-29Ø7. Tenders for the works included in this specification were invited from pre-qualified contractors as a part of the tender for Stage 3 of the Project.

The tenders for this stage of the works closed on 29 March 1984 and the lowest tender (received from Thiess Contractors Pty Ltd) was accepted on 13 April 1984.

9.5 Construction

(i) Contract TW12 of 83/84, Hendrie Constructions Pty Ltd

Hendrie Constructions Pty Ltd were granted possession of the site on 23 August 1983, and commenced the rehabilitation of Whites Overburden Heap on 1 September 1983.

After having completed approximately 75% of the works under the contract, the contractor advised on 31 January 1984 that, due to financial problems, he was unable to complete the works. On 14 February 1984, contract TW12 of 83/84 was terminated.

(ii) Contract TW126 of 83/84, Thiess Contractors Pty Ltd

Possession of the site for the purpose of the completion of the rehabilitation of Whites Overburden Heap was granted to Thiess Contractors Pty Ltd on 19 April 1984.

Works under the contract were completed on 21 December 1984.

9.6 Expenditure

The direct costs of the rehabilitation of Whites Overburden Heap were $1,376,782, made up of:

Contract TW12 of 83/84	$ 672,232
Contract TW126 of 83/84	$ 589,898
Other costs	$ 114,652

Stage 3 of the Project included the removal of the tailings contained in the Old Tailings Dam and from Tailings Creek the low grade copper ore from the Copper Heap Leach Pile the copper launders and the contaminated soils from the Old Tailings Dam and the Copper Heap Leach Pile area and the disposal of those materials in Dysons Open Cut. The Old Tailings Dam and the resulting landform of Dysons Open Cut were then covered and revegetated. The covering and revegetation of the area formerly under the Copper Heap Leach Pile was delayed for one wet season and included in Stage 4 of the Project to enable the wet seasonal flushing effects prior to the installation of covers.

1Ø.1 Scope of Stage 3

This stage of the Project included the detailed design, documentation and construction necessary to rehabilitate the Old Tailings Dam, Tailings Creek, Copper Creek and Dysons Open Cut and to remove the contaminated and pyritic material from the Copper Heap Leach Pile area. Stage 3 included the following works:

- The removal of the tailings and associated sub soils from the Old Tailings Dam (Plate 6.5) and their placement in Dysons Open Cut;
- The removal of the low grade copper ore and the contaminated sub soils from the Copper Heap Leach Pile (Plate 6.8) and their placement in Dysons Open Cut;
- The removal of the copper launders and associated ponds from the Copper Heap Leach Pile area (Plate 6.8);
- The removal of accumulated tailings from Tailings Creek, and the reshaping of the creek (Plates 6.12 and 6.13);
- The removal of contaminated sediments from Copper Creek and the reshaping of the creek;

- The covering, drainage and revegetation of the Old Tailings Dam Area (Plates 6.6 and 6.7) and Dysons Open Cut (Plate 6.11); and,

- The construction of subsoil drainage on the Copper Heap Leach Pile area.

10.2 Design of Stage 3

In the development of the design of Stage 3 of the Project, extensive use was made of the details developed during the Stage 2 works.

The works were designed by a consultant group (see Appendix C) during the period from November 1983 to March 1984 and construction commenced in May 1984.

10.2.1 Old Tailings Dam

Detailed site investigations carried out during the design phase showed that the depth of tailings in the Old Tailings Dam ranged in depth from a thin veneer up to three metres, and covered an area of thirty five hectares. The average depth of tailings in the dam was one metre. The volume of tailings to be removed was estimated at 350,000 cubic metres.

Downstream from the Old Tailings Dam, eroded tailings had been deposited in the bed of (and along the banks of) Tailings Creek and on flood flats beside the creek.

(i) Earthworks

Test pits excavated in the Old Tailings Dam revealed that there was a distinct separation between the tailings and the subsoil and that the interface was readily identifiable by the colour change from the grey of the tailings to the red/yellow subsoil. Analysis of the samples gathered from the test pits showed that radioactivity was largely confined to the tailings material. Consequently, the removal of a depth of 100 mm below the tailings/soil interface would result in the reduction of the radium levels to meet the criteria set out in Chapter 3. The analysis also revealed that conditions toxic to plant growth on the Old Tailings Dam do not decline with depth and that there would have been little to gain by removing greater depths of soil.

The earthworks for the rehabilitation of the Old Tailings Dam were then specified as:

. The complete removal of the tailings and their placement in Dysons Open Cut, as discussed in Section 10.5.

. The removal of an average thickness of 100mm of subsoil below the soil/subsoil interface and its placement in Dysons Open Cut (with the actual amount to be removed determined by measurement of radioactivity). This resulted in the removal of an average depth of 200 mm of material from below the tailings.

. The contouring of the remaining surface to conform to the drainage requirements.

The earthworks for the rehabilitation of the Old Tailings Dam are included on Drawing W(C)83-4005, sheets 3, 4 (Appendix G) and 12 to 26.

(ii) Chemical Treatment

Due to the acid and heavy metals expected to remain in the subsoil after the removal of the material to Dysons Open Cut, the surface of the Old Tailings Dam was treated with lime.

The exposed surface was sampled on a 40 metre grid to a depth of 150 mm. The average lime requirement of each grid section was determined by measuring the extent to which the contributors to acidity in the soil sample depressed a buffer solution. This was reflected in the pH of the solution, which could then be equated to lime requirement in tonnes/hectare of pure calcium carbonate ($CaCO_3$). An adjustment was then made to this figure to correct for the differences in neutralising value between the form of lime used (hydrated lime) and pure $CaCo_3$.

Lime was spread and the surface tyned to mix the lime with the top 150 mm of the soil. The lime requirement ranged from 5 to 20 tonnes/hectare, and averaged 7 tonnes/hectare over the 33 hectare site. Following liming, approximately 300 mm of plant rooting medium was spread on the surface.

(iii) Erosion Control

Erosion control on the new landform comprised surface protection of the rehabilitated tailings dam and erosion control banks to control overland flow.

(a) Surface Protection

Surfaces of the Old Tailings Dam area were protected from erosion by the cover system and by the developed vegetation. The cover system is described in Section (v) below and the vegetation is described in Section (vi).

(b) Erosion Control Banks

- Bank Spacing

  Spacing of erosion control banks on the Old Tailings Dam Area was based on dividing the surface of the Dam into subcatchments whose maximum size was 2 ha, with a maximum spacing of 85 metres between banks.

- Bank Discharge

  The estimated 1 in 1ØØ year discharge from the erosion control banks is Ø.1 m^3/s.

The erosion control banks discharge to a rip rap lined drain in the centre area of the tailings dam with erosion control drain outlets protected by rip rap and Reno mattresses.

Design details for the erosion control banks are included on Drawing W(C)83/4ØØ5, sheets 3, 4, 6 and 43 (Appendix G).

(iv) Drainage

Two drains service the Old Tailings Dam Area as shown in Figure 6.1Ø. Drain 1, on the alignment of an existing water course, drains the area to the north of the Old Tailings Dam as well as the discharge from Drain 2 and discharges to Tailings Creek. Drain 2 drains the Old Tailings Dam area, the Treatment Plant area and the Stockpile area to the west of the Old Tailings Dam.

Details of the design of the drains are summarised in Table 1Ø.1.

Both Drains 1 and 2 are lined with rip rap and have geotextile fabric basement protection.

Table 10.1

DETAILS OF DRAINS ON OLD TAILINGS DAM AREA

Drain	Catchment Area (ha)	Peak Discharge (m^3/s)	Base Width	Batter Slope	Depth of Flow	Vel (m/s)
1	200	23.9	7 m	3:1	1.2 m	2.9
2	50	13.6	1 m	3:1	1.2 m	2.5

Details of the drains are included on Drawings numbered W(C)83/4005, sheets 3, 4 and 6 (Appendix G) and shown on Plate 6.7.

(v) Covers

Covers on the Old Tailings Dam area were required to provide erosion resistance for the finished surface and a seed bed for the revegetation of the area. The covers were specified as 300 mm minimum thickness of Zone 1B type material.

(vi) Revegetation

The cover system on the Old Tailings Dam area was not intended to reduce infiltration into the subsoils, but to provide erosion resistance and a seed bed. Accordingly, as root penetration was not detrimental to the function of the covers, the seed species selected included native trees and shrubs. The seed species for the Old Tailings Dam area are summarised in Table 10.2.

Layout of revegetation is included on Drawing W(C)83/4005, sheets 40 and 41 (Appendix G).

Table 10.2

SEED SPECIES AND SOWING RATES FOR OLD TAILINGS DAM AREA

Species Name	Common Name	Sowing Rate (kg/ha)
Slopes (Mix s)		
Sorghum bicolor	Hybrid dwarf sorghum	4
Chloris gayana	Rhodes grass	5
Paspalum notatum	Pensacola Bahai grass	3
Urochloa mozambicensus	Sabi grass	3
Stylosanthes hamata var. Verano	Verano stylo	5
Channels (Mix c)		
Chloris gayana	Rhodes grass	5
Brachiaria mutatica	Para grass	10
Paspalum plicatum var. Bryan	Bryan Plicatulum	10
Native Trees and Shrubs (Mix n)		
Acacia aulacocarpa	Wattle	150 g/ha
A. auriculiformis	Wattle	200 g/ha
A. gonocarpa	Wattle	100 g/ha
A. holosericea	Wattle	150 g/ha
A. multisiliqua	Wattle	100 g/ha
Eucalyptus clavigera	Cabbage Gum	50 g/ha
E. miniata	Woolly Butt	50 g/ha
E. papuana	Ghost Gum	50 g/ha
E. polycarpa	Bloodwood	50 g/ha
Grevillea sp. Mt. Brockman		40 g/ha
G. pteridiifolia		40 g/ha
Melaleuca viridiflora	Paperbark	20 g/ha

Seeding techniques are as shown in Table 6.3.

Areas specified to be seeded prior to the onset of reliable rains (vegetated channels) were specified to be watered as set out below.

Pre-sowing (24 hrs before sowing)	- 25 mm
Immediately after sowing	- 25 mm
1st week (every day)	- 25 mm
2nd week (every 2nd day)	- 25 mm
Next 3 weeks, or until sufficient natural rainfall (twice weekly)	- 25 mm

In order to provide a reasonable chance of the successful establishment of vegetation (and to minimise the potential for erosion damage) the schedule for seeding was specified as shown in Table 9.5.

Short term maintenance of the vegetation was limited to mowing of established pastures,

re-seeding of failed areas, removal of tree seedlings and noxious weeds and the application of fertiliser.

10.2.2 Copper Heap Leach Pile

The Copper Heap Leach Pile was constructed from low grade copper ore from Intermediate Open Cut during the mining of that ore body. In the period since the leach pile was abandoned, the products of the pyritic oxidation taking place in the pile had contaminated the underlying and surrounding area. The ponds constructed as part of the copper extraction process also effectively concentrated acidic, copper rich liquor from the heap leach pile which then leaked to the surrounding soils. A set of concrete launders also remained from the experiment.

Stage 3 of the Project included the removal of the low grade ore, the ponds, the concrete copper launders and surrounding contaminated soils and the construction of a subsoil drainage system to promote flushing of contaminated groundwater.

(i) Earthworks

Earthworks associated with the removal of the Copper Heap Leach Pile were limited to:

- removal of the concrete launders and their placement in Dysons Open Cut;
- removal of the remnants of the process ponds and their placement in Dysons Open Cut;
- removal of the low grade copper ore comprising the Copper Heap Leach Pile and its placement in Dysons Open Cut on top of the tailings from the Old Tailings Dam, compacted and sandwiched between layers of subsoil;
- removal of the contaminated subsoils from the heap leach area and their placement in Dysons Open Cut with the low grade copper ore; and,
- reshaping of the remaining area to form even grades draining to Copper Creek.

The details of these earthworks are illustrated on Drawings numbered W(C)83/4005, sheets 7, 8 (Appendix G) and 27 to 32.

Final covering and vegetation were delayed for one wet season and included in Stage 4 of the Project.

(ii) Drainage

In order to promote subsoil drainage and subsequent leaching of the acidic soils remaining after the removal of the leach pile and surrounding soils, a subsoil drainage system outfalling to Copper Creek was specified. The details of this drainage system are shown on Drawing W(C)83/4ØØ5, sheets 7 and 8 (Appendix G).

1Ø.2.3 Dysons Open Cut

Dysons Open Cut was used as the disposal site for the tailings from the Old Tailings Dam, the low grade ore from the Copper Heap Leach Pile, the associated soils from the Old Tailings Dam and the heap leach area and the contaminated materials from Copper Creek and Tailings Creek.

During the mine operating period, Dysons Open Cut had been used as a tailings disposal site and, at the commencement of the rehabilitation programme, contained approximately 3ØØ,ØØØ cubic metres of tailings. The tailings had been discharged by spigotting from the south-western end of the pit resulting in a beach of coarse material in the discharge area and in saturated tailings in the remainder of the pit. The presence of these saturated tailings which would underly the materials to be disposed of in the open cut was expected to result in substantial settlement of the fill material as the porewater held by the wet tailings was released during consolidation. The design details had to take account of this possible settlement as well as to provide controlled drainage for the released porewater, preventing it from infiltrating the low grade copper ore and potentially supporting further pyritic oxidation.

These saturated tailings also gave rise to substantial construction problems which are discussed below.

The landform that resulted from the filling of Dysons Open Cut was covered, drained and revegetated.

(i) Earthworks

The earthworks for Dysons Open Cut included the placement of the materials in the open cut and the shaping and trimming of the resultant landform.

Specific requirements for the earthworks were:

- tailings material to be placed, uncompacted, in the lower region of the open cut with the surface of the tailings graded with a minimum transverse grade of 1%, and graded to the lower end of the open cut;
- a rock blanket one metre thick to provide drainage and separation;
- low grade copper ore from the Copper Heap Leach Pile to be placed in layers approximately one metre thick with a layer of approximately 300 mm of subsoil material between each layer of heap leach material;
- all material above the tailings to be compacted as per Table 10.3; and,
- finished surface grades on the landform to be as summarised in Table 10.4.

Table 10.3

COMPACTION OF MATERIAL IN DYSONS OPEN CUT

Height above Rock Blanket	Compaction (standard max dry density)
0 to 2 metres	90%
2 metres to surface	95%

Table 10.4

SURFACE GRADES FOR DYSONS OPEN CUT

Location	Grade
Top Surface	5% to 10%
Batters	33%

The earthworks for Dysons Open Cut are detailed on Drawing W(C)83/4005, sheets 9, 10 (Appendix G) and 34 to 39.

(ii) Erosion Control

(a) Surface Protection

The surfaces of the cover system (top surface and batter surface of the

heaps) were protected from erosion by the vegetation and by the selection of suitably graded materials, with the material selected for the batter being uniformly graded quarried rock coarser than that for the top surface. These materials are discussed in Section (iv) below.

(b) Erosion Control Banks

Erosion control banks are constructed from Zone 2A type material and outfall to the main drain (Drain 3). The outlets to the erosion control drains are protected with Reno mattresses and rip rap.

- Bank Spacing

  The maximum bank spacing for the surface of the fill material was 55 metres.

- Bank Discharge

  The estimated 1 in 1ØØ year flow rate from the erosion control drains is Ø.3 m^3/s.

(iii) Drainage

The drainage on the landform of Dysons Open Cut included the provision of surface drainage to collect runoff from the top of the mound and to intercept drainage from the area to the north of the open cut, subsoil drainage to collect and control porewater released from the tailings, and filter drainage zones to intercept infiltration into the Copper Heap Leach Pile material.

(a) Surface Drainage

Surface drainage of Dysons Open Cut consists of two drains as shown in Figure 6.14. Both outfall to a drain at the lower eastern end of the open cut which discharges to the East Branch of the Finniss River upstream of the Acid Dam.

Drain 3 is the main drain for the open cut. Collecting surface water from the top of the landform and the discharge from the erosion control banks, Drain 3 is approximately central to the top surface and incorporates a drop structure at the lower end. A cutoff drain (Drain 4) intercepts overland flow from the higher area to the north of the open cut. An informal drain collects the discharge from Drains 3

and 4. The details of Drains 3 and 4 are summarised in Table 10.5.

Table 10.5

DETAILS OF DRAINS FOR DYSONS OPEN CUT

Drain	Catchment Area (ha)	Peak Discharge (m^3/s)	Base Width	Batter Slope	Depth of Flow	Vel (m/s)
3	5.8	3.1	2 m	2:1	0.32m	3.7
4	5.8	3.4	1 m	3:1	0.43m	3.5

Drain 3 is lined with Reno mattresses and has geotextile basement protection. Drain 4 is an unlined drain.

Details of the drains are included on Drawing W(C)83/4005, sheets 9, 10 and 11 (Appendix G), and shown on Plate 6.11.

(b) Subsoil Drainage

The major component of the upper portion of the fill in Dysons Open Cut is compacted pyritic material from the Copper Heap Leach Pile. In order to minimise the possibility of the material continuing to oxidise, subsoil drainage was specified to intercept infiltrating soil moisture from:

- porewater being driven out of the saturated tailings which were already in the open cut;
- surface runoff moving down the intersection of the original wall of the open cut and the fill material; and,
- infiltration through the cover system.

The elements of this subsoil drainage system were:

- The Rock Blanket

  A one metre thick rock blanket was constructed directly on top of the tailings from the Old Tailings Dam to control porewater released from these and Dysons tailings. Underlain by a geotextile fabric

basement, the rock blanket was graded towards the eastern end of the open cut. In addition to forming a drainage layer, the rock blanket provided a working platform for the placement of the material from the heap leach area.

The rock blanket extended (500 mm thick) up the eastern face of the open cut to intercept possible groundwater movement along that face.

. Filter Layer

A filter drainage layer, outfalling to a piped subsoil drain, was incorporated in the underside of the batter covers.

Details of the subsoil drainage system are included on Drawing W(C)83/4005, sheets 9 and 10 (Appendix G).

(iv) Covers

Infiltration reducing covers, the details of which are described in Chapter 6, were specified for the resultant landform of Dysons Open Cut. The cover system is illustrated on Drawing W(C)83/4005, sheets 9 and 10 (Appendix G).

(v) Revegetation

Details of the revegetation of Dysons Open Cut are included on Drawing W(C)83/4005, sheets 42 and 43 (Appendix G).

(a) Seed Species

The seed species specified for the final landform of Dysons Open Cut as shown in Table 6.2.

(b) Fertiliser

Three applications of fertiliser were specified for all revegetated pastures, with the applications as set out below.

At seed sowing - 400 kg/ha, 'Tropigro'
4 weeks after germination - 100 kg/ha, 'Agran'
8 weeks after germination - 100 kg/ha, 'Agran'

(c) Seeding Techniques

The seeding techniques are as those specified (Table 6.3).

(d) Watering

Areas specified to be seeded prior to the onset of reliable rains (vegetated channels) were specified to be watered as set out below.

Pre-sowing (24 hrs before sowing)	- 25 mm
Immediately after sowing	- 25 mm
1st week (every day)	- 25 mm
2nd week (every 2nd day)	- 25 mm
Next 3 weeks, or until sufficient natural rainfall (twice weekly)	- 25 mm

(e) Scheduling of Vegetation

In order to provide a reasonable chance of the successful establishment of vegetation and to minimise the potential for erosion damage, the same seeding schedule as used for Whites Overburden Heap was used (Table 9.5).

(f) Maintenance

Short term maintenance of the vegetation was limited to mowing of established pastures, re-seeding of failed areas, removal of tree seedlings and noxious weeds and the application of fertiliser.

10.2.4 Tailings Creek and Copper Creek

(i) Tailings Creek

As a result of the lack of containment of the tailings in the Old Tailings Dam, tailings material had been spread down Tailings Creek to it's junction with the East Branch of the Finniss River (Plate 6.12). Stage 3 of the programme included the removal of this contaminated material and its placement in Dysons Open Cut with the tailings from the Old Tailings Dam.

The works are illustrated in Drawing W(C)83/4005, sheets 5 and 6 (Appendix G) and shown on Plate 6.13.

(ii) Copper Creek

The stream bed of Copper Creek had become acidified and contained heavy metals, largely as a result of the transport of these pollutants from the Copper Heap Leach Pile. Stage 3 of the rehabilitation programme included the removal of

contaminated sediments from the stream bed and their placement in Dysons Open Cut. These works are illustrated in Drawing W(C)83/4ØØ5, sheets 7 and 8 (Appendix G).

1Ø.3 Documentation

The works comprising Stage 3 of the rehabilitation programme are included in specification W84/2876.

1Ø.4 Tender and Award

Tenders for Stage 3 of the rehabilitation programme were invited from pre-selected contractors by the Northern Territory Department of Transport and Works. Tenders closed on 29 March 1984, and Contract TW 126 of 83/84 was awarded to the lowest tenderer, Thiess Contractors Pty Ltd on 13 April 1984.

Due to the unusual nature of the work to be carried out under the contract, a risk sharing arrangement was negotiated between the Northern Territory Government and the contractor. In essence, the arrangement entitled the contractor to additional costs incurred if his tendered method of removal of tailings from the Old Tailings Dam and their placement in Dysons Open Cut was not successful.

1Ø.5 Construction

The operation of handling the tailings material was controlled by the provisions of the Code of Practice on Radiation Protection in the Mining and Milling of Radioactive Ores (Reference 15). Compliance with the provisions of the Code of Practice required that:

- the Project appoint a Radiation Safety Officer to implement programmes aimed at identifying and monitoring the radiation regime at the mine site;
- a "Controlled Area" be declared encompassing all areas of the site where tailings were being handled;
- specific measures be implemented to ensure that exposure of personnel to harmful radioactivity was minimised;
- wash down and ablution facilities be constructed at the site to prevent the spread of radioactive materials outside of the "Controlled Area", and that all plant and equipment leaving the "Controlled Area" be thoroughly cleaned of radioactive materials; and,
- all personnel entering the "Controlled Area" undertake medical examination prior to commencing work in that area.

The contractor was granted possession of the site on 19 April 1984.

On the morning of 26 April 1984, the contractor carried out trials aimed at establishing work methods for the handling of the tailings material. From these and other trials, it was established that the handling of the tailings would require, at least in part, the use of specialised low ground pressure equipment. After several attempts, the work method outlined below was developed and applied to the removal of the tailings:

- In the centre areas and in the wetter areas around the edges of the Old Tailings Dam, the tailings were pushed up into windrows approximately ten metres high utilising two Caterpillar D6 LGP low ground pressure dozers and a Komatsu D65P dozer;

- Around the outer edges of the Old Tailings Dam, in the areas where the tailings were firmer, tailings were pushed into windrows with Caterpillar D8 and D9 dozers;

- The tailings were loaded into Volvo 86Ø BM low ground pressure haul trucks using a track mounted excavator and carted to hardstand areas on the edge of the Old Tailings Dam; and,

- Accessible tailings in the Old Tailings Dam and the tailings stockpiled on the hardstands were loaded and hauled to Dysons Open Cut using conventional earthmoving equipment.

For the majority of the period of handling the tailings, the low ground pressure equipment operated on two nominally ten hour shifts per day, six days per week.

The tailings which were already in Dysons Open Cut also presented special problems in the filling of the open cut.

As noted, the tailings which were placed into Dysons Open Cut from 1961 until 1965 were discharged from the southern end of the open cut forming a beach of the coarser fraction of the tailings around the discharge point with the saturated tailings (slimes) forming a pool in the remainder of the open cut. To contain these tailings, a low embankment had been built across the downstream end of the open cut.

During the 1983/84 wet season this downstream embankment was breached and the retained water released to the East Branch of the Finniss River.

The tailings from the Old Tailings Dam were placed in Dysons Open Cut over the in situ tailings, commencing from the dryer, southern end and from the eastern rim of the open cut. A rock embankment was built across the downstream end of the open cut to retain any

tailings displaced by the fill operation. A further embankment was built upstream in the open cut to retain liquefied tailings as the fill operation progressed.

Tailings were placed by dumping on previously placed tailings and pushing over an advancing face. Low shear strength saturated tailings failed regularly in generally circular failure surfaces. The underlying tailings were generally displaced towards the centre of the open cut; excess pore water appeared as boils at the toe of the failure surface. Occasionally the whole tailings fill liquified and flowed. Filling was achieved by taking advantage of this somewhat dangerous procedure with further fill placed over the previously failed material.

As further tailings were placed in Dysons Open Cut, the pool of liquefied tailings rose with the level of the fill as they were displaced by tailings from the Old Tailings Dam. In order to traverse this area, a double layer of geotextile fabric was placed over the liquid tailings, with low ground pressure dozing equipment being used to spread tailings over the geotextile fabric until sufficient material had been placed to allow access by conventional earthmoving plant.

The removal of the tailings and soils from the Old Tailings Dam and their placement in Dysons Open Cut was completed on 3 October 1984, and the revegetation of the completed landform was completed in December 1984.

Subsequent to the completion of the filling of Dysons Open Cut, there has been (as expected) significant settlement of the fill material, with associated cracking of the cover materials. A set of permanent survey marks has been established, enabling the magnitude of the settlement to be monitored. The maximum settlement to date has been measured at 900 mm.

The removal of the low grade copper ore from the Copper Heap Leach Pile area commenced in September 1984 and was completed during December 1984.

The subsoil drains for the area occupied by the Copper Heap Leach Pile were deferred from contract TW 126 of 83/84 because of uncertainties surrounding the use of the area in the treatment of the water from Whites Open Cut. The drains were installed during early 1985 under a separate contract (order number SD5447/84).

10.6 Expenditure

The direct costs of Stage 3 of the rehabilitation programme were $3,366,186, made up of:

Contract TW 126 of 83/84	$3,210,000
Supply of Lime	$ 89,500
Other Works	$ 66,686

Stage 4 of the rehabilitation programme was the final major stage of the Project and included the rehabilitation of the following areas:

- Dysons and Intermediate Overburden Heaps;
- The Treatment Plant Area;
- The Stockpile Area;
- Acid and Sweetwater Dams;
- Completion of Whites North Overburden Heap;
- Completion of the Copper Heap Leach Pile area; and,
- The rediversion of the East Branch of the Finniss River.

The design of the works included in this stage of the Project was undertaken during the period September 1984 to May 1985. The works were executed under a contract awarded on 14 March 1985 and practical completion was certified in December 1985.

11.1 Scope of Stage 4

The rediversion of the East Branch of the Finniss River is discussed in Chapter 7. The scope of the remainder of Stage 4 of the rehabilitation programme comprised the following elements.

(i) Dysons Overburden Heap

The rehabilitation of Dysons Overburden Heap included the following works:

- the reshaping of the top surface of the heap to form even grades capable of being drained and revegetated;
- the construction of erosion control and a formalised drainage system on the top surface of the heap;

- the construction of a zoned cover system on the top surface of the heap; and,
- the revegetation of the top of the heap.

(ii) Intermediate Overburden Heap

The rehabilitation of Intermediate Overburden Heap (Plate 6.3) included the following works:

- the reshaping of the heap to provide stable internal and external slopes which can be drained and revegetated;
- the liming of the top surface of the heap;
- the covering of the heap with a low permeability cover system consisting of three zones;
- construction of a formalised drainage system on the heap; and,
- revegetation of the heap.

The rehabilitated heap is shown in Plate 6.4.

(iii) The Treatment Plant Area

The Treatment Plant was located to the east of the Old Tailings Dam and had been filled in 1977 using the material from the lead ore stockpile. The scope of the rehabilitation of this area included:

- reshape the area to form stable grades;
- lime treat the area;
- construct a formalised drainage system;
- construct a low permeability zoned cover system consisting of four zones; and,
- revegetate the area.

(iv) The Stockpile Area

The scope of work for the rehabilitation of the Stockpile Area included:

- re-grade the area and fill minor erosion gullies;
- apply hydrated lime;
- construct a vegetation-supporting cover system on the area;

- construct formal drainage on the area; and,
- revegetate the area.

(v) Acid and Sweetwater Dams

The scope of the rehabilitation of the Acid and Sweetwater Dams was limited to the removal of the remnants of the dam walls and some revegetation of the creek banks in the area, as shown in Plate 6.14.

(vi) Whites North Overburden Heap

Whites North Overburden Heap was substantially removed to the toe zone of Whites Overburden Heap as Stage 1 of the Project. The remainder of the heap was rehabilitated under this stage. Rehabilitation included:-

- treat the surface of the area with lime;
- construction of a low permeability cover system on the area;
- construction of erosion control banks on the area; and,
- revegetation of the area.

(v) Copper Heap Leach Pile Area

The low grade copper ore and the contaminated soils from the Copper Heap Leach Pile area were removed and the area reshaped as part of Stage 3 of the rehabilitation programme. The works carried out as part of this stage of the programme included the covering of the area with a four zoned low permeability cover system, construction of an erosion control bank and the revegetation of the area, as shown in Plate 6.9.

(vi) Minor Works

Minor works carried out as part of Stage 4 of the rehabilitation programme included the rehabilitation of borrow areas, the repair of erosion scours in the area adjacent to Whites Overburden Heap, some drainage works and the removal of the washdown and ablution facilities constructed for the removal of the tailings from the Old Tailings Dam.

11.2 Design of Stage 4

The works comprising Stage 4 of the rehabilitation programme were designed in two stages. The first stage included the rehabilitation of Dysons and Intermediate Overburden Heaps, the Treatment Plant and Stockpile areas, Whites North Heap and the removal of Acid and

Sweetwater Dams. The remainder of the works were designed as part of the second stage.

The works were designed by a consultant group commissioned by the Project.

11.2.1 Dysons Overburden Heap

Studies carried out by the Australian Atomic Energy Commission (Reference 64) showed that Dysons Overburden Heap contributed approximately one percent to the overall pollution at Rum Jungle. Observations and monitoring during the rehabilitation of Whites Overburden Heap also showed that the majority of the rehabilitation benefits were realised by the covering of the top of the heap. In view of the high cost of reshaping the batters of Dysons Heap (contributed to by the heap's proximity to the East Branch of the Finniss River) it was decided to rehabilitate the top surface only and to leave the batters essentially as they existed.

Consequently, the rehabilitation of Dysons Overburden Heap (Figure 6.5) was limited to the reshaping, covering, drainage and revegetation of the top of the heap.

(i) Reshaping

The top surface of Dysons Overburden heap was reshaped according to the criteria set out in Chapter 6, and shown in Figure 6.6.

(ii) Erosion Control

Protection against erosion of the top of the heap was provided by the cover materials, vegetative cover and by erosion control banks.

(a) Surface Protection

The surface of the cover system is protected from erosion by the selection of suitably graded materials and by the establishment of vegetation on the surface. These are discussed below.

(b) Erosion Control Banks

. Bank Spacing

The maximum spacing of the erosion control banks on Dysons Heap is 45 metres.

. Bank Discharge

The 1 in 1ØØ year peak discharge from the erosion control banks is Ø.2 cubic metres per second.

The erosion control drains discharge to Drains 5 and 6 with rip rap and Reno mattress protected outlets.

The details of the erosion control banks are included on Drawing W85/4Ø42, sheets 6 and 4Ø (Appendix G).

(iii) Drainage

The top surface of Dysons Heap is drained by two rip rap lined drains, Drains 5 and 6. The details of these drains are summarised in Table 11.1, and their layout is shown in Figure 6.6.

Table 11.1

DETAILS OF DRAINS ON DYSONS OVERBURDEN HEAP

Drain	Catchment Area (ha)	Peak Discharge (m^3/s)	Base Width	Batter Slope	Depth of Flow	Vel (m/s)
5	6.Ø	3.Ø	2 m	2:1	Ø.3 m	4.3
6	1.3	Ø.8	2 m	3:1	Ø.18m	2.1

Drain 5 is lined with Reno mattresses and Drain 6 is lined with rip rap. Both drains have geotextile fabric basement protection. A rock filled gabion drop structure is incorporated in the downstream end of Drain 5.

Drawing W85/4Ø42, sheets 6 and 7 (Appendix G) illustrate the details of the drains on Dysons Heap.

(iv) Covers

The detailed specification of the cover system is dicussed in Section 6.1.4 and is illustrated on Drawing W85/4Ø42, sheet 6 (Appendix G). In order to prevent stormwater from overflowing onto the batters, a low bank was constructed around the perimeter of the top of the heap.

(v) Revegetation

The details of the revegetation of the top surface of Dysons Overburden Heap are shown on Drawing W85/4Ø42, sheet 35 (Appendix G).

(a) Seed Species

The seed species specified for Dysons Overburden Heap are seed Mix t and seed Mix c in Table 6.2.

(b) Fertilisation

Three applications of fertiliser were specified for all revegetated pastures, with the applications as set out below.

At seed sowing - 4ØØ kg/ha, 'Tropigro'
4 weeks after germination - 1ØØ kg/ha, 'Agran'
8 weeks after germination - 1ØØ kg/ha, 'Agran'

(c) Seeding Techniques

The seeding techniques are those specified in Table 6.3.

(d) Watering

Areas specified to be seeded prior to the onset of reliable rains (vegetated channels) were specified to be watered as set out below.

Pre-sowing (24 hrs before sowing)	- 25 mm
Immediately after sowing	- 25 mm
1st week (every day)	- 25 mm
2nd week (every 2nd day)	- 25 mm
Next 3 weeks, or until sufficient natural rainfall (twice weekly)	- 25mm

(e) Scheduling of Vegetation

In order to provide a reasonable chance of the successful establishment of vegetation and to minimise the potential for erosion damage, the schedule for seeding as previously used for Whites Overburden Heap was specified (Table 9.5). The exception was that batters were not seeded.

(f) Maintenance

Short term maintenance of the vegetation was limited to mowing of established pastures, reseeding of failed areas, removal of tree seedlings and noxious weeds and the application of fertiliser.

11.2.2 Intermediate Overburden Heap

(i) Reshaping

In the construction of the rock blanket on the tailings in Dysons Open Cut, approximately 40,000 cubic metres of dolomitic rock was won from the south-western corner of Intermediate Overburden Heap.

The heap was reshaped by shifting the material from the higher eastern side of the heap to the area from where the dolomitic material had been removed. Compare Figure 6.7 with Figure 6.8, and Plate 6.3 with Plate 6.4.

The criteria for reshaping is set out in Chapter 6 of this report and the details of the heap are included on Drawing W85/4042, sheets 3, 5 (Appendix G) and 14 to 25.

(ii) Chemical Treatment

The top surface of Intermediate Heap was treated with lime to correct soil acidity.

(iii) Erosion Control

(a) Surface Protection

The surfaces of the cover system (top surface and batter surface of the heaps) were protected from erosion by the selection of suitably graded materials, with the material selected for the batter being coarser than that for the top surface. These materials are discussed in Section (v) below.

(b) Erosion Control Banks

- Bank Spacing

The maximum spacing of the erosion control banks is 70 metres.

- Bank Discharge

The estimated 1 in 1ØØ year flow rate from the erosion control drains is Ø.6 m^3/s.

Details of the erosion control banks are shown on Drawing W85/4Ø42, sheets 3, 5 and 4Ø (Appendix G).

(iv) Drainage

There are three elements to the drainage of Intermediate Overburden Heap, as shown in Figure 6.8. Drain 7 drains the top surface of the heap, collecting the discharge from the erosion control drains and overland flow. It outfalls to the diversion channel of the East Branch of the Finniss River. Drain 8 is a diversion channel for Wandering Creek, whose original course was along the southern toe of Intermediate Heap. It also collects the discharge from Drain 9 which drains the north-eastern batter of the heap.

The downstream section of Drain 7 is lined with Reno mattresses, all other drains are lined with rip rap. All of the drains have geotextile fabric basement protection.

Table 11.2 is a summary of the drain details which are illustrated on Drawing W85/4Ø42, sheets 3 and 4 (Appendix G).

Table 11.2

DETAILS OF DRAINS FOR INTERMEDIATE OVERBURDEN HEAP

Drain	Catchment Area (ha)	Peak Discharge (m^3/s)	Base Width	Batter Slope	Depth of Flow	Vel (m/s)
7	Ø.8	2.Ø	2 m	3:1&2:1	Ø.25m	3.4
8	59.Ø	19.3	6 m	3:1	1.2Øm	2.5
9	4.4	2.Ø	2 m	3:1	Ø.5Øm	1.2

(v) Covers

The detailed specification of the cover system is discussed in Section 6.1.4, and is illustrated on Drawing W85/4Ø42, sheets 3 and 5 (Appendix G). In order to prevent stormwater from overflowing onto the batters, a low bank was constructed around the perimeter of the top of the heap.

(vi) Revegetation

The details of the revegetation of Intermediate Overburden Heap are shown on Drawing W85/4Ø42, sheet 34 (Appendix G).

(a) Seed Species

The seed species specified for Intermediate Overburden Heap are almost the same as those described in Table 6.2, with the following changes. Sabi grass (Urachloa mozambicensis) was substituted for Pensacola Bahai grass in Mix t and Mix s, Calopo was deleted from Mix b, and Green couch was added to Mix s.

(b) Seeding Techniques

Seeding techniques were as specified in Table 6.3.

(c) Scheduling of Vegetation

In order to provide a reasonable chance of the successful establishment of vegetation and to minimise the potential for erosion damage, the schedule for seeding as used for Whites Overburden Heap (Table 9.5) was specified.

(d) Fertilisation, Watering and Maintenance

These were the same as described for Dysons Overburden Heap earlier in this chapter.

11.2.3 The Treatment Plant Area and the Stockpile Area

Rehabilitation of these areas was identical with the exception of the cover systems adopted.

(i) Reshaping

The area was reshaped in accordance with the criteria set out in Chapter 6 of this report. Some minor erosion gullies in the Treatment Plant Area were filled. Drawing W85/4Ø42, sheets 11 and 12 (Appendix G) illustrate details of the reshaping.

(ii) Chemical Treatment

The area was treated with lime to correct soil acidity.

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(iii) Erosion Control

(a) Surface Protection

The surfaces of the cover system were protected from erosion by the selection of suitably graded materials. These materials are discussed in Section (v) below.

(b) Erosion Control Banks

- Bank Spacing

The maximum spacing of the erosion control banks is 8Ø metres.

- Bank Discharge

The estimated 1 in 1ØØ year flow rate from the erosion control drains is Ø.6 m^3/s.

Details of the erosion control banks are shown on Drawing W85/4Ø42, sheets 11 and 12 (Appendix G).

(iv) Drainage

Drain 2, an upstream extension of the drain in the Old Tailings Dam, collects the runoff from the erosion control banks and from overland flow. This drain discharges, via the Old Tailings Dam, to Tailings Creek. The drain, which is lined with rip rap and has geotextile fabric basement protection, is illustrated on Drawing W85/4Ø42, sheets 11 and 12 (Appendix G).

In summary, the details of this drain are:

Catchment Area	8.3 ha
Peak Discharge	3.9 m^3/s
Base Width	2.5 m
Batter Slope	3:1
Depth of Flow	Ø.39 m
Velocity	2.7 m/s

To intercept any groundwater migrating along the underside of the cover system and to collect water accumulating in the porebreaking layer of the covers, a rubble drain is incorporated under the cover system in the drainage of the Treatment Plant Area. The details of this drain are shown on Drawing W85/4Ø42, sheet 11 (Appendix G).

11.6 Expenditure

The approximate direct costs of the execution of Stage 4 of the Project were $2,148,000, made up as below. Details of these costs are included in Appendix H.

Dysons Overburden Heap	$ 305,000
Intermediate Overburden Heap	$ 677,000
Treatment Plant Area and Stockpile Area	$ 557,000
Whites North Heap	$ 200,000
Acid and Sweetwater Dams	$ 89,000
Copper Heap Leach Pile	$ 320,000

(v) Covers

The cover system as described in Section 6.5 was specified for the Treatment Plant and Stockpile Areas. Details are included on Drawing W85/4Ø42, sheets 11 and 12 (Appendix G).

(vi) Revegetation

The details of the revegetation of the top surface of the Treatment Plant and Stockpile areas are shown on Drawing W85/4Ø42, sheet 38 (Appendix G).

(a) Seed Species
The seed species specified for the Treatment Plant and Stockpile areas are as for the Old Tailing Dam, listed in Table 1Ø.2.

(b) Fertilisation, seeding techniques, watering scheduling of vegetation and maintenance were the same as described for Dysons Overburden Heap earlier in this chapter.

11.2.4 Acid and Sweetwater Dams

The rehabilitation of Acid and Sweetwater Dams was limited to the removal of the remnants of the old dam walls and some minor stream training in the area occupied by the walls. Some revegetation around the verges of the dam was also included.

11.2.5 Whites North Overburden Heap

A large part of the overburden comprising Whites North Heap was removed and placed around the toe of Whites Overburden Heap and the remainder reshaped to form even grades as Stage 1 of the rehabilitation programme. The works carried out as part of Stage 4 of the programme comprised the covering of the area with a four zoned cover system, the construction of erosion control banks and the revegetation of the area.

The details of these works are included on Drawing W85/4Ø42, sheets 9 and 36 and Drawing W85/4Ø49, sheets 5 and 15 (Appendix G).

The species used in the revegetation of the area and the revegetation techniques are described in Section 11.2.3.

11.2.6 Copper Heap Leach Pile

The material comprising the Copper Heap Leach Pile and the surrounding contaminated soils were removed to Dysons Open Cut as part of Stage 3 of

the Project. The works carried out as part of Stage 4 of the programme were limited to the construction of a four zoned cover system over the area, the construction of an erosion control bank and the revegetation of the area.

The details of these works are included on Drawing W85/4Ø49, sheet 4 (Appendix G). Comparison of Plate 6.8 with Plate 6.9 shows the effect of rehabilitation.

The revegetation of the area utilised seed species and seeding techniques as described in Section 11.2.3.

11.2.7 Minor Works

The extent of minor works is described in Section 11.1 (viii) of this Chapter. Details of these works are included on Drawing W85/44Ø9, Sheets 3, 7, 13, 14 and 17 and Drawing W85/4Ø42, sheets 1Ø and 37 (Appendix G).

11.3 Documentation

The above works are incorporated in specifications W85-3429 (Stage 4.1) and W85-3646 (Stage 4.2).

11.4 Tender and Award

Tenders for the works comprising Stage 4.1 were invited from previously qualified contractors by the Northern Territory Department of Transport and Works, closing on 14 March 1985. The lowest tender was received from Thiess Contractors Pty Ltd. Their tender was accepted on 7 May 1985 and contract TW 117 of 84/85 was formalised.

Tenders for the works comprising Stage 4.2 of the programme were invited from the same pre-qualified contractors and the lowest tender was received from Thiess Contractors Pty Ltd. That tender was accepted and the works were incorporated with the contract for Stage 4.1.

11.5 Construction

Possession of the site was granted to the contractor on 13 May 1985 and the contractor commenced work on this stage of the Project on 27 May 1985.

Practical completion of the works was dated 19 December 1985.

12.1 Reason for Monitoring

The monitoring programme was established within the Rum Jungle Rehabilitation Project. Its aims were to enable an assessment of the degree to which the rehabilitation works satisfied the objectives as set out in the Agreement and to enable the on-going assessment of the implementation of the measures.

The objectives of the rehabilitation programme, as per Clause 7 of the Agreement, were to achieve:

(a) major reduction in pollution in the water courses feeding the river and in particular the reduction of the average annual releases of copper, zinc and manganese into the river by 70%, 70% and 56% respectively, as measured at the junction of the river (East Branch) with the Finniss River. By agreement the point of measurement was estabished at gauge station GS 815097 on the East Branch;

(b) reduction in public health hazards. In particular reduction of radiation levels at the site at least to the standards set out in the Code of Practice on Radiation Protection in the Mining and Milling of Radioactive Ores (Reference 15);

(c) reduction of pollution in the water contained in the open cut pits known as Whites and Intermediate; and,

(d) aesthetic improvements including revegetation.

Considering each of the objectives in turn:

12.1.1 Objective (a): Reduction of pollution in the East Branch of the Finniss River

The basis of assessment of this objective is the group of studies carried out by the Australian Atomic Energy Commission and reported in "Rum Jungle Environmental Studies" (Reference 64). These studies defined the baseline pollution levels as set out in Table 12.1. Using

information gained over subsequent monitoring seasons, flow figures for gauge station GS 815Ø97 were revised as a result of refinement of the rating curve. Pollution loads for 1971 to 1974 were recomputed by the Northern Territory Department of Mines and Energy (Reference 112) using the same basis of calculation used by the Australian Atomic Energy Commission. These baseline values are listed in Table 12.2. Note that the flow data from the 1969/7Ø and 197Ø/71 wet seasons has been omitted in the re-calculation because the mill was operating during these particular seasons and the data may exhibit some form of bias.

Table 12.1

EAST BRANCH OF THE FINNISS RIVER
POLLUTION LOADING PRIOR TO REHABILITATION

Season	1969/7Ø	197Ø/71	1971/72	1972/73	1973/74
Rainfall(mm)	896	1611	1542	1545	2ØØØ
Total Flow $m^3 x 1Ø^6$	7.Ø	33.2	3Ø.9	26	na
Metal Load(t)					
Copper	44	77	51	45	13Ø
Manganese	46	11Ø	64	49	1ØØ
Zinc	na	24	19	16	4Ø

na = not available

Table 12.2

EAST BRANCH OF THE FINNISS RIVER
REVISED POLLUTION LOADING VALUES

Season	1971/72	1972/73	1973/74
Rainfall (mm)	1542	1545	2ØØØ
Total Flow $m^3 x 1Ø^6$	31	22	69
Metal Load (t)			
Copper	77	67	1Ø6
Manganese	84	77	87
Zinc	24	22	3Ø

Monitoring of the water quality of the East Branch of the Finniss River forms a major component of the monitoring programme and has been carried out since the start of the Project. Results have been analysed for the period from 1982/83 to 1985/86 (Reference 112) and are summarised in Table 12.3.

Table 12.3

SUMMARY OF MONITORING RESULTS FOR THE EAST BRANCH OF THE FINNISS RIVER AT GS 815Ø97

Season	1982/83	1983/84	1984/85	1985/86
Rainfall	1121	17Ø4	1112	91Ø
Total Flow $m^3 x 1Ø^6$	9.5	48	11.7	11.4
Metal Load(t)				
Copper	23	28	9	4
Manganese	6	21	7	8
Zinc	5	9	4	3

The information contained in Tables 12.2 and 12.3 has been plotted on Figures 12.1, 12.2 and 12.3 for copper, manganese and zinc respectively. Smooth curves drawn through the origin and the revised 1971 to 1974 load/flow data can be used to provide estimates of the copper, manganese and zinc loads to be expected during this period for the river flows measured in the 1982 to 1986 period. These estimates can be used to assess the reduction in pollution load of most but not all of the rehabilitation works (1985/86). The results in Table 12.4 indicate that the targets set in Objective (a) have been achieved.

Table 12.4

PERCENTAGE REDUCTION IN POLLUTION OF THE EAST BRANCH OF THE FINNISS RIVER

Season	1983/84 (Stage 1& part Stage 2 complete)	1984/85 (Stage 3 complete)	1985/86	Target
Metal				
Copper	7Ø%	8Ø%	91%	7Ø%
Manganese	76%	88%	86%	56%
Zinc	67%	73%	79%	7Ø%

12.1.2 Objective (b): Reduction of public health hazards

As indicated in Chapter 4 of this report, the radiation standards and limits set out in Code of Practice on Radiation Protection in the Mining and Milling of Radioactive Ores (Reference 15) apply only to areas disturbed by man. Subclause 8 (1) specifically excludes doses due to natural radiation (other than those arising from the mining and milling of radioactive ores) from the assessment of compliance with the Code. In assessing the degree of compliance with Objective

(b) only that radiation which has resulted from the mining and milling of radioactive ores is to be considered. Accordingly, no absolute statement can be given on the degree to which the rehabilitated site meets dose limits for the public.

In accordance with the requirements of the Code of Practice, the annual dose equivalent limit for a member of the public is 5 mSv per annum, or Ø.8 uSv per hour.

The sources of radiation at Rum Jungle covered by the Code of Practice include:

- the Old Tailings Dam;
- the tailings containment site at Dysons Open Cut;
- the waste rock heaps; and,
- ore stockpiles.

Of these sites, the Old Tailings Dam was the most significant source of radiation. On completion of the rehabilitation of the Old Tailings Dam, the maximum measured external gamma dose rate was Ø.5 uSv per hour, below the Code requirements.

It is known that other sources of radiation exist within the Rum Jungle mine site (and elsewhere in the area). These sources however, are natural and do not come within the provisions of the Code of Practice.

12.1.3 Objective (c): Reduction of pollution in the open cut pits

This objective is assessed on the basis of comprehensive profile sampling in both Whites and Intermediate Open Cuts. Results are shown in Tables 12.5 and 12.6 respectively, for profiling before treatment of the water contained in the open cuts, after treatment, and for February 1986 after rediversion of the East Finniss River through the open cuts (Reference 5).

The water body in Whites Open Cut was found to be complex in its chemical composition with depth . From the surface to about 15 metres the water body contained a number of chemoclines and thermoclines, while from 15 metres to the bottom the chemical composition was constant (Alcock and Connolly, Reference 5). After-treatment values in Table 12.5 are for the interval from the surface to 18 metres depth, as this lies within the 22 metres of water treated. The Table also shows the effect of flushing of the East Branch of the Finniss River (18 February 1986).

Table 12.5

WATER QUALITY IN WHITES OPEN CUT BEFORE AND AFTER TREATMENT
(concentration in mg/L)

	Before Treatment		After Treatment			Design
Date:	30/7/84		1/11/85	18/2/86	18/2/86	Target
Depth:	Ø-18m	15m to 35m	Ø-18m	Ø-18m	5m	
Parameter						
pH units	2.8	2.6	7.3	5.8	6.Ø	7
Manganese	18Ø	23Ø	2.3	1.5	Ø.4	<1.Ø
Iron	28Ø	44Ø	<Ø.1	<Ø.1	Ø.1	<1.Ø
Cobalt	13	15	Ø.2	Ø.2	Ø.1	<1.Ø
Nickel	13	15	Ø.2	Ø.2	Ø.1	<1.Ø
Copper	55	6Ø	<Ø.1	Ø.3	Ø.2	<1.5
Zinc	8.2	7.9	<Ø.1	Ø.1	Ø.1	<5
Sulphate	7ØØØ	85ØØ	27ØØ	9ØØ	2ØØ	<2ØØØ

The water body in Intermediate Open Cut was less severely polluted than Whites Open Cut, and its chemical composition was almost uniform from the surface to the bottom (78 metres). Table 12.6 shows the average chemical composition before treatment, after treatment, and after flushing by rediversion of the East Branch of the Finniss River (information from Reference 5).

Table 12.6

WATER QUALITY IN INTERMEDIATE OPEN CUT BEFORE AND AFTER TREATMENT
(concentrations in mg/L)

	Before Treatment	After Treatment			Design
Date:	26/6/85	16/12/85	25/2/86	25/2/86	Target
Depth:	average	average	average	5m	
Parameter:					
pH units	3.5	9.5	7.Ø	5.9	7
Manganese	5Ø	<Ø.1	Ø.8	Ø.7	<1.Ø
Iron	1.3	<Ø.1	<Ø.1	<Ø.1	<1.Ø
Cobalt	13.5	<Ø.1	Ø.3	Ø.2	<1.Ø
Nickel	12.5	<Ø.1	Ø.3	Ø.2	<1.Ø
Copper	65	<Ø.1	Ø.5	Ø.8	<1.5
Zinc	6.3	<Ø.1	Ø.2	Ø.1	<5.Ø
Sulphate	31ØØ	325Ø	225Ø	2ØØ	<2ØØØ

The information presented in Tables 12.5 and 12.6 shows that the objective (as defined by the design targets in Tables 3.4 and 6.5) is close to being met. Both treatment and rediversion of river water into the open cuts and resultant mixing have been effective in significantly reducing pollution contained in the open cuts. Monitoring of further mixing events is necessary to show if the trend is toward meeting the objective.

12.1.3 Objective (d); Aesthetic improvements including revegetation

This objective is subjective in its assessment. Examination of the Plates in Chapter 6, comparing the mine site before and after the rehabilitation works, shows the aesthetic improvements to and revegetation of the site. The monitoring results for this objective are further discussed in Section 12.3.

Although the project work to be carried out under the rehabilitation programme has been completed, the full effects of the environmental response to those works may not be evident for some time to come. In order to enable a more complete assessment of the rehabilitation measures it is important that the monitoring programme continue for the two year period allowed for in the Agreement after the completion of those measures.

12.2 Monitoring Programme

The Agreement establishing the Rum Jungle Rehabilitation Project included provision for an environmental monitoring programme to be set up to determine the effects of the rehabilitation work on the site and on the river. The Agreement includes provision for the monitoring programme to continue for a period of up to two years after the Ministers agree that the measures to be adopted (as defined in the Agreement) have been completed.

Monitoring in accordance with the Agreement commenced in the 1982/83 wet season with the implementation of a detailed water sampling programme of the Finniss River and the East Branch of the Finniss River by the Water Division of the Department of Transport and Works, and with the continuation of the chemical activity monitoring of Whites Overburden Heap by the Australian Atomic Energy Commission.

In April 1985, a detailed review of the monitoring programme was completed and endorsed by the Rum Jungle Liaison Committee. As a result of that review the monitoring programme changed to that described below.

The monitoring activities at Rum Jungle are carried out by specialist agencies on behalf of the Project and are co-ordinated by the Monitoring Committee which is chaired by the Project Manager.

The programme and the implementing agencies comprise:

12.2.1 The Copper Heap Leach Pile

(i) Monitor revegetation of the area.
Visual inspection of the revegetation of the area by the Conservation Commission of the Northern Territory.

(ii) Monitor erosion of the area.
Visual inspection by the Conservation Commission of the Northern Territory.

12.2.2 The Old Tailings Dam

(i) Monitor the migration of radium in the subsoil. A study completed by the Australian Atomic Energy Commission to determine the extent of migration of radium in the subsoil below the tailings in the Old Tailings Dam, if any .

(ii) Monitor revegetation of the area
Visual inspection of the revegetation of the area by the Conservation Commission of the Northern Territory.

(iii) Monitor erosion of the area.
Visual inspection by the Conservation Commission of the Northern Territory.

12.2.3 Dysons Open Cut

(i) Monitor local groundwater regime.
A number of observation bores have been established on the down slope side of Dysons Open Cut (Figure 12.4) monitoring the groundwater around the open cut to confirm the containment of the tailings material. Monitoring by Water Resources Division of the Department of Mines and Energy.

(ii) Monitor erosion of covers and drains.
Visual inspection of the covers and drains by the Conservation Commission of the Northern Territory.

(iii) Monitor vegetation condition.
Visual inspection of the condition of the vegetation on the fill in the open cut by the Conservation Commission of the Northern Territory.

(iv) Monitor settlement of fill.
Periodic survey of the established grid system on the open cut to determine the extent of, and any changes to, the settlement of the fill material in the open cut. The survey is conducted on request by the Northern Territory Department of Lands.

12.2.4 Whites Open Cut

(i) Monitor water quality and temperature profiles.
Regular assessment of the quality and temperature of the vertical profiles of the open cut by Water Resources Division of the Department of Mines and Energy.

(ii) Monitor revegetation of embankments.
A visual programme conducted by the Conservation Commission of the Northern Territory.

12.2.5 Intermediate Open Cut

(i) Monitor water quality and temperature profiles.
Regular assessment of the quality and temperature of the vertical profiles of the open cut by Water Resources Division of the Department of Mines and Energy.

(ii) Monitor revegetation of embankments.
A visual programme conducted by the Conservation Commission of the Northern Territory.

12.2.6 Dysons Overburden Heap

(i) Monitor erosion of covers and drains.
A visual programme of inspection by the Conservation Commission of the Northern Territory.

(ii) Monitor condition of vegetation.
A visual programme by the Conservation Commission of the Northern Territory.

12.2.7 Whites Overburden Heap

(i) Monitor the water balance of the heap.
Programme of measurement of infiltration through the cover system (by the Australian Atomic Energy Commission) and runoff from the heap (by the Water Resources Division of the Department of Mines and Energy).

(ii) Monitor groundwater in and around the heap.
An observation bore has been established through Whites Overburden Heap and a network of shallow and deep observation bores have been established around the heap (Figure 12.4). The water levels and quality of the aquifer system are monitored. The recording of levels, sampling and data analysis for this programme are being conducted by the Water Resources Division of the Department of Mines and Energy. After June 1986 the

assessment of the data is being conducted by the Australian Atomic Energy Commission.

(iii) Monitor erosion of covers and drains.
A visual programme of inspection and assessment by the Conservation Commission of the Northern Territory.

(iv) Monitor chemical activity.
Chemical activity within the overburden heap is monitored by the measurement of temperature and gas composition within the heap. This programme is conducted by the Australian Atomic Energy Commission.

(v) Monitor condition of vegetation on the heap.
A visual programme of monitoring the condition and extent of vegetation by the Conservation Commission of the Northern Territory.

12.2.8 Intermediate Overburden Heap

(i) Monitor infiltration into the heap.
Programme of measurement of infiltration through the cover system by the Australian Atomic Energy Commission.

(ii) Monitor groundwater in and around the heap.
A network of shallow and deep observation bores has been established around the heap (Figure 12.4). Water levels and quality of the aquifer system are monitored. The sampling and data assessment for this programme is being carried out by the Water Resouces Division of the Department of Mines and Energy. After June 1986 the assessment of the data is being conducted by the Australian Atomic Energy Commission.

(iii) Monitor erosion of covers and drains.
A visual programme of inspection and assessment by the Conservation Commission of the Northern Territory.

(iv) Monitor chemical activity.
Chemical activity within the overburden heap is monitored by the measurement of temperature and gas composition within the heap. This programme is carried out by the Australian Atomic Energy Commission.

(v) Monitor condition of vegetation on the heap.
A visual programme of monitoring condition and extent of vegetation carried out by the Conservation Commission of the Northern Territory.

12.2.9 Area of former Whites North Overburden Heap

(i) Monitor erosion of the area.
A visual programme of inspection by the Conservation Commission of the Northern Territory.

(ii) Monitor condition of vegetation.
A visual programme carried out by the Conservation Commission of the Northern Territory.

12.2.1Ø Acid and Sweetwater Dams

Monitor stream bed and embankment condition.
A visual assessment of the condition and vegetation of the stream beds and banks by the Conservation Commission of the Northern Territory.

12.2.11 Other Areas

Monitor the regeneration of vegetation around the site, in particular on the rehabilitated borrow areas. Conducted by the Conservation Commission of the Northern Territory.

12.2.12 Water Treatment Plant

Groundwater at filter cake disposal site.
Regular sampling of groundwater observation bores around the filter cake disposal site by the Water Resources Division of the Department of Mines and Energy.

12.2.13 Regional Monitoring

(i) Regional groundwater monitoring to detect possible movement of heavy metals away from the mine site.
Regular monitoring of water levels and sampling of established observation bores in and around the mine site, and monitoring of spring flows (Figure 12.4). Conducted by the Water Resources Division of the Department of Mines and Energy.

(ii) Water quality of the Finniss River system.
Stream flows in the Finniss River and the East Branch of the Finniss River are measured at sites shown in Figure 12.5. Monitoring for water quality and flow regime during each wet season is conducted by the Water Resources Division of the Department of Mines and Energy.

(iii) Stream bed sediments of the East Branch of the Finniss River.

Random sampling and analysis of the sediment deposits in the bed of the East Branch of the Finniss River by the Water Resouces Division of the Department of Mines and Energy.

12.3 Results from the Monitoring Programme.

The results of monitoring to date are integrated and assessed in this section. For more detailed results, including both data collected and its analysis, the reader is referred to a number of reports listed in Chapter 15 (References 1, 4, 5, 6, 1Ø, 11, 12, 26, 27, 28, 29, 42, 43, 62, 63, 64, 73, 74, 75, 76, 77, 78, 79, 8Ø, 81, 82, 83, 84, 85, 86, 87, 88, 91, 113, 12Ø, 121, 122, 123, 127, 128, 129 and 13Ø).

Copies of these reports are held in the Northern Territory Department of Mines and Energy library.

12.3.1 Surface Water and Groundwater Hydrology (Reference 112)

The most important surface water data available to gauge the success of rehabilitation are the pollution loads in the East Branch of the Finniss River at GS 815Ø97. This information is presented in Section 12.1.1. Pollutant concentrations varied widely with time and discharge. The highest concentrations occurred during the early wet season flows and baseflows at the end of the wet; much of the total pollutant load, particularly copper, was transported by relatively low flow.

Interpretation of the data has been difficult because of the changes to the site each year, the most recent being rediversion of the river through the two treated open cuts. Nevertheless, it is observed that:

- All annual loads estimated for 1983/84 to 1985/86 are significantly less than annual loads prior to rehabilitation.
- Based on the 1984/85 and 1985/86 wet season, Table 12.4 suggests that the rehabilitation surface water quality design targets have been met.
- The copper load in 1985/86 was approximately 8Ø% less than the load in 1982/83; the total flow in each year was similar.
- Comparable reductions were not observed in other pollutant loads, although the trend in reduction of zinc has been consistent.
- The Radium-226 load (in solution) fell dramatically from 23 gigabecquerels in 1983/84 to 1.6 in 1984/85. This was probably due to the removal and

covering of the Old Tailings Dam during the intervening dry season.

Further downstream, in the Finniss River, the improvement in water quality has not been as great as might be expected given the improvement in the East Branch. This is because of the highly variable dilution rate, especially in the early part of the wet season when high flow in the East Finniss can coincide with relatively low flow in the Finniss. Most of the samples taken downstream from the confluence conformed with current NHMRC desirable maxima drinking water criteria. Manganese concentration was occasionally excessive in 1982/83 and 1983/84, but not so more recently; sulphate was excessive in some samples in 1983/84 only.

Groundwater investigations (as reported in References 112 and 13Ø) have resulted in a distinction being made between a shallow aquifer system (the shallow unconsolidated weathered zone) and the deep aquifer system (variously comprising granite, dolomite, shales and schists). The shallow aquifer is heavily contaminated with metals and sulphate within the mine site.

The deep aquifer is contaminated in the vicinity of Whites Overburden Heap, but not elsewhere. From monitoring of regional wells outside the mine site, it appears that the movement of solutes in the deep aquifer is restricted to the highly saline zone inside the site.

The heaviest metal contamination is in the aquifer near Whites Overburden Heap. Because significant monitoring did not commence until 1984/85, it is impossible to establish significant trends in the groundwater quality data at present.

Most of the local groundwater recharge, including any which occurs over Whites Intermediate and Dysons Heaps, moves though the shallow aquifer system and is released as springs, as seepage along the banks of the streams within the site, or as baseflow. Monitoring of surface discharge and pollutants has recently commenced to enable the groundwater pollution mechanisms to be related quantitively to the surface water system.

From the above discussion, while the groundwater system is contaminated within the site, all contaminants leaving the site do so in the surface water system. A

proportion of pollution entering the streams does so by direct run off, or from spring flow at the base of the heaps.

From Reference 112.
"There is evidence that there is much polluted water remaining in the groundwater system and that this will continue to be released for some time, whereas pollution from surface runoff has already been significantly reduced." And from the same Reference, "Assuming that the main source of groundwater pollution has been dealt with by capping of the heaps, pollution to the surface water will further improve as the store of polluted groundwater is gradually exhausted."

Continued quantitative assessment over at least the next two years is necessary to test the above assumption.

12.3.2 Water Quality of Whites and Intermediate Open Cuts

Information presented in Section 12.1.3 and in reports by the Department of Mines and Energy (References 5, and 84) shows that treatment of pit waters and rediversion of river water into the open cuts have had the effect of significantly reducing pollution of pit waters. Most design targets have been achieved.

Following treatment of pit waters, Henkel and Alcock (Reference 84) monitored the effect of rediversion of river water through the pits, and have drawn conclusions on a long term water quality. For Whites Open Cut in the wet season, inflow water had an average specific conductance of 200 microsiemens/cm and an average pH of 6. This water mixed with pit water to about 15m depth and resulted in a pit water quality varying with depth; for example, specific conductance ranged from about 450 at the surface to 3800 at 15m depth. The untreated water below 22m depth remained undisturbed.

In Whites Open Cut it was found that quality changed during the colder dry season. Mixing of water within the top 12 metres resulted in a 12 metre column of water with specific conductance of 1150 microsiemens/cm.

Henkel and Alcock (Reference 84) conclude that rediversion has and will continue to provide a successful mechanism for annual flushing of the top 15m of water. An

overall improvement in water quality is forecast for the long term; the top 15m of water will tend to a quality with specific conductance of about 200 microsiemens/cm and pH of 6.

For Intermediate Open Cut, Henkel and Alcock (Reference 84) found that river water via Whites Open Cut was effective in improving quality for the top 15 metres of pit water. During the wet season specific conductance ranged from 500 microsiemens/cm near the surface to 4000 at 15m depth. Mixing of water between various levels occurred during the dry season, with resulting complex profiles.

Work to date shows that monitoring of flushing and mixing events for at least two years is necessary to confirm the trend to an improved long term water quality in both pits. In particular, the quality trend of Intermediate Open Cut waters at various depths will need analysis.

12.3.3 Chemical Activity and Water Balance of the Overburden Heaps.

Chapter 3 describes how the overburden heaps were the major source of heavy metal and acid pollution on site before rehabilitation. Assessing and quantifying the effects of reshaping and sealing the heaps is thus an important component of the monitoring programme.

As described by Bennett et.al. (Reference 29), the overburden heaps contain pyritic material which oxidises in the presence of water and oxygen to produce ferric sulphate and sulphuric acid. These in turn oxidise other sulphides making the heavy metals copper, manganese and zinc available for leaching. The clay seal and covers placed during rehabilitation were designed to reduce the amount of rain water infiltrating the heaps, hence reducing the transport of soluble pollutants from the heaps to the East Branch of the Finniss River. The cover was also expected to reduce the transport of oxygen into the heaps, hence reducing the oxidation of pyritic material and the production of further soluble oxidation products.

The report by Bennett et.al. (Reference 29) is the most recent in a series of reports by the Australian Atomic Energy Commission. These reports describe the measuring techniques, data and assessment of the amount of water passing through the clay seal, the transport of oxygen into the

heaps, and the rate of oxidation in the heaps before, during and after rehabilitation.

An important element in this part of the monitoring programme is to measure the amount of water which passes through the clay layer to confirm that the clay achieves the desired low infiltration. The pre-rehabilitation water balance is described by Daniel et.al. (Reference 62), Harries and Ritchie (Reference 75) and Bennett et.al. (Reference 29).

Pre and post rehabilitation measurements on and near the heaps indicate that the cover has proved effective in reducing infiltration. However different approaches have yielded different results, indicating the range of interpretations given the small data set and the relatively short period of monitoring. Bennett et.al. (Reference 29) tentatively conclude that the infiltration rate has been reduced from 5Ø to 6Ø per cent of incident rain to about three percent. If correct they surmise that it is reasonable to expect a tenfold decrease in the amount of pollutants released from the heaps. Salama and Scott (Reference 13Ø), using a different technique, conclude that groundwater flow from the heaps has halved.

Continued monitoring and analysis over the next two years is essential to better quantify the water balance, and in doing so to resolve the above discrepancy.

The chemical activity in the heaps is monitored by temperature profiling and measuring pore gas composition. As oxidation of pyritic material is a reaction which produces elevated temperatures within the heaps, measuring temperatures within the heaps can be used to determine the location and rate of oxidation.

An example of temperature change with time, graphed for different depths, is that for hole An in Whites Overburden Heap plotted in Figure 12.6 (Reference 29). This Figure shows the following:

- temperatures exceeding 5Ø°C below 1Øm before rehabilitation (a heat source);
- temperatures from the surface to about 5m depth showing the variation with the seasonal temperature change;
- a gradual decrease in temperature before rehabilitation; and,
- an accelerated rate of temperature decrease since the heap was covered.

Bennett et.al. (Reference 29) state that the rate of oxidation has been reduced, and could now be zero. However, as the thermal conductivity of the heap material is still uncertain, it is not possible to conclude that heat production and hence the oxidation has stopped. This is being investigated.

Although before rehabilitation the supply of oxygen limited the oxidation rate in the heaps, enough oxygen entered the top and sides of the heaps to produce large amounts of soluble pollutants. The cover on the heaps should reduce the supply of oxygen and the production rate of pollutants.

Oxygen levels were measured before rehabilitation, and are now measured regularly since rehabilitation, by analysing samples of gas collected from ports in probe holes on the heaps. These measurements should show how effectively the cover has reduced the oxygen supply to the oxidation sites.

Harries and Ritchie (References 78 and 79) found that there was a rapid decrease in the oxygen concentration in the interstitial gas near the surface in Whites Heap as soon as the clay seal was put in place. Further measurements with time showed that the transport of oxygen into the heap was effectively stopped during and after the first wet season, as indicated in Figure 12.7. However, measurements in August 1984 showed that the levels of oxygen near the surface have increased (Figure 12.7) and that concentrations were changing over the period of a day (Bennett et.al., Reference 29). Oxygen levels increased late in the dry season, presumably via cracking of the clay seal, and remained high during the following wet season. Although the transmission rate of gas through the seal appears to have increased, the transmission rate of water measured by lysimeters, remained low. Even so, the levels of oxygen within the heap are still much less that they were before rehabilitation. It remains to quantify the oxidation rates within the rehabilitated heaps.

12.3.4 Radiation Levels

The findings of the Radiation Safety Consultant are summarised in Section 12.1.2. The Consultant's report (Reference 81) concludes that not all the work proposed was carried out because of:

- time limitations; and,

. lack of information on the radiological condition of Rum Jungle prior to mining and prior to rehabilitation.

Furthermore, where it is available, pre and post rehabilitation data are difficult to compare because of the small data set and because some parameters are influenced by factors (listed in Reference 82), including:

(i) physical changes to the Old Tailings Dam area;
(ii) rainfall and flow variations between seasons;
(iii) the chemistry of the radionuclides concerned; and,
(iv) changes in river water quality which may have occurred since mining ceased.

As discussed in Section 12.1.2, the Consultant (Reference 81) concludes that no absolute statement can be given on the degree to which the rehabilitated site meets dose limits for the public because the limit applies to that part of an individual radiation dose brought about by man's activities. Since the normal background radiation of the Rum Jungle area, prior to mining and milling, is not known, the increment is also not known. No hard and fast recommendations can be given on land use restrictions for the same reason. Additionally, radiation dose is a function of radiation levels and occupancy times, thus it is only when a proposed land use is identified that an assessment can be made of the radiological consequence of that land use.

The Consultant concludes that the limited data available shows that the relocation and burial of the tailing has substantially reduced the radiation hazard of the Rum Jungle site. This is also borne out by water quality sampling described in Section 12.3.1.

The Consultant reported (Reference 81) that the radiological safety of the workforce was assured by both engineering controls (eg air-conditioned plant cabins) and the application of the Code of Practice in the Mining and Milling of Radioactive Ores and the NT Mines Safety (Radiation Protection) Regulations. Radiation doses received by rehabilitation workforce have been assessed and are well below Regulatory Limits.

As noted above, proposed occupancy times must be known to assess the use of the Rum Jungle Mine Site for residential and/or

recreational purposes. It is therefore recommended that proposals for use of the site are submitted to the NT Department of Health for radiation dose assessment.

Finally, it should be noted that the Consultant's report does not relate to radiation ouside the mine site.

12.3.5 Aesthetic Improvements including Revegetation

Pasture status, soil chemistry, erosion and drainage stability have been and are being monitored by the Conservation Commission. They are to a large extent interrelated, and the results are detailed in References 42, 127 and 128.

Ryan (Reference 128) reports that as of late 1986 pastures remained dynamic, displaying seasonal shifts in species dominance coupled with the influence of colonising species. Of the many grass species planted, Chloris gayana (Rhodes grass), Urochloa mozambicensis (Sabi grass) and to a lesser extent Cynodon dactylan (Couch grass) dominate. Ryan described probable species changes with time. It was also noted that naturalised and native species are colonising the new landforms; the effects of this are considered beneficial to the long term viability of pastures.

The establishment of vegetation on the new landforms is very good from a stability and cover point of view. Ryan (References 127, 128) notes that active and developing soil-plant-faunal environments are being formed on the surfaces. Being the oldest, the surface of Whites Heap is the most developed, displaying strong pastures, a deepening organic matter layer, diverse soil fauna, and the development of soil fabric and structure. At the other extreme, pasture development on Dysons Heap has been retarded. The maintenance programme for pastures is described in Section 14.2.

On the subject of soil chemistry Ryan (Reference 128) observes that the pH and eC of soil cover saturation pastes remain within the desirable levels. To date there is no indication of salt or metal movement within the covers. This is reinforced by the healthy appearance of the pastures, as shown in Plates 6.2, 6.4, 6.7, 6.9 and 6.11.

Ryan (Reference 128) concludes that trees will colonise the rehabilitated surfaces over time. For several years this will be restricted to the Acacia species, which are

mostly shallow-rooting, although they have the ability to penetrate compacted clay. From trials conducted on the site during the last two years, Ryan concludes that the development of trees will be retarded once they strike the surface of the 1A layer (Figure 6.2). Also, whilst vigorous pastures remain, trees will have difficulty competing and establishing. It is concluded that trees will also slowly colonise the rock mulched batters.

Throughout the Project the colonisation of clay sealed surfaces by trees has been questioned because of the potential for tree root penetration and windthrow which may compromise the cover system. As noted above, some trials have already been conducted. Further investigation has been recommended to the Monitoring Committee for approval.

It has been found that some stability problems have been and will continue to be experienced with rip rap drains. Maintenance requirements are described in Section 14.2. However, the stability of vegetated surfaces at present is good, and major scouring is absent.

As part of his program of soil fauna monitoring Ryan (Reference 128) recorded the first colonisation of a new surface by termites, in late 1986. Fourteen small termite mounds have been found on Whites Heap; monitoring is underway to determine the species involved and the type of material being used for mound construction. If, for example, it was found that 1A clay material was being used significantly, this could have long term implications for the viability of the seal on the overburden heaps.

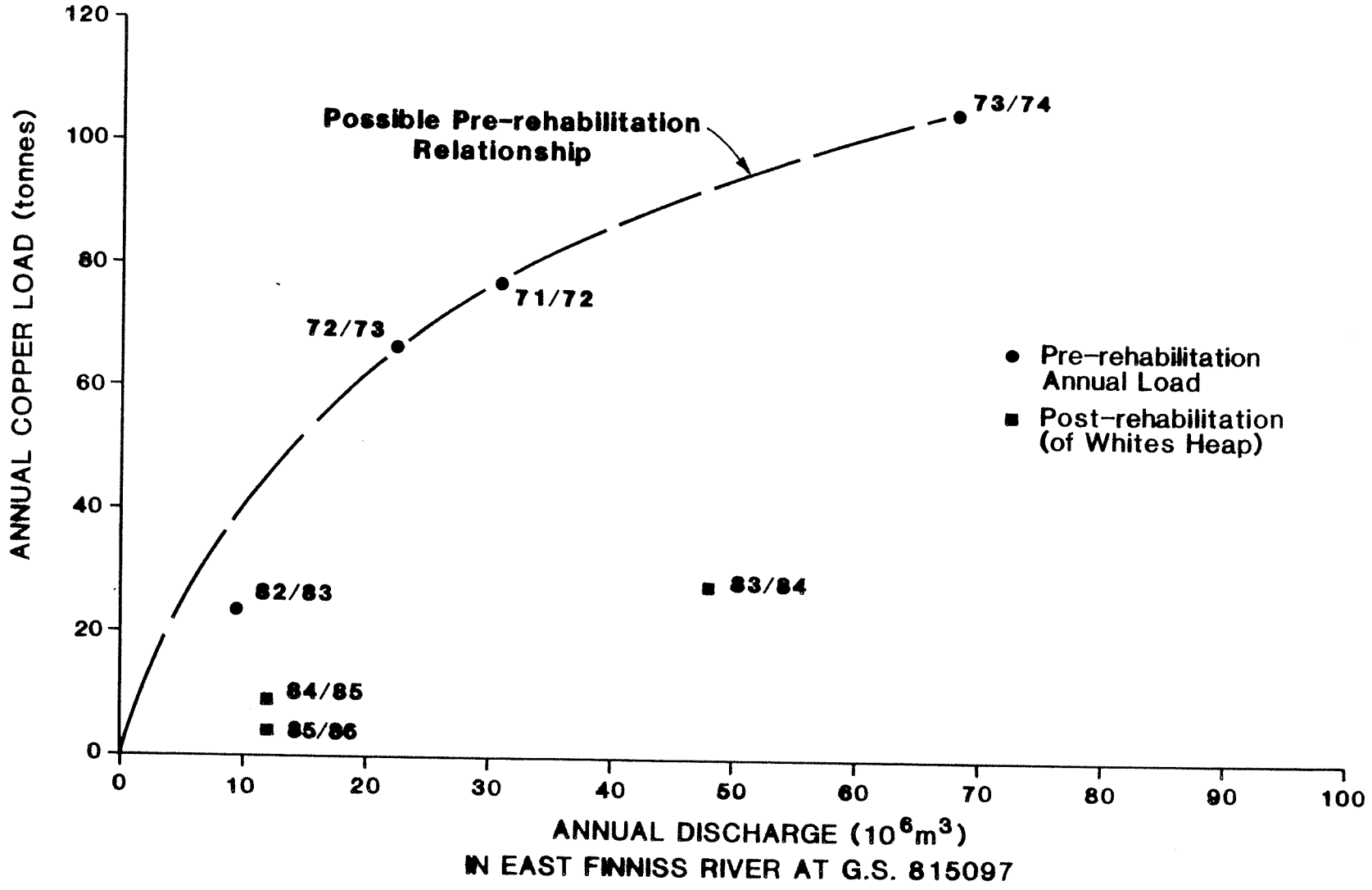


Figure 12.1 – ANNUAL COPPER LOADS IN THE EAST FINNISS RIVER

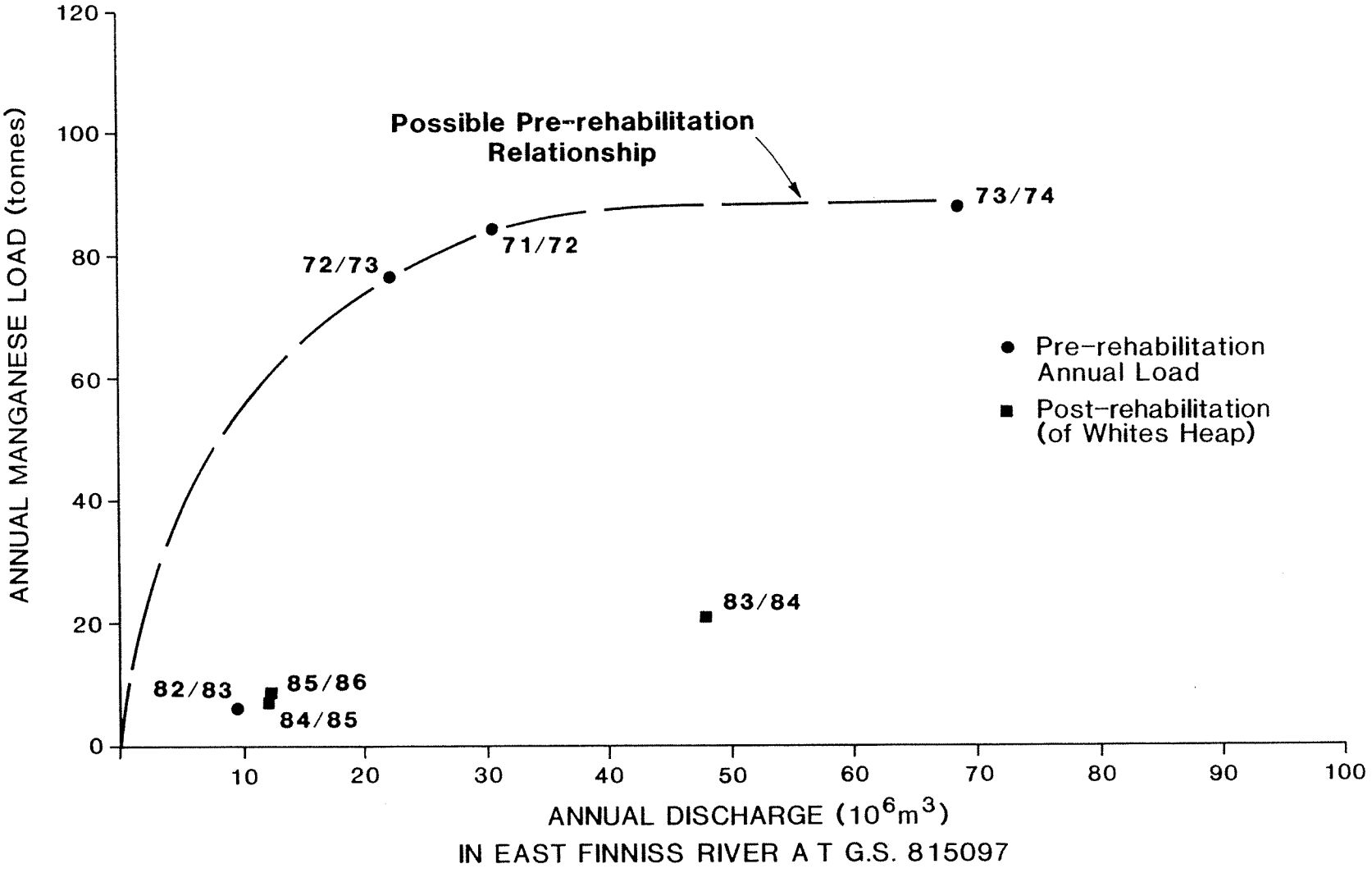


Figure 12.2 - ANNUAL MANGANESE LOADS IN THE EAST FINNISS RIVER

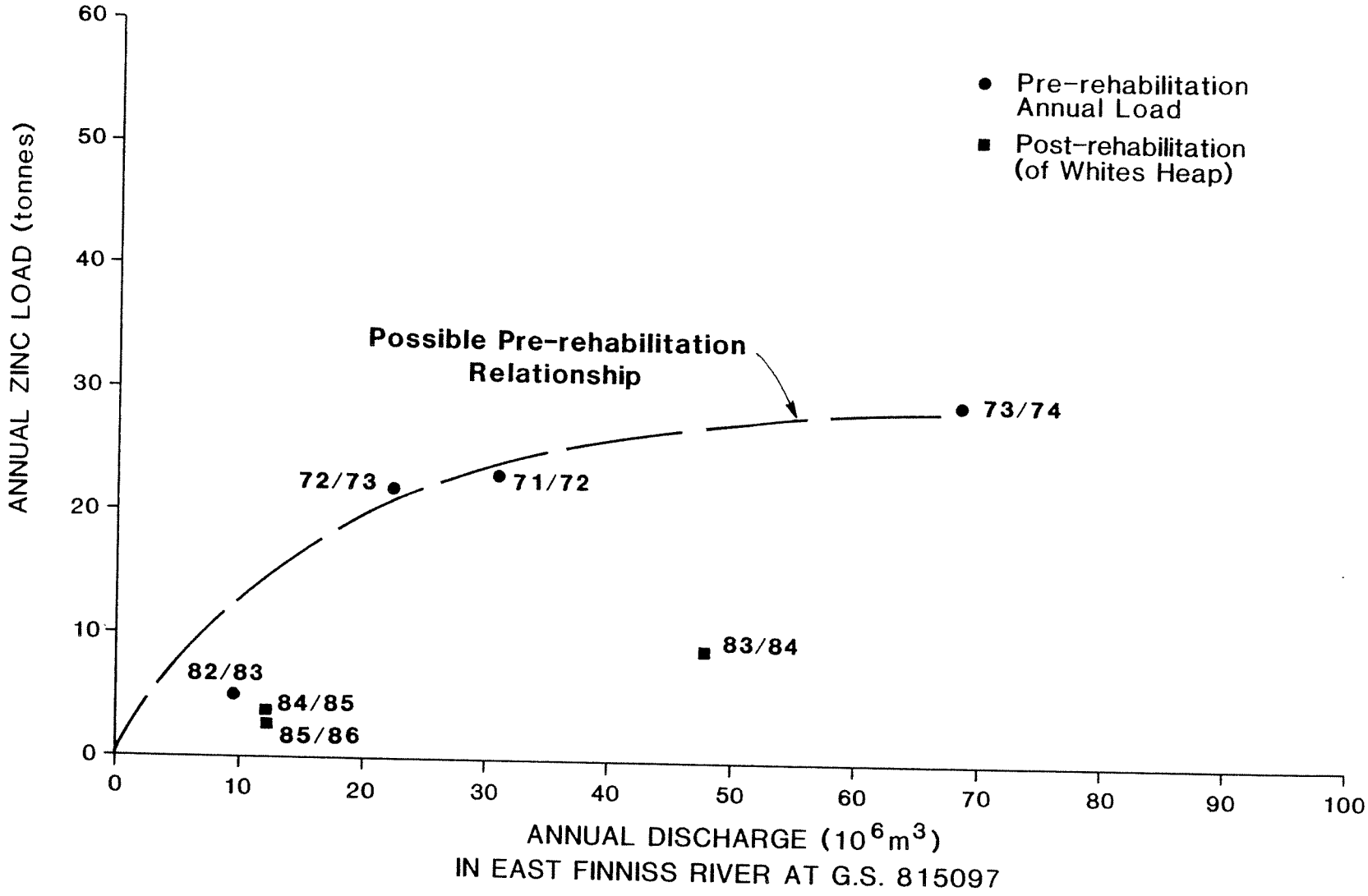


Figure 12.3 - ANNUAL ZINC LOADS IN THE EAST FINNISS RIVER

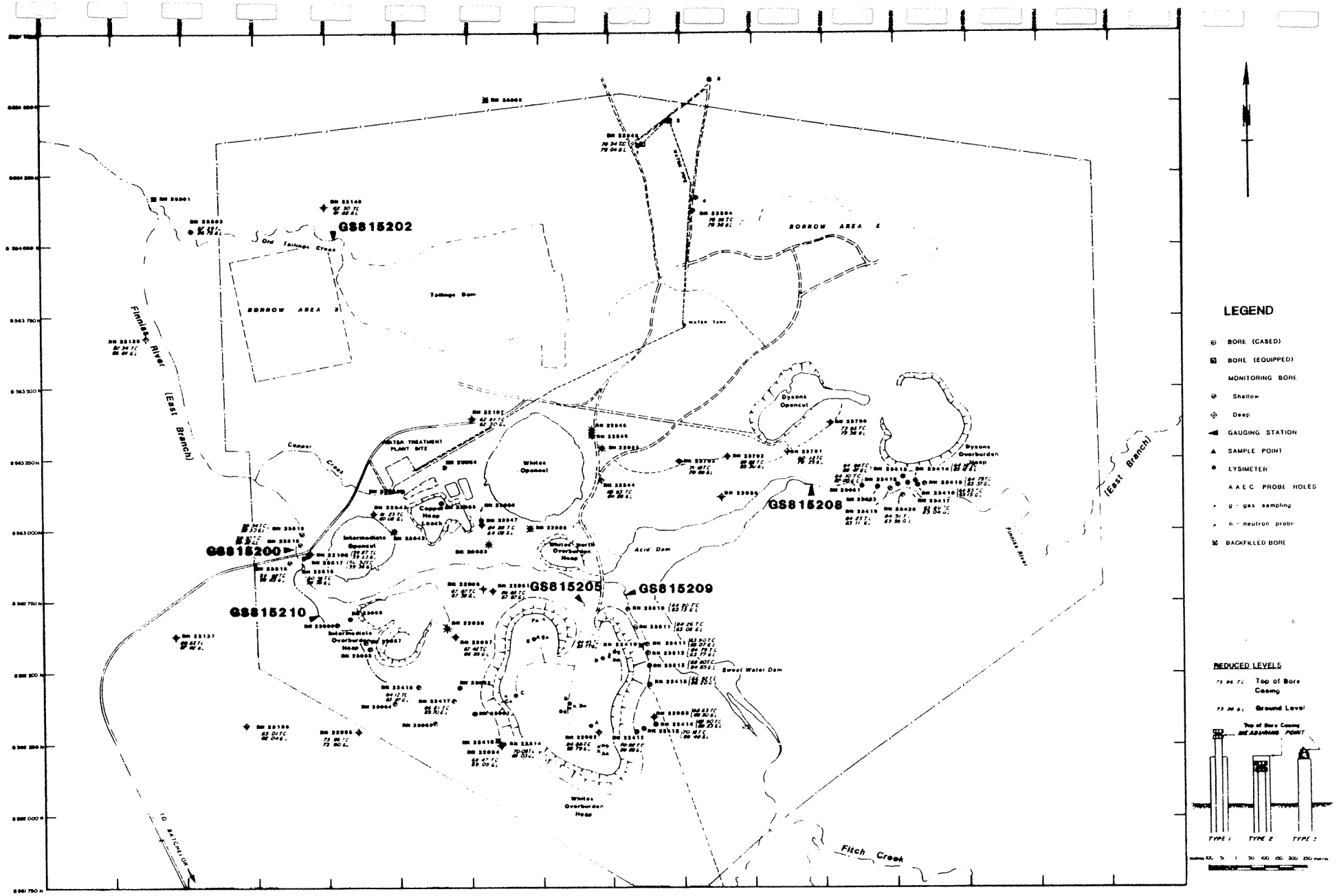


Figure 12.4 – MONITORING PROGRAMME – SITES OF MONITORING POINTS

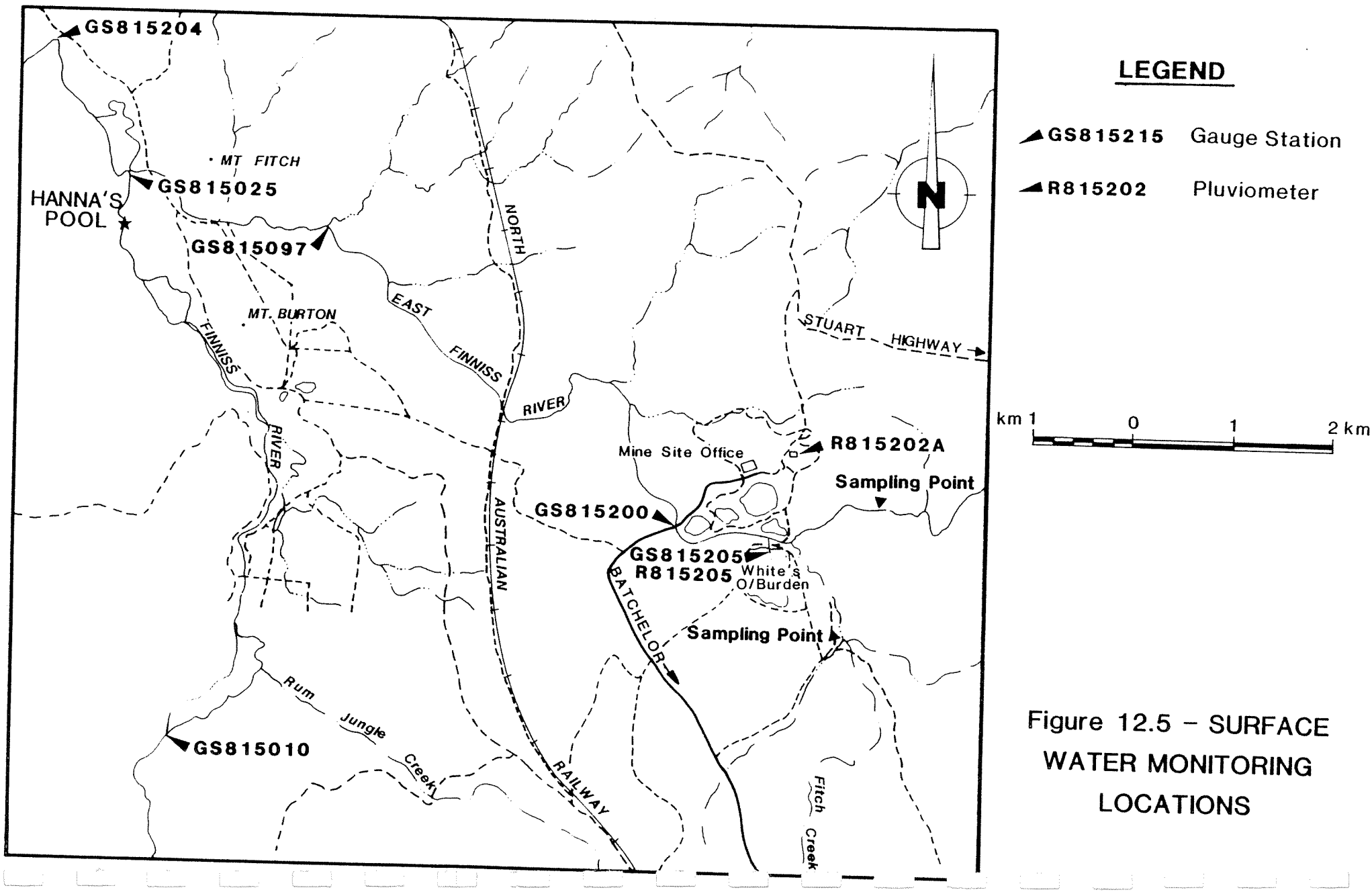


Figure 12.5 – SURFACE WATER MONITORING LOCATIONS

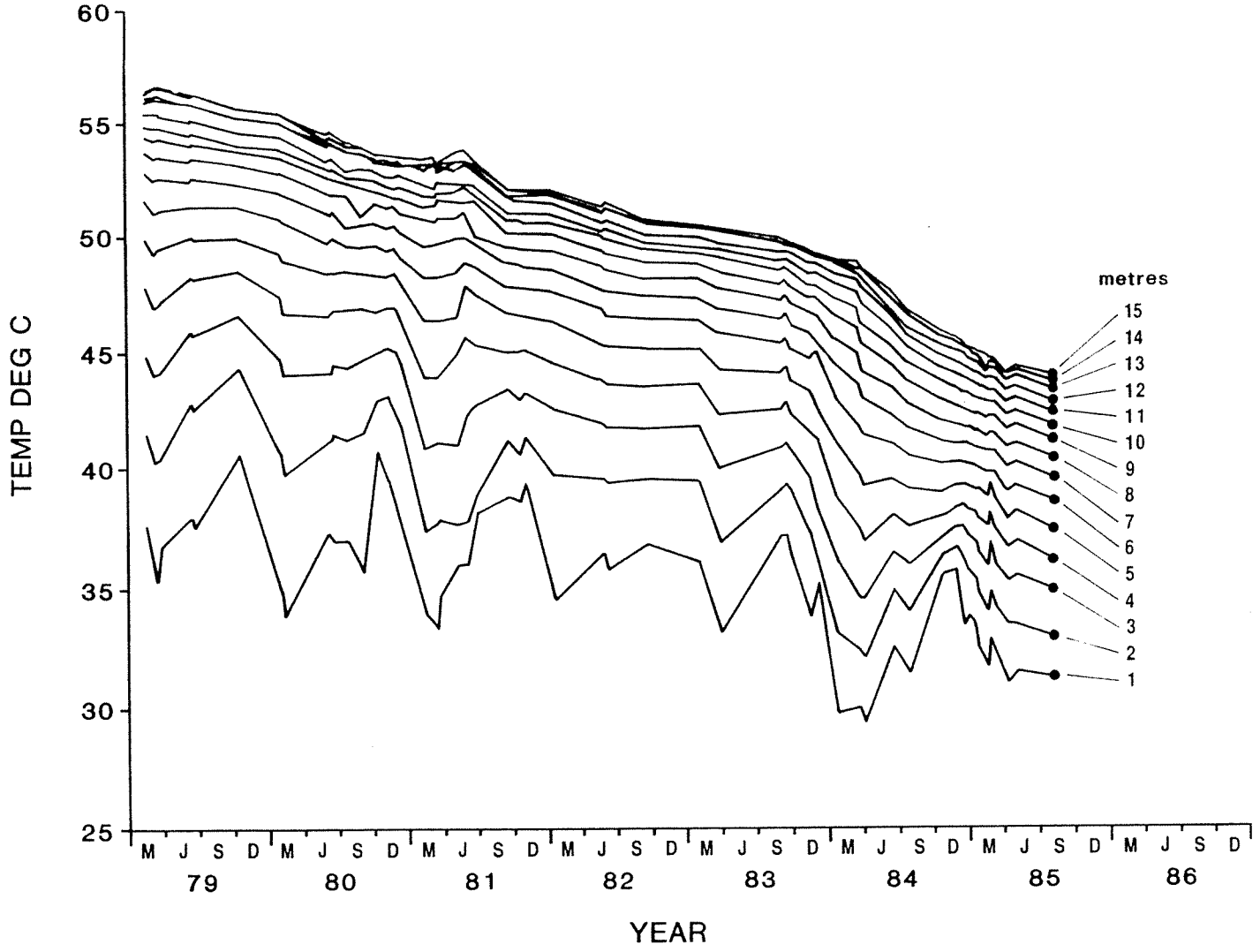


Figure 12.6 – TEMPERATURE VARIATIONS IN HOLE An IN WHITES OVERBURDEN HEAP AT VARIOUS DEPTHS BEFORE AND AFTER REHABILITATION

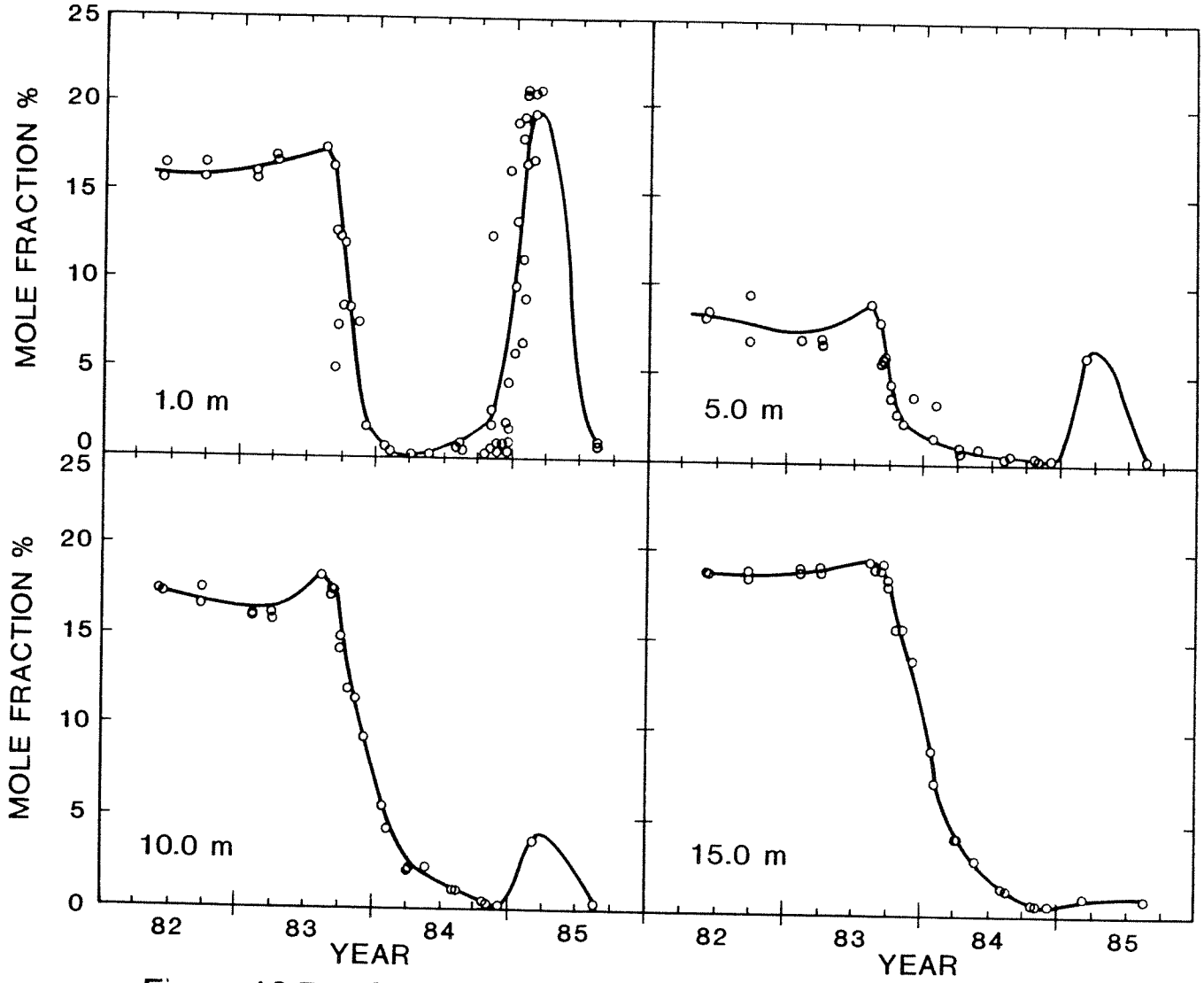


Figure 12.7 – CHANGE IN OXYGEN CONCENTRATION IN HOLE Ag ON WHITES OVERBURDEN HEAP

The dump was reshaped in September 1983 and the cover around the hole completed by December 1983. The post-August 1984 variability is due to diurnal atmospheric pressure changes. Each line is an 'eye-ball' fit through the points.

13.1 Summary

Up to 30 June 1986, expenditure on the Rum Jungle Rehabilitation Project totalled $18.6 million. This comprised the items shown in Table 13.1.

These totals cannot be directly compared with the financial allocations listed in Chapter 4, as those allocations are quoted in 1982 values. The effects of price escalation needs to be included for valid comparison.

13.2 Escalation

The Commonwealth Government considered the $12.14 million (February 1980 values) appropriate for the rehabilitation works. Because of changing prices with time from 1980, an escalation formula was proposed as a means of validly comparing the total cost of the project from year to year, and to realistically carry price rises. The formula has been used by large mining companies carrying out similar earthmoving exercises and uses the Commonwealth Bureau of Statistics indices for a number of related items.

Application of the formula raised the $12.14 million (February 1980 values) to $16.2 million (June 1982 values) (Reference 98). The escalation formula was included under the provisions of the 1983 Agreement (Reference 125) establishing the Project. The limit of Commonwealth funding ($16.2 million in 1982 values) was thereby escalated in accordance with the agreed formula, as set out below.

Table 13.1

SUMMARY OF PROJECT EXPENDITURE

Category	Description	Expenditure Up to 30 June 1986
CATEGORY A. EARTHWORKS ETC		
A1	Copper Heap Leach	3,539,670
A2	Tailings Dam	138,157
A3	Dysons Open Cut	8,098
A4	Whites Open Cut	320,268
A5	Intermediate Open Cut	240
A6	Dysons Overburden Heap	262,047
A7	Whites Overburden Heap	1,376,783
A8	Whites North Overburden Heap	696,771
A9	Intermediate Overburden Heap	491,396
A10	Acid/Sweetwater Dams	204,231
A11	Other Areas	379,981
A12	Site Establishment Including Protective Fence	1,194,932
	Sub Total Category A	8,612,574
CATEGORY B CONSTRUCTION WORKS		
B1	Water Treatment Plant	2,016,228
B2	Pipeline	1,012
B3	Construction Camp	227,065
	Sub Total Category B	2,244,305
CATEGORY C PROJECT MANAGEMENT, SITE SERVICING, MONITORING		
C1	Camp Services - power, water, sewerage	52,493
C2	CAMP Generator, Fuel and maintenence	161,587
C3	Camp Accommodation	1,617
C4	Monitoring	322,346
C5	Engineering and Management	3,028,293
C6	Site Services	0
	Sub Total for Category C	3,566,389
CATEGORY D	SUPPLY OF CHEMICALS FOR WATER TREATMENT PLANT	2,824,581
CATEGORY E	OPERATION OF WATER TREATMENT PLANT	1,392,400
	CONTINGENCY	600,000
	GRAND TOTAL (not including contingency)	18,640,249

The following escalation was applied to the value of outstanding or uncompleted work in each category at the end of each quarter.

$$P_n = (P_{n-1} - E_n) \cdot M_n$$

Where:

P_n is the limit of the Commonwealth's obligation to fund outstanding work under a category of work at the end of quarter n, valued at costs operating at the end of quarter n.

E_n is the actual certified expenditure on an item or category of work during quarter n.

Subscript n refers to the successive quarters or three month periods ending 30 September, 31 December, 31 March and 30 June.

Subscript n-1 refers to the quarter immediately preceeding quarter n.

M_n is an adjustment factor calculated by measuring the change in costs for a category of work between the end of quarter n and the end of quarter n-1. It is calculated by applying the relevant formula set out below.

(i) Category A

The formula for the calculation of factor M_n for Category A (Earthworks) is:

$$M_n(A) = 0.38 \frac{L_n}{L_{n-1}} + 0.17 \frac{F_n}{F_{n-1}} + 0.08 \frac{T_n}{T_{n-1}} + 0.15 \frac{S_n}{S_{n-1}} + 0.22 \frac{I_n}{I_{n-1}}$$

Where:

L is the actual cost of labour based upon the relevant Transport Workers (NT) Award for a Truck Driver, semi articulated 35-36 tonnes, 40 hours per week.

F is the ABS Catalogue No 6401.0 Consumer Price Index, Table 7, Transportation; Automotive Fuel - weighted average of eight cities.

T is the wholesale price of tyres based upon 11.00 x 22.5 Michelin XYZ Tubeless tyres.

S is the index for Equipment - spare parts, based upon the ABS Catalogue No 6412, Price indices for articles produced by Manufacturing Industry - transport equipment.

I is for Industrial Machinery and Equipment, based upon the ABS Catalogue No 6407.0, Table 2.

(ii) Category B

The escalation formula to be applied to Category B (construction work) is:

$$M_n(B) = 0.45 \frac{L_n}{L_{n-1}} + 0.55 \frac{R_n}{R_{n-1}}$$

Where:

L is the actual cost of labour based upon the relevant Metal Industry (NT) Award for Fitters.

R is the index for materials based upon ABS Catalogue 6407.0, Material Price Index for Darwin for Other Than House Buildings.

(iii) Category C

The formula for Category C (Project management, site services, monitoring) is:

$$M_n(C) = 0.80 \frac{L_n}{L_{n-1}} + 0.20 \frac{C_n}{C_{n-1}}$$

Where:

L is the cost of labour based upon Engineer Class 2 salary scale in the Northern Territory Public Service.

C is the Consumer Price Index for Darwin from the ABS.

(iv) Category D

The relevant formula for Category D (Supply of chemicals for water treatment plant) is:

$$M_n(D) = \frac{R_n}{R_{n-1}}$$

Where:

R is the cost index for Materials based upon ABS Catologue 6407.0, Price index for

Materials other than House Building, Table 3 - Cement.

(v) Category E

The relevant formula for Category E (Operation of water treatment plant) is:

$$M_n(E) = \frac{L_n}{L_{n-1}}$$

Where:

L is the cost of labour based upon the relevant Uranium and Metalliferous Mining (NT) Award - Treatment Plant Operation Fitter.

(vi) Contingency

There is no escalation applied to Contingency.

Escalation calculated as set out above, as applied to Project funding, is summarised in Table 13.2.

13.3 Variation Between Categories.

As indicated in Chapter 4, the Agreement made provision for the transfer of funds within a category of the programme and for variations to be made between the various categories of the programme, subject to agreement between Ministers. Examples of this are shown in Table 13.2:

- Compare the original financial committment (P.O.) with the adjusted financial committment at the start of the Project (P ADJ).
- Adjustment P9 ADJ

13.4 Expenditure to June 1986

The expenditure information summarised in Section 13.1 is presented in more detail in Table 13.3. The annual cash flows of expenditure for the Project are listed, and compared with the escalated funding provided by the Commonwealth. Note that the difference of $5Ø5849 between expenditure and Commonwealth funding is accounted for by the application to expenditure of the proceeds from the sale of assets.

Tables 13.1 and 13.3 include expenditure on contract variations incurred in 1985/86 but not paid until early 1986/87. These tables do not include expenditure incurred on minor works in 1986/87.

13.5 Budget to June 1988

Programmed work for the two years June 1986 to June 1988 consists of minor maintenance works on the site, and monitoring by the Department of Mines and Energy

(Water Resources Division), the Conservation Commission of the Northern Territory, and the Australian Atomic Energy Commission (see Chapter 14).

The budget for this work is tentatively $200,000 for maintenance distributed over two years, and $150,000 for monitoring, totalling $350,000.

Other expenditure items include minor contracts being finalised in 1986/87.

During this period the Project will realise further revenue from the sale of assets, including the water treatment plant, vehicles and equipment. Revenue is to be refunded to the Commonwealth either directly, or as an offset against expenditure.

Table 13.2

QUARTERLY ESCALATION CALCULATED FOR RUM JUNGLE PROJECT

	CATEGORY A	B	C	D	E	TOTAL	CONTINGENCY	COMMONWEALTH COMMITMENT
O.	5258.0	2380.0	4922.0	2300.0	740.0	15600	600	16200
ADJ	6168.0	2278.0	4114.0	2300.0	740.0	15600	600	16200
(See notes below)								
1	0.0	0.0	0.0	0.0	0.0			
	6523.0	2430.0	4361.0	2411.0	740.0	16465	600	17065
	355.0	152.0	247.0	111.0	0.0	865		
FACTOR	1.05762	1.06671	1.06013	1.04810	1.00000			
2	0.0	0.0	49.0	0.0	0.0	49		
	6614.0	2633.0	4336.0	2477.0	774.0	16834	600	17483
	91.0	203.0	24.0	66.0	34.0	418		
FACTOR	1.01390	1.08367	1.00556	1.02740	1.04624			
E3	0.0	23.0	128.0	0.0	0.0	151		
	6689.0	2642.0	4225.0	2597.0	774.0	16927	600	17727
	75.0	31.0	17.0	121.0	0.0	244		
FACTOR	1.01131	1.01193	1.00410	1.04867	1.00000			
E4	286.0	72.0	242.0	0.0	0.0	600		
	6408.0	2591.0	3998.0	2589.0	815.0	16401	600	17801
	5.0	21.0	15.0	-8.0	41.0	74		
FACTOR	1.00078	1.00827	1.00369	0.99682	1.05263			
E5	228.0	59.0	162.0	0.0	0.0	449		
	6290.0	2562.0	3846.0	2607.0	815.0	16120	600	17969
	110.0	30.0	10.0	18.0	0.0	168		
FACTOR	1.01775	1.01199	1.00268	1.00702	1.00000			
E6	660.0	21.0	345.0	0.0	0.0	1026		
	5795.0	2589.0	3626.0	2696.0	850.0	15556	600	18431
	165.0	48.0	125.0	89.0	35.0	462		
FACTOR	1.02933	1.01901	1.03563	1.03420	1.04299			
E7	75.0	466.0	367.0	0.0	0.0	908		
	5746.0	2150.0	3267.0	2751.0	850.0	14764	600	18545
	26.0	26.0	8.0	54.0	0.0	114		
FACTOR	1.00456	1.01232	1.00247	1.02021	1.00000			
P7 ADJ	6644.0	1551.0	2968.0	2751.0	850.0	14764	600	18545
E8	1204.0	846.0	437.0	484.0	0.0	2971		
P	5599.0	719.0	2610.0	2884.0	885.0	12134	600	18838
M	158.0	14.0	79.0	7.0	35.0	293		
FACTOR	1.02912	1.02017	1.03129	1.00300	1.04088			
E9	1356.0	598.0	233.0	0.0	29.0	2216		
P	4266.0	121.0	2385.0	2305.0	856.0	9933	600	18905
M	25.0	1.0	10.0	31.0	0.0	67		
FACTOR	1.00601	0.99680	1.00406	1.01376	0.00000			
P9 ADJ	4266.0	121.0	1835.0	2305.0	1406.0	9933	600	18905
E10	1464.0	67.0	449.0	379.0	247.0	2006		
P	2810.0	54.0	1389.0	1930.0	1157.0	7342	600	18921
M	8.0	0.0	3.0	5.0	0.0	16		
FACTOR	1.00268	1.00460	1.00196	1.00236	1.00000			
E11	457.0	37.0	261.0	508.0	214.0	1477		
P	2391.0	17.0	1130.0	1435.00	945.0	5918	600	18975
M	38.0	1.0	2.0	13.0	0.0	54		
FACTOR	1.01616	1.01323	1.00179	1.00883	1.00000			
E12	295.0	39.0	198.0	567.0	191.0	1290		
P	2234.0	-22.0	953.0	881.0	774.0	4820	600	19169
M	139.0	-1.0	23.0	13.0	20.0	194		
FACTOR	1.04599	1.02343	1.02463	1.01459	1.02596			
P12 ADJ	2191.0	21.0	953.0	881.0	774.0	4820		

Table 13.2 Cont.

QUARTERLY ESCALATION CALCULATED FOR RUM JUNGLE PROJECT

	CATEGORY							
	A	B	C	D	E	TOTAL	CONTINGENCY	COMMONWEALTH COMMITTMENT
E13	664.0	13.0	261.0	642.0	416.0	1996		
P	1597.0	8.0	696.0	242.0	358.0	2901	600	19205
M	27.0	0.0	5.0	4.0	0.0	36		
FACTOR	1.01614	1.00739	1.00694	1.01611	1.00000			
E14	1047.0	3.0	173.0	244.0	219.0	1686		
P	550.0	5.0	522.0	0.0	140.0	1217	600	19205
M	0.0	0.0	0.0	0.0	0.0	0		
FACTOR	1.00968	1.00900	1.03086	1.01416	1.00000			
E15	853.0	0.0	107.0	0.0	77.0	1037		
P	-	-	-	-	-	-	600	19205
M	-	-	-	-	-	-	-	
FACTOR	-	-	-	-	-	-	-	
E16	22.0	0.0	152.0	0.0	0.0	174		
P	-	-	-	-	-	-	600	19205
M	-	-	-	-	-	-	-	
FACTOR	-	-	-	-	-	-	-	

Notes

P.O. Original financial committment provided in the Agreement (see Chapter 4)

P ADJ Adjusted financial committment at the start of the Project. Note that the totals of P.O. and P ADJ are equal.

Table 13.3

ANNUAL EXPENDITURE ON PROJECT TO 30 JUNE 1986

Category Description		1982/83	1983/84	1984/85	1985/86	TOTAL
CATEGORY A: EARTHWORKS ETC						
A1	Copper Heap Leach	0	127673	3022780	389217	3539670
A2	Tailings Dam	0	129767	2465	5925	138157
A3	Dysons Open Cut	0	6414	981	703	8098
A4	Whites Open Cut	0	0	260	320008	320268
A5	Intermediate Open Cut	0	0	0	240	240
A6	Dysons Heap	0	0	0	262047	262047
A7	Whites Heap	0	1005356	331583	39844	1376783
A8	Whites North Heap	230475	21601	0	444695	696771
A9	Intermediate Heap	0	0	0	491396	491396
A10	Acid Sweetwater Dams	0	0	0	204231	204231
A11	Other Areas	0	400	41391	338190	379981
A12	Site Establishment	55288	876322	173296	90026	1194932
	Sub Total	285763	2167533	3572756	2586522	8612574
CATEGORY B: CONSTRUCTION WORKS						
B1	Water Treatment Plant	0	1308354	691962	15912	2016228
B2	Pipeline	0	0	659	353	1012
B3	Construction Camp	94987	83897	48063	118	227065
	Sub Total	94987	1392251	740684	16383	2244305
CATEGORY C: PROJECT MANAGEMENT, SITE SERVICING, MONITORING						
C1	Camp Services	0	26921	7966	17605	52493
C2	Camp Generator	0	112003	35600	13984	161587
C3	Camp Accommodation	0	0	1485	186	1671
C4	Monitoring	55410	22224	176184	68528	322346
C5	Engineering	363835	1149206	921768	593484	3028293
C6	Site Services	0	0	0	0	0
	Sub Total	419245	1310354	1143003	693787	3566389
CATEGORY D: SUPPLY OF CHEMICALS FOR WATER TREATMENT PLANT						
D	Chemicals	0	484450	1454032	886099	2824581
CATEGORY E: OPERATION OF WATER TREATMENT PLANT						
E	Plant Operation	0	0	679959	712441	1392400
TOTAL		799995	5354588	7590434	4895232	18640249
COMMONWEALTH FUNDING		800000	5300000	7590000	4444400	18134400
DIFFERENCE		5	(54583)	(434)	(450832)	(505849)

To ensure the lasting integrity of the rehabilitation measures after completion of the works, it is necessary to properly manage the site and to maintain the rehabilitation measures. This is recognised in the Agreement. Provision is made for ongoing monitoring and maitenance, funded by the Commonwealth, a period of up to two years after completion of the works, that is, to 1988.

14.1 Monitoring

The monitoring programme for the remainder of the monitoring period is basically a continuation of the previously approved programme. Its elements are:

(i) Conservation Commission
The Conservation Commission will continue to monitor, as described by Ryan (Reference 128):
(a) the condition of vegetation on all re-seeded areas;
(b) the condition of and erosion of the cover systems on the site; and,
(c) the presence and impact of flora and fauna, particularly feral buffalo.

(ii) Australian Atomic Energy Commission
The Australian Atomic Energy Commission will continue to monitor the chemical activity and water balance of Whites and Intermediate Overburden Heaps. The Commission will also analyse groundwater data gathered by the Department of Mines and Energy (Water Resources Division).

(iii) Department of Mines and Energy (Water Resources Division)
Water Resources Division will continue its monitoring programme as described in Reference 112:
(a) detailed monitoring and analysis of surface water in the Finniss River and the East Branch of the Finniss River;

(b) collection of data from observation bores and chemical analysis of collected samples of both the shallow and the deep aquifer systems at Rum Jungle. This data will be analysed by the AAEC;
(c) monitoring and analysis of water quality in Intermediate and Whites Open Cuts;
(d) monitoring and analysis of stream flow in the main drain at Whites Overburden Heap and other drains and streams on site; and,
(e) monitoring of rainfall at the site.

This monitoring programme is the responsibility of, and is to be co-ordinated by the Water Resources Division of the Department of Mines and Energy. The Division will be responsible for the collation of the requisite reports including the annual reports and the final report at the end of the monitoring period. The Division will also chair the regular Monitoring Commitee meetings.

14.2 Maintenance

The maintenance programme for Rum Jungle is aimed at carrying out the inspection and works required to preserve the integrity of the rehabilitation. The programme consists of:

(i) Maintenance of Covers

Maintenance of the cover system comprises the detailed inspection of the covers during and at the end of the wet season and the repair of any significant erosion damage, particularly gully erosion, during the ensuing dry season. Repairs to the covers should be made with material similar to that which has eroded from the area, sourced from one of the previously established borrow pits from around the site and placed in a similar manner as the original material. Reasons for damage should be ascertained to enable design of approximate remedial works and repairs.

(ii) Maintenance of Vegetation

This comprises the inspection and re-seeding at the start of the wet season of any significant areas where seeding has failed during the previous dry season, the re-seeding of any repaired areas and the subsequent fertilising and slashing of all revegetated areas of the site. Re-seeding should utilise seed mixes similar to those used for the original seeding.

Fertilising and slashing should be carried out twice during the wet season, the first being early February and again during April (the exact timing will be dependant on seasonal weather conditions. Selection of a suitable fertiliser should be based on an analysis of vegetation at

the time of application and should take into account any recognised soil deficiencies. Details are described by Ryan (Reference 128).

Unfortunately, the two year period may not be sufficient time to ensure successful site revegetation to a point where maintenance fertilisation and slashing can cease. Nor may it be sufficient time to conclude that revegetation works have been totally successful in the longer term. These issues will need to be carefully considered before the works cease.

(iii) Maintenance of Rediversion Works

Maintenance of the rediversion works should be limited to the inspection of culverts and weirs during and at the end of the wet season, the removal of any accumulated debris from the structures, and the repair of any damage to the structures or their foundations before the next wet season.

(iv) Maintenance of Drainage

This programme comprises inspection (formally on an annual basis after the wet season but also during the wet season when appropriate) and rectification as described below.

(a) Inspect all erosion control drains and repair any damage, particularly the drain outlet area.
(b) Inspect all rip rap lined drains for signs of movement of lining material and any other damage, and repair as necessary.
(c) Inspect all mattress lined drains for signs of the deterioration of wire mattresses, movement of fill material and any other damage, and repair as required.
(d) Inspect all half round pipes (berm drain and drop down drains on Whites heap) for signs of deterioration or erosion of drain foundations and repair as required.
(e) Inspect all drainage structures (gabion drop structures, manholes, energy dissipators, culverts etc) and carry out repairs as neccessary.
(f) Inspect subsoil drains and repair as required.

(v) Roadworks

Inspect and repair the designated road pavements to maintain servicability, to the standard of gravel all weather roads.

(vi) Fencing

Inspect the cattleproof fences around the site and around the filter cake disposal area annually

after the wet season and carry out repairs as required.

(vii) Building Maintenance

Inspect all buildings remaining on the site and repair as required to maintain their servicability.

(viii) Monitoring Facilities

Inspect all monitoring facilities (gauging stations, pluviometer stations, etc) prior to the start of and during the monitoring season and repair as required.

(ix) Water Supply

Inspect the site water supply facilities and repair as required.

(x) Buffalo Control

On completion of repairs to fencing (item (vi) above), eradicate feral buffalo from within the site.

(xi) Fire Breaks

Inspect and maintain the fire break around the site perimeter fence annually.

(xii) Weeds

Inspect at six monthly intervals, and keep at tolerable levels by the use of herbicides and mowing, weeds including Hyptis sauveolens, Sida acuta and Mimosa pigra.

This maintenance programme is the responsibility of, and to be co-ordinated by the Water Resources Division of the Department of Mines and Energy.

14.3 Site Management

Although the final land use of the Rum Jungle Mine Site has yet to be determined, there are several aspects of the management of the site that require implementation to ensure the continued integrity of the rehabilitation measures, and to ensure the early recognition of potential problems. The monitoring and maintenance programmes discussed above are essential components of the management of the site.

Abuse of the rehabilitated mine site may result in damage to the cover systems employed to prevent the further spread of pollution. Management of the Rum Jungle Mine Site should be aimed at protecting the fragile aspects of the site whilst using the other less fragile areas for beneficial purposes if this is possible.

Any decision on an intended land use should be made on the basis of land capability, that is, what the surface is capable of withstanding without detriment.

As Ryan (Reference 128) discusses, public awareness and general educational interest in the site are high, and will continue to be so for a number of years. Work has commenced by the Department of Mines and Energy to cater for such interest in a controlled manner, be it by guided tours or information displays. Unsupervised access by the public is not recommended at any stage, as this will result in damage from vehicles and vandals.

During the implementation phase of the rehabilitation programme, the mine was administered within the provisions of the Mine Safety Control Act. This Act is no longer appropriate to the administration of the site. A legislative framework is still required to maintain an adequate degree of control at Rum Jungle. It is therefore recommended that the mine area be declared a "Restricted Use Area" within the provisions of the Soil Conservation and Land Utilisation Act 1978.

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APPENDIXES

Appendix A

Impact Of 1 in 100 Year Hydrologic Event

IMPACT OF 1 IN 100 YEAR HYDROLOGIC EVENT

One of the criteria for the design of the works under the Project was that the works should have a design life of 1ØØ years. This criteria has been interpreted as requiring the works to be designed to withstand events whose recurrence interval is 1ØØ years. Such an event has an annual exceedance probability (AEP) of 1 in 1ØØ, or 1%.

All hydraulic structures designed as part of the rehabilitation programme have a design AEP of 1 in 1ØØ. It is important to understand the impact of an event whose magnitude is greater than that. It should also be realised that two factors will decrease the impact of such an event:

(i) The measures were designed to withstand an event with AEP of 1 in 1ØØ should it occur during the first wet season after the construction of the works and consequently in an unvegetated state.

(ii) The rehabilitation measures become, in many instances, more stable with time as vegetation establishes and voids in rock lining and other locations fill with particulate matter, thus improving the ability of the measures to withstand extreme events.

Aside from gully erosion of the top cover layers, the most significant effect of the extreme event will be on the hydraulic structures associated with the drainage measures and the rediversion works.

A.1 Rediversion Works

As described in Chapter 7 of this report, the rediversion of the East Branch of the Finniss River returns part of the river flows to their original course through Whites and Intermediate Open Cut pits. The hydraulics of the rediversion works ensure that:

(i) more water can leave the open cuts than can enter via the rediversion works; and,

(ii) in high flood flows the majority of the flow passes via the original diversion channel.

The likely problem with an extreme rainfall event will be in the system's ability to cope with the headwater in the original Acid and Sweetwater Dam area at the confluence of the East Branch of the Finniss River and Fitch Creek. In designing the works a freeboard of 800 mm over the maximum water level was selected as being appropriate to ensure that overtopping of the walls of the open cuts did not occur in the design events. From the investigations carried out for the Options and Design Criteria for Stage 4.2 of the Project (Cameron McNamara, Reference 40), 800 mm of freeboard corresponds to an increase in the river flow from 360 cubic metres per second to of the order of 500 cubic metres per second which, conservatively estimated, relates to a recurrence interval of 400 years. The probability of overtopping the walls of the open cut pits then is low, but nevertheless it is a possibility.

Should the headwater level rise sufficiently to overtop the pit walls, then it is reasonable to expect that the majority of the flow in the river would pass via the open cuts rather than the diversion channel. As a result Whites Open Cut and later as water levels rise, Intermediate Open Cut, would be inundated.

The consequences of that inundation would be:

(i) the entry culvert to Whites Open Cut could be expected to be washed out, possibly into the open cut;

(ii) the bypass culvert in Copper Creek, upstream of the entry to Intermediate Open Cut would be washed out as the low embankment above it is overtopped; and,

(iii) the embankments surrounding both Whites and Intermediate Open Cut pits would be breached as they became overtopped.

It is repeated that the event giving rise to these consequences is most likely an extreme event and it could be expected that major flooding would occur throughout the region.

A.2 Drainage Structures

Drainage structures form the other potential area for major damage in the event of an extreme event. These structures were constructed within the rehabilitation works particularly on the covered areas. As with the rediversion works, freeboard has been built into the drainage works to provide a margin of security against failure in extreme events but, as with the rediversion works, the possibility does exist of failure under such conditions.

The occurrance of an extreme event could be expected to result in:

(i) the erosion of the rip rap drain lining as the flow velocity in the drains increases, and the erosion of the floor of the drain as the rock protection is lost; and,

(ii) erosion of cover materials around the edges of the drains, leading ultimately to possible failure of the cover systems.

Unlike the rediversion works, an extreme event affecting the drainage structures need not be wide spread, and may not even effect all of the mine site.

Appendix B

Contract Summary

CONTRACT SUMMARY

CONTRACTOR:	ROADMAKERS
JOB DESCRIPTION:	Relocation of Overburden (Stage 1)
CONTRACT NUMBER:	TW 102 OF 82/83
AWARDED:	15-4-83
CONTRACT SUM:	$197,840.00
AS VARIED:	$236,432.00
COMPLETION DATE:	10-6-83
EXTENDED DATE:	22-7-83
FINAL CERTIFICATE:	1-9-83
COMMENTS:	

CONTRACTOR:	HENDRIE CONSTRUCTION P/L
JOB DESCRIPTION:	Stage 2 Whites Overburden Heap
CONTRACT NUMBER:	TW 12 OF 83/84
AWARDED:	17-8-83
CONTRACT SUM:	$1,384,060.00
AS VARIED:	$1,417,169.00
COMPLETION DATE:	14-3-84
EXTENDED DATE:	
FINAL CERTIFICATE:	
COMMENTS:	CONTRACT TERMINATED; VALUE OF WORK DONE $868,867; VALUE OF SECURITY RETAINED $51,500

CONTRACTOR:	WILLIAM BOBY & CO PTY LTD
JOB DESCRIPTION:	Filter Press and Pumps
CONTRACT NUMBER:	TW 26 OF 83/84
AWARDED:	29-9-83
CONTRACT SUM:	$333,745.00
AS VARIED:	$361,679.40
COMPLETION DATE:	10-4-84
EXTENDED DATE:	17-10-84
FINAL CERTIFICATE:	16-10-85
COMMENTS:	

CONTRACTOR:	LAROX PROPRIETARY LTD
JOB DESCRIPTION:	Supply Secondary Clarifier and Tank
CONTRACT NUMBER:	TW 27 OF 83/84
AWARDED:	29-9-83
CONTRACT SUM:	$58,000.00
AS VARIED:	$62,954.62
COMPLETION DATE:	10-4-84
EXTENDED DATE:	11-4-84
FINAL CERTIFICATE:	7-8-85
COMMENTS:	

CONTRACTOR:	ASOMA AUSTRALIA PTY LTD
JOB DESCRIPTION:	Supply of Hydrated Lime
CONTRACT NUMBER:	TW 28 OF 83/84
AWARDED:	17-6-84
CONTRACT SUM:	$2,693,503.00
AS VARIED:	$2,954,182.00
COMPLETION DATE:	6-10-85
EXTENDED DATE:	
FINAL CERTIFICATE:	31-12-86
COMMENTS:	

CONTRACTOR:	THOMAS ROBINSON & SON P/L
JOB DESCRIPTION:	Supply of Lime Surge Bin and Equipment
CONTRACT NUMBER:	TW 29 OF 83/84
AWARDED:	3-9-83
CONTRACT SUM:	$16,082.00
AS VARIED:	$16,872.80
COMPLETION DATE:	23-3-84
EXTENDED DATE:	5-3-84
FINAL CERTIFICATE:	24-7-85
COMMENTS:	

CONTRACTOR:	WILLIAM BOBY & CO PTY LTD
JOB DESCRIPTION:	Supply of Primary Clarifier
CONTRACT NUMBER:	TW 34 OF 83/84
AWARDED:	7-10-83
CONTRACT SUM:	$31,760.00
AS VARIED:	$31,760.00
COMPLETION DATE:	20-4-84
EXTENDED DATE:	16-4-84
FINAL CERTIFICATE:	8-8-85
COMMENTS:	

CONTRACTOR:	LIGHTNIN MIXERS PTY LTD
JOB DESCRIPTION:	Supply of Four Agitators
CONTRACT NUMBER:	TW 43 OF 83/84
AWARDED:	14-10-83
CONTRACT SUM:	$18,845.00
AS VARIED:	$19,934.00
COMPLETION DATE:	6-4-84
EXTENDED DATE:	25-1-84
FINAL CERTIFICATE:	24-7-84
COMMENTS:	

CONTRACTOR:	BLAKERS & THOMPSON PUMPS
JOB DESCRIPTION:	Supply of Five Slurry and Sump Pumps
CONTRACT NUMBER:	TW 49 OF 83/84
AWARDED:	25-10-83
CONTRACT SUM:	$28,295.00
AS VARIED:	$37,136.55
COMPLETION DATE:	18-4-84
EXTENDED DATE:	
FINAL CERTIFICATE:	7-10-85
COMMENTS:	

CONTRACTOR:	TRANS AUST. CONST. PTY LTD
JOB DESCRIPTION:	Supply of Flocculent Mixing and Storage System
CONTRACT NUMBER:	TW 80 OF 83/84
AWARDED:	30-3-84
CONTRACT SUM:	$9,600.00
AS VARIED:	$9,600.00
COMPLETION DATE:	30-3-84
EXTENDED DATE:	
FINAL CERTIFICATE:	29-3-85
COMMENTS:	

CONTRACTOR:	ELMEC PTY LTD
JOB DESCRIPTION:	Supply and Install two 200KW Diesel Generator Sets
CONTRACT NUMBER:	TW 96 OF 83/84
AWARDED:	3-2-84
CONTRACT SUM:	$123,154.00
AS VARIED:	$123,154.00
COMPLETION DATE:	4-5-84
EXTENDED DATE:	29-6-84
FINAL CERTIFICATE:	4-1-86
COMMENTS:	

CONTRACTOR:	FINDLAY CIVIL CONTRACTORS
JOB DESCRIPTION:	Water Treatment Plant Earthworks and Slab
CONTRACT NUMBER:	TW 101 OF 83/84
AWARDED:	17-2-84
CONTRACT SUM:	$106,529.00
AS VARIED:	$134,089.41
COMPLETION DATE:	30-3-84
EXTENDED DATE:	7-6-84
FINAL CERTIFICATE:	6-12-84
COMMENTS:	

CONTRACTOR:	TRANS AUST. CONST. PTY LTD
JOB DESCRIPTION:	Water Treatment Plant Steelworks and Tanks
CONTRACT NUMBER:	TW 106 OF 83/84
AWARDED:	9-3-84
CONTRACT SUM:	$275,795.00
AS VARIED:	$435,858.27
COMPLETION DATE:	21-6-84
EXTENDED DATE:	20-6-84
FINAL CERTIFICATE:	1-4-85
COMMENTS:	

CONTRACTOR:	QUARRY INDUSTRIES LTD
JOB DESCRIPTION:	Supply of 45,000 Tonnes Crushed Rock
CONTRACT NUMBER:	TW 108 OF 83/84
AWARDED:	9-3-84
CONTRACT SUM:	$537,375.00
AS VARIED:	$543,534.76
COMPLETION DATE:	27-4-84
EXTENDED DATE:	20-6-84
FINAL CERTIFICATE:	20-6-84
COMMENTS:	

CONTRACTOR:	KILPATRICK GREEN PTY LTD
JOB DESCRIPTION:	Water Treatment Plant Fabrication and Mechanical Works
CONTRACT NUMBER:	TW 117 OF 83/84
AWARDED:	23-3-84
CONTRACT SUM:	$321,288.00
AS VARIED:	$325,031.52
COMPLETION DATE:	15-6-84
EXTENDED DATE:	25-7-84
FINAL CERTIFICATE:	24-1-85
COMMENTS:	

CONTRACTOR:	THIESS CONTRACTORS PTY LTD
JOB DESCRIPTION:	Earthworks Stage 3 and Completion of Stage 2
CONTRACT NUMBER:	TW 126 OF 83/84
AWARDED:	13-4-84
CONTRACT SUM:	$2,651,266.00
AS VARIED:	$3,939,350.73
COMPLETION DATE:	21-12-84
EXTENDED DATE:	
FINAL CERTIFICATE:	26-6-85
COMMENTS:	

CONTRACTOR:	JOHN HOLLAND CONST. PTY LTD
JOB DESCRIPTION:	Water Treatment Plant Electrical Work and Instrumentation
CONTRACT NUMBER:	TW 127 OF 83/84
AWARDED:	19-4-84
CONTRACT SUM:	$58,926.00
AS VARIED:	$117,449.50
COMPLETION DATE:	21-6-84
EXTENDED DATE:	27-7-84
FINAL CERTIFICATE:	3-1-85
COMMENTS:	

CONTRACTOR:	CJ PROPERTY MAINTENANCE
JOB DESCRIPTION:	Disposal of Used Lime and Flocculent Bags
CONTRACT NUMBER:	TW 33 OF 84/85
AWARDED:	14-9-84
CONTRACT SUM:	$12,109.00
AS VARIED:	$12,109.00
COMPLETION DATE:	28-2-86
EXTENDED DATE:	30-10-85
FINAL CERTIFICATE:	30-10-85
COMMENTS:	

CONTRACTOR:	THIESS CONTRACTORS PTY LTD
JOB DESCRIPTION:	Stages 4.1 and 4.2 Intermediate/Dyson Overburden Heaps
CONTRACT NUMBER:	TW 117 OF 84/85
AWARDED:	7-5-85
CONTRACT SUM:	$1,626,329.00
AS VARIED:	$2,644,007.05
COMPLETION DATE:	16-1-86
EXTENDED DATE:	19-12-85
FINAL CERTIFICATE:	
COMMENTS:	CONTRACTOR SEEKING ADDITIONAL PAYMENTS.

Appendix C

Consultancies

CONSULTANT:	MINING AND PROCESS ENGINEERING SERVICES
COMMISSION:	Design Options and Criteria Report
VALUE:	$32,227
STATUS:	Completed.

CONSULTANT:	MINING AND PROCESS ENGINEERING SERVICES
COMMISSION:	Design and Commission Water Treatment Plant
VALUE:	$410,320
STATUS:	Completed.

CONSULTANT:	MINING AND PROCESS ENGINEERING SERVICES
COMMISSION:	Operate and Manage Water Treatment Plant
VALUE:	$1,194,994
STATUS:	Final claims being negotiated.

CONSULTANT:	DAMES AND MOORE (In Conjunction with Cameron McNamara, and Meahan Burgess, and Yeates)
COMMISSION:	Design and Documentation of Whites and Whites North
VALUE:	$174,250
STATUS:	Completed.

CONSULTANT:	CAMERON McNAMARA (In Conjunction with Dames and Moore, and Peter J Burgess & Assoc)
COMMISSION:	Design and Documentation of Tailings Dam, Copper Heap Leach Pile and Dysons Open Cut
VALUE:	$181,529
STATUS:	Completed

CONSULTANT:	CAMERON McNAMARA
COMMISSION:	Design and Documentation of Intermediate and Dysons Overburden Heaps
VALUE:	$232,562
STATUS:	Completed.

CONSULTANT:	DAMES AND MOORE
COMMISSION:	Soil Testing Associated with Tailings Dam and Copper Heap Leach Pile
VALUE:	$226,547
STATUS:	Completed.

CONSULTANT:	DAMES AND MOORE
COMMISSION:	Soil Testing for Stage 4.2
VALUE:	$18,500
STATUS:	Completed.

CONSULTANT:	UNISEARCH LTD
COMMISSION:	Design Study of Water Treatment Plant
VALUE:	$39,450
STATUS:	Completed at $29,000.

CONSULTANT:	CAMERON McNAMARA
COMMISSION:	Redocumentation of Whites Overburden Heap
VALUE:	$32,970
STATUS:	Completed.

CONSULTANT:	CAMERON McNAMARA
COMMISSION:	Measure of Whites Reshaping
VALUE:	$12,122
STATUS:	Completed.

CONSULTANT:	CAMERON McNAMARA
COMMISSION:	Final Measure of Whites Overburden Heap and Tailings Dam
VALUE:	$32,282
STATUS:	Completed.

Appendix D

Orders Placed

83/84

ORDER NO	PLACED ON	DESCRIPTION	VALUE $
SD5388	Conservation Comm.	Mulching	14,456.17
SD5370	Spraypave	Terolas	9,067.31
SD5498	Agtracts	Fertiliser	1,289.00
SD5517	Spec. Engineering	Geotextile	50,179.50
SD5563	Agtracts	Slashing	875.00
SD5439	Wolpers & Flowers	3-phase ATS/OFF	1,450.00
SD5719	Bruce Elect. Cont.	Equip bore RN22548	27,543.00
SD5285	Agtracts	Construct fence	21,906.00
SD5367	Findlay	Construct 840m R/M	13,090.00
39D0885	Humes	Concrete pipe	8,564.00
SD5396	Roebuck	Revegetation	8,500.00
SD5462	Findlay	Washdown facility	99,225.00
SD5103	Production Machinery	Lime elevator	5,531.60
SD5104	Prom. Fluid Cont.	Lime slurry pumps	6,179.50
SD5105	Blakers & Thompson	Priming system	1,225.00
SD5260	Tristar	Air dryer	1,650.00
SD5334	A Hinch	Dust filter	5,249.14
SD5436	Kent Instruments	Switches & Inst.	1,078.00
SD5366	Wolpers & Flowers	Earthworks	23,150.00
SD5562	J Sharples	Cleaning	600.00
SD5653	Amdel	Density transmitter	6,540.00
SD5089	G B Dowell	Clear 11km fence	4,000.00

D.1

ORDER NO	PLACED ON	DESCRIPTION	83/84 VALUE $
SD5437	Fischer & Porter	Flow transmitter	4,679.00
SD5411	Kent Instruments	3 x pH systems	6,477.00
SD5102	Thomas Robinson	Lime meter equipment	6,675.00
SD5419	Elmec	Dist. boards	20,610.80
SD5438	Control Engineering	6 level switches	4,248.00
SD5466	Kilpatrick Green	Power con. cables	43,118.89
SD5571	Ramsey Engineering	Weightometer	8,152.00
SD5412	Hinco	Level controllers	2,709.00
SD5413	Hinco	2 flow switches	1,520.00
SD5442	Powerphase	Level transducer	1,859.00
SD5267	Kelair	Air compressor	8,750.00
SD5101	Mono Pumps	Floc. met. pump	4,129.70
SD5464	Kent Instruments	Multipoint recorder	1,438.00
SD5710	Tesco Pearce	Various equipment	2,576.01
SD5711	Control Engineering	Kasitrol A101	698.00
SD5715	Air Power	Solenoid & freight	262.00
SD5716	Anal. Cont. Inst.	Solenoid driver	357.00
SD5717	Spec. Engineering	Level switches	104.00
SD5728	Kent Instruments	Various equipment	2,282.00
39D1026/83	Norman Ross	Rerigerators	1,350.00
SD5335	J R Roe	Electric hoist	2,551.00
SD5306	Allied Colloids	Supply flocculent	22,900.00

ORDER NO	PLACED ON	DESCRIPTION	VALUE $
SD5464	Kent Instruments	Multipoint recorder	1,438.00
39D0127/84	Dynapacific Corp.	Micro fans	124.00
39D1079/83	Radiation Res.	H_20 qual. mon system + freight	8,501.03
RJP001	NT Port Authority	Hyster Forklift (used)	6,000.00
RJP003	Thiess Toyota	Landcruiser HJ60RV-MCQ	14,003.10
RJP004	Thiess Toyota	Hilux 4WD LN46R-KRQ3	9,064.65
RJP006	AARQUE	Drafting Machine - Mutoh	658.00
RJP007	Dobbie Instruments	Drafting stand - Nike 'President'	638.00
RJP008	Homecrafts	Simpson stove 200l	599.00
RJP009	Australian National Railways	Railway sleepers	2,500.00
RJP010	Green's Steel Constructions	Crane hire	843.00
RJP011	Green's Steel Constructions	Truck hire	544.00
RJP012	Darwin Business Machines	Brother EM100 Electronic Typewriter	850.00
RJP013	Datsun (Distr) Pty Ltd	Nissan 4WD diesel - VRG160GM	13,181.54
RJP014	Palmerston Furniture	Plan tables	692.23
RJP015	Specialised Engineering Services	Level switches	350.00
RJP016	Tristar Sales P/L	Solenoid valves & flow switch	255.70
RJP017	Austral Engineering	Air supply solenoid valve	390.00
RJP018	Dobbie Instruments	Temperature indicators	412.50
RJP019	Jaybee Engineering	Level indicator	351.00
RJP020	Tesco-Pearce	Limit switches	93.96
RJP021	Aust. Analytical Control & Inst.	Solenoid driver	353.00

ORDER NO	PLACED ON	DESCRIPTION	VALUE $
RJP022	Telecom Australia	Key stations at site office	522.00
RJP023	Dobbie Instruments	Planex plan cabinet	660.00
RJP024	M.O.D.E.	3M lettering machine	889.92
P033/83	J R Roe Co Pty Ltd	6x4 box trailer	400.00
P036/83	J R Roe Co Pty Ltd	Lister/Powerlite generator set	1,800.00
P035/83	Thiess Toyota Pty Ltd	Landcruiser BJ42RV.MCQ	10,871.63
39D0254/84	Surescreen Sales Pty Ltd	Screens with sockets	278.00
39D1328/82	Cuthbert Packaging	Polyethylene plastic drums	1,528.00
39D0126/84	S.B.A. Distributors Pty Ltd	Shelving units	782.47
39D0619/83	BP Australia Pty Ltd	Diesel	19,105.00
39D0841/83	Humes Ltd	Half section concrete pipes 450mm dia	6,788.08
39D0865/83	Video Productions	Video camera & recorder	6,415.00
39D0869/83	Humes Ltd	Half section concrete pipes 600mm dia	9,516.00
39D0940/83	Medical & Laboratory Supplies	pH meter, probe, soil test kit	1,531.65
39D0956/83	Cameron McNamara Pty Ltd	Aerial photography	1,785.00
39D0960/83	Furniture Re-upholsterers	Visitors chairs	252.00
39D0961/83	S.B.A. Distributors Pty Ltd	Chairs & cabinets	959.06
39D0962/83	Craft Service Joinery Pty Ltd	Desks	560.22
39D0963/83	Palmerston Furniture	Bookcases	371.28

84/85

ORDER NO	PLACED ON	DESCRIPTION	VALUE $
SD5033/84	Batchelor Drillers	Hire plant	36,803.60
SD5024/84	Ensign	Signs	2,850.00
SD5176/84	L G Thomas	U/G septic tank	2,020.00
SD5221/84	Batchelor Drillers	Hire plant	9,500.00
SD5273/84	D Roebuck	Transp. lime bags	1,300.00
SD5447/84	J Stedman	Const. drains	6,176.19
SD5013/84	Fischer & Porter	Flow indicator	516.00
LPO34091	Tesco Pearce	Relay	81.00
SD5041/84	Auslec	Elec. spares for filter press	1,156.00
SD5032/84	Plant Control & Automation	1 proximity switch	30.85
SD5140/84	William Boby	Netzsch spares	540.50
39D0332/84	Kilpatrick Green	PVC pipe	1,665.99
39D0347/84	Hardie Iplex	PVC pipe	1,293.74
SD5151/84	Auslec	Electrical spares	501.00
LPO41647	Hardie Iplex	Couplings	72.00
SD5194/84	William Boby	Spares- filter press	221.50
SD5234/84	Blakers & Thompson	Spares for P.C.	4,120.00
SD5348/84	Cyanamid	Chemicals	4,860.00
SD5027/84	Powerlite	Alternator spares	829.50
SD5026/84	Powerlite	Spares for generator control panel	4,189.85
SD5025/84	Powerlite	Spares - gen. engine	665.56
SD5079/84	N & B Marine	Injectors	1,218.00

ORDER NO	PLACED ON	DESCRIPTION	84/85 VALUE $
39D0218/84	Dabsco	Tarpaulin	1,180.00
39D0467/84	Selby Scientific	Conductivity meter	1,616.00
SD5376/84	Amdel	Water analysis	4,000.00
P/117/84	Yamaha Pitmans	4 wheel cycle	2,195.00
SD5414/84	Detroit	Rebuild gen. set	23,298.50
SD5200/84	G Setterberg	Weir wall	12,040.00
39D0696/84	A G Barker & Assoc.	Quartz timers	1,185.00
39D0585/84	FSE Scientific	Density meter	7,129.50
34D0629/84	Selby Scientific	Compressor Pump & accessories	1,145.30
34D0643/84	Selby Scientific	Metrohm carry case	1,830.00
39D0641/84	Spot On Marine	Punt	695.00
39D0660/84	Hydrological services	Pressure unit	3,340.00
SD5178/84	Fuel Installation Services	Fuel tank	825.00
SD5177/84	Transcon	Destratification system	9,980.00
39D0382/84	BP Australia	50,000 litres diesel	23,611.00
39D0535/84	BP Australia	60,000 litres diesel	23,310.00
SD5247/84	Porters Haulage	Disposal of filter cake	37,746.50
SD5361/84	P&H Earthmoving	Disposal of filter cake	7,785.00
WDO1693/84	BP Australia	100,000L diesel	40,000.00
2925-+	BP Australia	Bulk diesel	22,895.00
2926-8	Porters Haulage	Hire loader & truck	9,900.00

84/85

ORDER NO	PLACED ON	DESCRIPTION	VALUE $
2927-6	Rum Jungle Farms	Hire bulldozer	5,500.00
2929-2	Radiation Research	Sensor probe & water analyser	500.00
2930-5	GB Melville	Hay	3,450.00
2931-3	Purkiss Seeds Pty Ltd	Seed	7,771.40
2932-1	Alex Armstrong	Seed	4,828.00

ORDER NO	PLACED ON	DESCRIPTION	85/86 VALUE $
2933-+	BP Australia	Diesel	28,000.00
2934-8	Porters Haulage	Disposal of filter cake	27,358.75
2935-6	Allied Colloids	Magnafloc	7,900.00
2936-4	Franklin Electric Pty Ltd	Motor	2,424.00
2938-0	BP Australia	Diesel	27,648.00
2940-1	Tropigro Garden Products Pty Ltd	Seed	4,120.00
2941-+	Mobile Electrics	Circuit breakers	651.00
2942-8	Commonwealth Industrial Gases	Gases	2,000.00
2943-6	J & R Pump & Bore Services	Repair & maintenance work	1,804.52
2944-4	BP Australia	Diesel	26,676.00
2946-0	Selby Scientific	Metrohm electrodes	444.00
2947-9	Rotor Services Pty Ltd	Charter Jetranger helicopter	886.20
2948-7	Selby Scientific	Conductivity electrodes	465.60
2949-5	Quarry Industries Ltd	600 tonnes crushed rock	8,580.00
2950-8	D G Roebuck	Application of fertiliser	5,588.00
2951-6	Agtracts	Mowing of pasture	3,900.00
2952-4	A.A.E.C.	Drilling of bore holes	18,041.60
2953-2	Amdel	Analyses of Radium 226	3,000.00
2954-0	3M Australia	Lettering type faces & holder	380.18
2955-9	Hastings Deering Pty Ltd	Repairs to gen sets	796.60
2956-7	Carolin Removals Pty Ltd	Pick up & transport furniture & eqpt	1,250.00
2957-5	Specialised Engineering Services	'Propex' geotextile fabric	2,466.00
2958-3	Downard Pickfords	Transport car & household goods	3,386.00

Appendix E

Audio-Visual Records

TABLE E.1

PHOTOGRAPH CATALOGUE

NEGATIVES AND PROOF SHEETS

NO.	DESCRIPTION	DATE
1	Removal of Whites North & Whites O/B Heap Prior to Rehabilitation	MAY 83
2	Removal of Whites North & Placement at Toe of Whites Heap	MAY 83
3	Bitumising Road & Whites Open Cut Sampling	JUN 83
4	Whites North, Site Office & Whites Heap	JUN 83
5	Helicopter Flight	JUN 83
6	Removal of Whites North & Whites Heap	JUN 83
7	Whites Overburden Heap & Surrounds	SEP 83
8	Clearing Borrow Areas, 1st Clay Material on Whites Heap	SEP 83
9	Capping Whites Overburden Heap	OCT 83
10	Wet Season Rains, Surrounds of Whites Heap	OCT 83
11	Whites Overburden Heap, Start of Drop Structure	OCT 83
12	Helicopter Flight	DEC 83
13	Draining Dysons O/C, Whites Heap (1st Drains)	DEC 83
14	Whites Heap (Toe Drain), Causeway	DEC 83
15	Whites Heap & Aerials	DEC 83

NO.	DESCRIPTION	DATE
16	Draining Dysons O/C, Whites Heap	DEC 83
17	Draining Dysons O/C, Finniss River & Diversion	DEC 83
18	Whites Heap (1st Vegetation) & Causeway	JAN 84
19	Erosion on Whites Heap & Surrounds	JAN 84
20	Erosion on Whites Heap & Surrounds	FEB 84
21	Snake Creek & Erosion on Whites Heap	MAR 84
22	Concrete Bunkers	MAR 84
23	Draining the Tailings Dam	APR 84
24	Construction of the Water Treatment Plant	APR 84
25	Hay Mulching Whites Heap, Drop Structure, 1st Tailings in Dysons O/C, W.T.P.	APR/MAY 84
26	Whites Heap Batters & Drop Structure, W.T.P. Construction	MAY 84
27	Water Pipe, Batters of Whites Heap, W.T.P. Construction	MAY 84
28	Mud Waves in Dysons O/C, Whites Drop Structure, Tailings Dam	MAY 84
29	Batters Whites Heap (& Surrounds), Evaporation Ponds, Dysons O/C, Washdown Facilities	MAY 84
30	Lime Delivery, Acid & Sweetwater Dams, Drop Structure	MAY 84
31	Batters of Whites Heap, Aerials of Whites Heap & W.T.P.	MAY/JUN 84
32	Batters & Drains, Whites Heap	JUN 84
33	Tailings Dam	JUN 84
34	Tailings Dam (& "Spine" Rd), Whites Heap Batters	MAY 84
35	Tailings Dam, Dysons O/C ("Salts"), Whites O/B Heap, W.T.P. Primary Clarifier	JUN/JUL 84
36	W.T.P., Vehicle Washdown, Tailings Dam, Dysons Open Cut	JUL 84

NO.	DESCRIPTION	DATE
37	Batters of Whites Heap, Dysons O/C, Generators, Whites O/C	JUL 84
38	Dysons Open Cut	JUL 84
39	Dysons Open Cut & Tailings Dam	JUL 84
40	Whites Heap (& Batters), Dysons Open Cut	JUL 84
41	Tailings Dam & Dysons Open Cut	JUL 84
42	Vegetation on Whites Heap (& Surrounds), Tailings Dam	JUL 84
43	Tailings Dam & Dysons Open Cut	JUL 84
44	Dysons Open Cut & Tailings Dam	JUL 84
45	Helicopter Flight	AUG 84
46	Helicopter Flight	AUG 84
47	Helicopter Flight	AUG 84
48	Helicopter Flight	AUG 84
49	Tailings Dam, Dysons Open Cut & W.T.P.	AUG 84
50	Dysons O/C, W.T.P., Tailings Ck & Tailings Dam	AUG 84
51	Tailings Dam, Tailings Creek, Dysons O/C, Evaporation Ponds, Borrow Area	AUG 84
52	Intermediate O/B Heap, Tailings Dam	AUG 84
53	Dysons Open Cut	AUG 84
54	Dysons Open Cut	AUG 84
55	Tailings Dam, Dysons O/C, Treatment Plant Area	SEP 84
56	Removing Copper Heap, Dysons O/C, & Drains on Tailings Dam	SEP 84
57	Dysons O/C, Liming Tailings Dam, Tailings Creek	SEP 84
58	Liming Tailings Dam, Whites O/C, Dysons O/C	SEP 84
59	Dysons O/C, Removal of Copper Heap	SEP 84
60	Whites O/C, Tailings Dam, Dysons O/C, Removal of Copper Heap	SEP 84

NO.	DESCRIPTION	DATE
61	Helicopter Flight	SEP 84
62	Helicopter Flight	SEP 84
63	Dysons O/C, Tailings Dam, Whites O/C	SEP 84
64	Tailings Dam, Dysons O/C, Whites O/C	OCT 84
65	Tailings Dam, Removal of Copper Heap	OCT 84
66	Drains on the Tailings Dam & Dysons O/C	OCT 84
67	Removal of Copper Heap, Dysons O/C	OCT/NOV 84
68	Drains on Tailings Dam, Copper Heap Area, Dysons O/C	NOV 84
69	Tailings Dam & Tailings Creek	NOV 84
70	Gypsum Deposits in Water Treatment Plant	NOV 84
71	Cleaning W.T.P., Dysons O/C Drains and Drop Structure	NOV 84
72	Dysons O/C	NOV 84
73	Dysons O/C, Seeding Batters of Whites Heap, Aerials	DEC 84
74	Helicopter Flight by P Ryan	DEC 84
75	Dysons O/C (Hay Mulching, Cracking)	DEC 84
76	Dysons O/C, Borrow Area, Whites O/C, Tailings Dam	NOV/DEC 84
77	Dysons O/C, Tailings Dam	DEC 84
78	Dysons O/C, Tailings Dam, Tailings Creek	DEC 84
79	Gauging Station, Whites O/B Drop Structure	JAN 85
80	Peter Loveday's Farewell, Tailings Dam, Drilling Rig, W.T.P.	JAN 84
81	Helicopter Flight	FEB 85
82	Helicopter Flight	FEB 85
83	Whites O/B Heap - Drop Structure, Gauging Station, Batters	FEB 85

NO.	DESCRIPTION	DATE
84	Concrete Bunkers, Treatment Plant Area	FEB 85
85	W.T.P. (Gypsum Deposits), Surrounds of Whites & Intermediate Heaps	FEB 85
86	Batter Drains on Whites Heap, Rubble Drains at Copper Heap	FEB 85
87	Whites North, Surrounds of Whites Heap, Intermediate Heap	FEB 85
88	Drains & Drop Structure, Whites O/B, During Rain	MAR 85
89	Batter Drains, Whites O/B (& Surrounds), Dysons O/B, Dysons O/C	MAR 85
90	Batter Drains, Whites O/B, Treatment Area, Borrow Areas, Dysons O/C, Whites Nth, Haul Road	APR 85
91	C.H.L.P. Area, Whites O/B Drains, Tailings Dam Drains, W.T.P., Dysons Drop Structure	APR 84
92	Delivery of Hydrated Lime	APR 85
93	Whites Open Cut	APR 85
94	Helicopter Flight	MAY 85
95	Helicopter Flight	MAY 85
96	Liming Surrounds of Whites O/B, W.T.P., Drilling Rig, Tailings Dam, Whites O/B	MAY 85
97	Causeway, Dysons Overburden Heap	MAY 85
98	C.H.L.P., Dysons Drain, Intermediate O/B Heap	JUN 85
99	Dysons O/B, Dysons Drain	JUN 85
100	Dysons O/B	JUN 85
101	Intermediate O/B	JUN 85
102	Intermediate O/B - Testing O/B, Dysons O/B, Haul Road	JUN 85
103	Dysons O/B, C.H.L.P., Intermediate O/B	JUN 85
104	C.H.L.P., Borrow Area, Intermediate O/B	JUN 85

NO.	DESCRIPTION	DATE
105	Dysons O/B, Intermediate O/B, Testing O/B, Whites O/C Surrounds	JUN 85
106	Intermediate O/B	JUL 85
107	Intermediate O/B Environs, C.H.L.P., Borrow Pit 5, Testing	JUL 85
108	Intermediate O/B	JUL 85
109	B.P. 5, Old Treatment Plant, Dysons O/B	JUL 85
110	Bridge, Intermediate O/B	JUL 85
111	Borrow Pits, Dysons O/B, Bridge	JUL 85
112	Old Treatment Plant, Borrow Pits, Intermediate O/B	JUL/AUG 85
113	Old Treatment Plant, Intermediate O/B, Dysons O/B, Borrow Pits	AUG 85
114	Whites O/C, Sweetwater Dam, Gauging Station	AUG 84
115	Dysons O/B Drains, Old Treatment Plant, Whites North	AUG 85
116	Dysons O/B Drains, C.H.L.P., Intermediate O/B & Testing	AUG 85
117	Borrow Pits, Old Treatment Plant Area	AUG 85
118	Dysons O/B (Drains), Intermediate O/B and Surrounds, Old Treatment Plant	AUG 85
119	Dysons O/B, Intermediate O/B, C.H.L.P., Acid/Sweetwater Dams	AUG 85
120	Old Treatment Plant, Tailings Dam Regrowth	AUG 85
121	Old Treatment Plant, Intermediate O/B, C.H.L.P., Culverts	AUG/SEP 85
122	Culverts, Intermediate O/B, Borrow Areas	SEP 85
123	Culverts, Old Treatment Plant, Intermediate O/B	SEP 85
124	Helicopter Flight - Whole Site	OCT 85
125	Helicopter Flight (Lindsay Baird)	OCT 85
126	Helicopter Flight (Lindsay Baird)	OCT 85

NO.	DESCRIPTION	DATE
127	Dysons O/B, Intermediate O/B	OCT 85
128	Dysons O/C Settlement, Cover Material, Intermediate O/B	OCT 85
129	Cover Material, Intermediate O/B, Whites O/C, Old Treatment Plant	OCT 85
130	Tailings Dam, Dysons Drain, Intermediate O/C, Whites O/B Surrounds	OCT 85
131	Old Treatment Plant, Cover Material, Intermediate O/B, Culverts	OCT 85
132	Culverts, Old Treatment Plant, Intermediate O/B, C.H.L.P.	NOV 85
133	Culverts, C.H.L.P., Copper Ck, Intermediate O/B	NOV 85
134	Intermediate O/B, Cover Materials	NOV 85
135	Intermediate O/B, Dysons O/B	NOV 85
136	Culverts, Filter Cake at W.T.P., Dysons O/C, Dysons O/B	NOV 85
137	Dysons O/B, Borrow Pits, Culverts	NOV 85
138	Culverts, Dysons Open Cut	NOV 85
139	Intermediate O/B, Culverts	DEC 85
140	Culverts, Intermediate O/B, Whites O/C, Old Treatment Plant	DEC 85
141	Intermediate O/B, Old Treatment Plant, Weir	DEC 85
142	Weir, Dysons O/B, Culverts, Surrounds of Whites O/B	DEC 85
143	Dysons O/B, Dysons O/C, Acid Dam, Weir	DEC 85
144	Old Treatment Plant Area	JAN 86
145	Dysons Toe Drain, Culverts, Intermediate O/B Drain	JAN 86
146	Copper Creek, Weir	JAN 86
147	Culverts, Old Treatment Plant, Intermediate O/B	JAN 86
148	Dysons O/B, Old Treatment Plant, Intermediate O/B Drain	JAN 86

NO.	DESCRIPTION	DATE
149	Culverts, Copper Creek, Dysons O/B	JAN 86
150	Old Treatment Plant, Tailings Dam	JAN 86
151	Culverts, Whites O/C, Intermediate O/B, Whites O/B, Acid Dam, Whites North	JAN 86
152	Culverts, Copper Creek C.H.L.P., Tailings Dam, Whites Batters, Borrow Areas	JAN 86
153	Culverts, Weir, Old Treatment Plant, Dysons O/B	JAN 86
154	Acid Dam, Weir, Old Treatment Plant, C.H.L.P., Whites North, W.T.P., Tailings Dam	FEB 86
155	Dysons O/B, Old Treatment Plant, C.H.L.P., Whites Batters, Whites O/C	MAR 86
156	Helicopter Flight	APR 86
157	Helicopter Flight	APR 86
158	Helicopter Flight	APR 86
159	Helicopter Flight	APR 86

TABLE E.2

VIDEO CATALOGUE

NO.	DESCRIPTION	DATE
A	CHANNEL 8 VIDEO OF ENTIRE SITE (60 minute cassette)	15-2-84
B	RUM JUNGLE TAPE 1 (By Film Company)	1982
C	RUM JUNGLE TAPE 2 (By T Howard)	10-12-83
D	RUM JUNGLE TAPE 3 (By T Howard)	10-12-83
1	ROUGH EDIT - PRECONSTRUCTION & PROGRESS AT DECEMBER 1983	1982 & DEC 1983
2	TAILINGS DAM (First Tailings Being Removed), WHITES OVERBURDEN HEAP, CONSTRUCTION OF WATER TREATMENT PLANT, EVAPORATION PONDS	24-4-84 & 13-5-84
3	BORROW PIT NO. 6, WHITES OVERBURDEN HEAP	5-6-84
4	HELICOPTER FLIGHT (Covering Entire Mine Site)	5-6-84
5	HELICOPTER FLIGHT (Covering Entire Mine Site)	5-6-84
6	WHITES OVERBURDEN HEAP, TAILINGS DAM	8-6-84
7	TAILINGS DAM, DYSONS OPEN CUT	26-6-84
8	HAUL ROAD (Trucking Tailings) DYSONS OPEN CUT	9-7-84
9	TAILINGS DAM	19-7-84
10	HELICOPTER FLIGHT (Covering Entire Mine Site)	1-8-84
11	HELICOPTER FLIGHT & GROUND SHOTS - TAILINGS DAM, HAUL ROAD, DYSONS OPEN CUT	1-8-84
12	DYSONS OPEN CUT	8-9-84

NO.	DESCRIPTION	DATE
13	DYSONS OPEN CUT, COPPER HEAP LEACH PILE	11-9-84
14	RADIATION WORK, Tim Harrington	12-9-84
15	DYSONS OPEN CUT, POLLUTION IN NORTH-EASTERN SECTION OF MINE SITE, TAILINGS DAM	15-9-84 & 5-10-84
16	HELICOPTER FLIGHT (Covering Entire Mine Site)	26-9-84
17	COPPER HEAP LEACH PILE, HAUL ROAD, DYSONS OPEN CUT, BORROW PIT 5, TAILINGS DAM	11-9-84 & 9-11-84
18	TAILINGS DAM, DYSONS OPEN CUT, COPPER HEAP LEACH PILE	3-10-84 & 9-11-84
19	DYSONS OPEN CUT, BORROW AREA, TAILINGS DAM	OCTOBER 1984
20	OLD TREATMENT PLANT SITE, DYSONS OPEN CUT, DYSONS OVERBURDEN HEAP, WHITES OVERBURDEN, WHITES NORTH, WHITES SURROUNDS, WANDERING CREEK, BORROW PIT	26-2-85 & 14-3-85
21	HELICOPTER FLIGHT (Covering Entire Mine Site)	9-5-85
22	BORROW PIT, DRILLING RIG, WATER TREATMENT PLANT, WHITES NORTH	14-3-85 & 1-6-85
23	WHITES NORTH, DYSONS HEAP, INTERMEDIATE HEAP	1-6-85 & 5-6-85
24	INTERMEDIATE OVERBURDEN HEAP, DYSONS OVERBURDEN HEAP, WHITES NORTH, ACID & SWEETWATER DAMS	18-6-85
25	DYSONS OVERBURDEN HEAP, INTERMEDIATE OVERBURDEN HEAP	18-6-85 & 9-7-85
26	INTERMEDIATE OVERBURDEN HEAP, OLD TREATMENT PLANT SITE	9-7-85
27	RADIATION WORK, (Tim Harrington), WHITES OPEN CUT, OLD TREATMENT PLANT, INTERMEDIATE HEAP, DYSONS HEAP	6-8-85
28	DYSONS HEAP, INTERMEDIATE HEAP, COPPER HEAP LEACH PILE, OLD TREATMENT PLANT	20-8-85
29	HELICOPTER FLIGHT (Covering Entire Mine Site)	1-10-85
30	INTERMEDIATE HEAP, DYSONS HEAP	16-10-85
31	ALL AREAS OF MINE SITE - GROUND SHOTS	18-3-86
32	HELICOPTER FLIGHT (Covering Entire Mine Site)	14-4-86

Appendix F

Drawing Register

TABLE F.1

DRAWING NO.	SHEET NO.	DESCRIPTION	DRAWN BY	DATE
W83/4001		RUM JUNGLE MINE SITE - PROPOSED PERIMETER FENCE	R.R.H.	10/83
W83/4002		RUM JUNGLE MINE SITE - STOCK FENCE	R.R.H.	10/83
W83/4003		RUM JUNGLE REHABILITATION PROJECT - UPGRADE DORMITORY 2	R.R.H.	11/83
W83/4004		RUM JUNGLE REHABILITATION - STAGE 2, WHITES OVERBURDEN HEAP	Cameron McNamara	5/83
	1	Locality Map, Locality Plan and Schedule of Associated Drawings		
	2	Site Plan		
	3	Setting Out, Levelling and Drainage Plan		
	4	Typical Cross Sections		
	5	Berm Drainage Take-off, Energy Dissipator, Grated Pit and Collar Joint Details		
	6	Berm Longitudinal Section and Drain Junction Details		
	7	Drop Structures D1, D2 and D3		
	8	Earthworks - Sections 280 - 300		
	9	Earthworks - Sections 320 - 340		
	10	Earthworks - Sections 360 - 380		

DRAWING NO.	SHEET NO.	DESCRIPTION	DRAWN BY	DATE
W83/4004 cont'd		RUM JUNGLE REHABILITATION - STAGE 2, WHITES OVERBURDEN HEAP	Cameron McNamara	5/83
	11	Earthworks - Sections 400 - 420		
	12	Earthworks - Sections 440 - 460		
	13	Earthworks - Sections 480 - 500		
	14	Earthworks - Sections 520 - 540		
	15	Earthworks - Sections 560 - 580		
	16	Earthworks - Sections 600 - 620		
	17	Earthworks - Sections 640 - 660		
	18	Earthworks - Sections 680 - 700		
	19	Earthworks - Sections 720 - 740		
	20	Earthworks - Sections 760 - 780		
	21	Earthworks - Sections 800 - 820		
	22	Revegetation - Layout of Techniques		
	23	Revegetation - Cross Sections and Plan Views		

DRAWING NO.	SHEET NO.	DESCRIPTION	DRAWN BY	DATE
W83/4005		RUM JUNGLE REHABILITATION - STAGE 3	Cameron McNamara	4/84
	1	Locality Map, Locality Plan and Schedule of Drawings		
	2	Site Plan		
	3	Setting Out, Levelling and Drainage Plan - Sheet 1 of 2) Tailings		
	4	Setting Out, Levelling and Drainage Plan - Sheet 2 of 2) Dam		
	5	Tailings Creek - Plan and Extent of Work		
	6	Tailings Dam & Tailings Creek - Typical Cross Sections & Detail		
	7	Copper Heap Leach Pile - Setting Out, Levelling & Drainage Plan		
	8	Copper Heap Leach Pile & Copper Creek - Typical Cross Sections and Copper Creek Long Section		
	9	Dysons Open Cut - Setting Out, Levelling and Drainage Plan		
	10	Dysons Open Cut - Typical Cross Sections and Details		
	11	Dysons Open Cut - Drain 3 Long Section & Drop Structures D1 and D2 Details		
	12	Tailings Dam - Cross Sections 717 020 to 717 060		
	13	Tailings Dam - Cross Sections 717 080 to 717 120		
	14	Tailings Dam - Cross Sections 717 140 to 717 180		

DRAWING NO.	SHEET NO.	DESCRIPTION	DRAWN BY	DATE
W83/4005 cont'd		RUM JUNGLE REHABILITATION - STAGE 3	Cameron McNamara	4/84
	15	Tailings Dam - Cross Sections 717 200 to 717 240		
	16	Tailings Dam - Cross Sections 717 260 to 717 300		
	17	Tailings Dam - Cross Sections 717 320 to 717 360		
	18	Tailings Dam - Cross Sections 717 380 to 717 420		
	19	Tailings Dam - Cross Sections 717 440 to 717 480		
	20	Tailings Dam - Cross Sections 717 500 - 717 540		
	21	Tailings Dam - Cross Sections 717 560 to 717 600		
	22	Tailings Dam - Cross Sections 717 620 to 717 660		
	23	Tailings Dam - Cross Sections 717 680 to 717 720		
	24	Tailings Dam - Cross Sections 717 740 to 717 780		
	25	Tailings Dam - Cross Sections 717 800 to 717 840		
	26	Tailings Dam - Cross Sections 717 860 to 717 900		
	27	Copper Heap Leach Pile - Cross Sections 717 140 to 717 240		
	28	Copper Heap Leach Pile - Cross Sections 717 260 to 717 300		
	29	Copper Heap Leach Pile - Cross Sections 717 320 to 717 360		

DRAWING NO.	SHEET NO.	DESCRIPTION	DRAWN BY	DATE
W83/4005 cont'd		RUM JUNGLE REHABILITATION - STAGE 3	Cameron McNamara	4/84
	30	Copper Heap Leach Pile - Cross Sections 717 380 to 717 420		
	31	Copper Heap Leach Pile - Cross Sections 717 440 to 717 480		
	32	Copper Heap Leach Pile - Cross Sections 717 500 to 717 540		
	33	Dysons Open Cut - Cross Sections 718 460 to 718 520		
	34	Dysons Open Cut - Cross Sections 718 540 to 718 600		
	35	Dysons Open Cut - Cross Sections 718 620 to 718 680		
	36	Dysons Open Cut - Cross Sections 718 700 to 718 760		
	37	Dysons Open Cut - Cross Sections 718 780 to 718 840		
	38	Dysons Open Cut - Cross Sections 718 860 to 718 920		
	39	Dysons Open Cut - Cross Sections 718 940		
	40	Tailings Dam - Revegetation - Layout of Techniques Sheet 1 of 2		
	41	Tailings Dam - Revegetation - Layout of Techniques Sheet 2 of 2		
	42	Dysons Open Cut - Revegetation - Layout of Techniques		
	43	Tailings Dam & Dysons Open Cut - Revegetation, Cross Section and Plan Views		

E.S.

DRAWING NO.	SHEET NO.	DESCRIPTION	DRAWN BY	DATE
W83/4006		WATER TREATMENT PLANT	M.P.E.S.	
	1	Treatment Plant - Layout Plan		1/84
	2	Treatment Plant - Elevations		1/84
	3	Lime Storage & Mixing Building - Plan & Elevations		1/84
	4	Project and Construction Schedule		1/84
	5	Civil Details (Sheet 1)		12/83
	6	Civil Details (Sheet 2)		12/83
	7	Primary Clarifier Foundation - Arrangement & Details		12/83
	8	Lime Storage & Mixing Building Foundations & Slabs - Details		12/83
	9	Site Works		12/83
	10	Access Ways to Primary & Secondary Clarifiers and Filter Surge Tanks - Details		1/84
	11	Access Ways to Primary Clarifier & Underflow Tanks - Details		1/84
	12	Access Ways to Lime Holding & Neutralising Tanks - Details		1/84
	13	Lime Storage & Mixing Building Steelwork - Plans & Elevations		1/84
	14	Lime Storage & Mixing Building Steelwork - Details - Sheet 1		1/84
	15	Lime Storage & Mixing Building Steelwork - Details - Sheet 2		1/84

DRAWING NO.	SHEET NO.	DESCRIPTION	DRAWN BY	DATE
W83/4006 cont'd		WATER TREATMENT PLANT	M.P.E.S.	
	16	Filtrate Building - Roof Plan and Elevations		1/84
	17	Filtrate Building - Floor Plan and Details		1/84
	18	Filtrate Building - Steelwork Details - Sheet 1		1/84
	19	Conveyor Structural G.A. and Details - Sheet 1		1/84
	20	Conveyor Structural G.A. and Details - Sheet 2		1/84
	21	Site Plan		12/83
	22	Filtrate Building - Control Room - Plan, Elevations & Details		1/84
	23	Structural Design Standard Stairways		1/84
	24	Structural Design Standard Handrailing		1/84
	25	Secondary Clarifier Tank Support Details		1/84
	26	Electrical Distribution - Single Line Diagram		1/84
	27	Lime Plant Cable Equipment & Lighting Layout (Plan)		2/84
	28	Main Plant Control Panel - Schematic Diagram		1/84
	29	Main Plant Control Panel - Layout & Termination Diagram		1/84
	30	Lime Plant Control Panel - Schematic/Termination Diagram & Layout		1/84

DRAWING NO.	SHEET NO.	DESCRIPTION	DRAWN BY	DATE
W83/4006 cont'd		WATER TREATMENT PLANT	M.P.E.S.	
	31	Main Plant Cable Equipment & Lighting Layout (Elevations)		2/84
	32	Main Plant Cable Equipment & Lighting Layout (Plan)		2/84
	33	Cable Schedule Sheet 1 of 2		2/84
	34	Cable Schedule Sheet 2 of 2		2/84
	35	Instrumentation & Miscellaneous Termination Diagrams		1/84
	36	Underground Feeder Reticulation		2/84
	37	Lightning Protection - Main Plant & Lime Plant		3/84
	38	Lime Holding Tank Details		1/84
	39	Primary Clarifier Tank 20m Diameter - Arrangement & Details		1/84
	40	Primary Clarifier - Underflow Tank Detail		12/83
	41	Neutralising Tanks No. 1 & 2 - Arrangement & Details		1/84
	42	Lime Storage & Mixing - Mechanical Arrangement & Details		1/84
	43	Lime Discharge Chamber Details		1/84
	44	Lime Mixing Tank - Arrangement & Details		1/84
	45	Pontoon Arrangement & Details		1/84

DRAWING NO.	SHEET NO.	DESCRIPTION	DRAWN BY	DATE
W83/4006 cont'd		WATER TREATMENT PLANT	M.P.E.S.	1/84
	46	Filter Cake Stacking Conveyor Arrangement		1/84
	47	Filter Cake Stacking Conveyor - Head End Arrangement		1/84
	48	Filter Cake Stacking Conveyor - Tail End Arrangement		1/84
	49	Filter Cake Transfer Conveyor - Arrangement		1/84
	50	Filter Cake Transfer Conveyor - Details		1/84
	51	Conveyor Details		1/84
	52	Mobile Weir Box - Arrangement & Details		1/84
	53	Filter Surge Tank - Arrangement & Details		1/84
	54	Filter Press Mechanical Arrangement & Details		1/84
	55	Filter Press Details		
	56	Site Piping Plan		
	57	Filtrate Building Piping Plan		
	58	Filtrate Building Piping Sections - Sheet 1		
	59	Lime Mixing Building Piping Plan		
	60	Whites Open Cut Suction & Discharge Piping Arrangement & Detail		

DRAWING NO.	SHEET NO.	DESCRIPTION	DRAWN BY	DATE
W83/4006 cont'd		WATER TREATMENT PLANT	M.P.E.S.	1/84
	61	Raw Water Pump Base & Suction Bell Details		
	62	Standard Pipe Support Details		
	63	Filtrate building & Piping Sections - Sheet 2		
	64	Piping & Instrumentation Diagram		
	66	Standard Process & Piping Symbols		
	67	Arrangement of Lime Surge Bin & Metering System	Thomas Robinson	1/84
	68	Chamber Filter Press (Netzsch) 1500 square - General Arrangement	Gebr Netzsch	1/84
	69	Agitator (Lightning) - Model NLDG-300	T & W	1/84
	70	Agitator (Lightning) - Model LQ-1500	T & W	1/84
	71	Agitator (Lightning) - Model NLDG-300	T & W	1/84
	72	Agitator (Lightning) - Model NLDG-300	T & W	1/84
	73	Primary Clarifier - General Arrangement	Boby & Co	1/84
	74	5.5m Diameter High Rate Thickener - General Arrangement	Larox P/L	1/84
	75	Goulds 3196 x LT Pump	) Blakers	1/84
	76	Aquastream AM 25 A Pump	) &) Thompson	1/84

DRAWING NO.	SHEET NO.	DESCRIPTION	DRAWN BY	DATE
W83/4006 cont'd		WATER TREATMENT PLANT	M.P.E.S.	1/84
	77	Aquastream AM 30 A Pump	) Blakers & Thompson	1/84
	78	Ebara 100 DV 57.5 Submersible	)	1/84
	79	Ebara 125 DVB 515 Submersible	)	1/84
	80	Seepex 62-500/17 6L 710.4 Pumps - General Arrangement	Prominant	1/84
	81	Flocculant Mixing & Holding Tanks	Transcon	1/84
	82-97	Electrical Diagrams - Pumps	Netzsch	2/84
	98	Peripheral Drive Clarifier - Electrical Wiring	Boby & Co	2/84
	99	Sewage Clarifier - Peripheral Drive - Wiring Diagram	Boby & Co	2/84
W83/4007		RISING MAIN, BORES 1, 2, 4 TO TANK	Anne Wheatley	11/83
W83/4008		HYDRANT AT BORE 2	Anne Wheatley	12/83
W84/4009		UPGRADING ACCOMMODATION UNITS 4 & 8	Anne Wheatley	1/84
W84/4010		UPGRADING TRANSPORTABLE HOME	Anne Wheatley	1/84
W84/4011		MINOR CLEAN UP - NORTH EASTERN AREA	Anne Wheatley	1/84
W84/4012	1	MONITORING PROGRAMME - SITES OF MONITORING POINTS	Anne Wheatley	1/84
	2	Enlargement of Fenced Area (Mine Site)	Anne Wheatley	1/84

DRAWING NO.	SHEET NO.	DESCRIPTION	DRAWN BY	DATE
W84/4013		REVEGETATION OF WHITES OVERBURDEN HEAP		
	1	Locality Map, Locality Plan & Schedule of Associated Drawings	Anne Wheatley	2/84
	2	Site plan	Anne Wheatley	2/84
	3	Revegetation - Layout of Techniques	Anne Wheatley	2/84
	4	Revegetation - Cross Sections & Plan Views	Anne Wheatley	2/84
W84/4014		(Rehabilitation Stage 3) VEHICLE WASHDOWN & ABLUTION FACILITIES	))) Cameron) McNamara)))	
	1	Locality Plan, Site Plan & Schedule of Drawings		2/84
	2	Site Plan & Vehicle Washdown Facility		2/84
	3	Ablution Facilities		2/84
W84/4015		WORK STATUS - Whites Overburden Heap - as of 17/2/84	Anne Wheatley	2/84
W84/4016	1	PROPOSED CAUSEWAY - Locality & Site Plans	Anne Wheatley	3/84
	2	PROPOSED CAUSEWAY - Plan, Elevation & Cross Section	Anne Wheatley	3/84
W84/4017		COMPLETION OF STAGE 2 - WHITES OVERBURDEN HEAP	Cameron McNamara	4/84
	1	Locality Map, Locality Plan & Schedule of Drawings		
	2	Site Plan		
	3	Setting Out, Levelling & Drainage Plan		

DRAWING NO.	SHEET NO.	DESCRIPTION	DRAWN BY	DATE
W84/4017 cont'd		COMPLETION OF STAGE 2 - WHITES OVERBURDEN HEAP	Cameron McNamara	4/84
	4	Extent of Work		
	5	Typical Cross Sections		
	6	Berm Drainage Off-Take, Energy Dissipator, Grated Pit & Collar Joint Details		
	7	Berm Longitudinal Section & Drain Junction Details		
	8	Drop Structure D1		
	9	Earthworks - Sections 280 to 300		
	10	Earthworks - Sections 320 to 340		
	11	Earthworks - Sections 360 to 380		
	12	Earthworks - Sections 400 to 420		
	13	Earthworks - Sections 440 to 460		
	14	Earthworks - Sections 480 to 500		
	15	Earthworks - Sections 520 to 540		
	16	Earthworks - Sections 560 to 580		
	17	Earthworks - Sections 600 to 620		

DRAWING NO.	SHEET NO.	DESCRIPTION	DRAWN BY	DATE
W84/4017 cont'd		COMPLETION OF STAGE 2 - WHITES OVERBURDEN HEAP	Cameron McNamara	4/84
	18	Earthworks - Sections 640 to 660		
	19	Earthworks - Sections 680 to 700		
	20	Earthworks - Sections 720 to 740		
	21	Earthworks - Sections 760 to 780		
	22	Earthworks - Sections 800 to 820		
	23	Revegetation - Layout of Techniques		
	24	Revegetation - Cross Sections & Plan Views		
W84/4018		PIPELINE - TANK TO LIME STORAGE BUILDING	Anne Wheatley	3/84
W84/4019		EQUIPPING OF BORE R.N. 22548	Anne Wheatley	3/84
W84/4020		BORROW PIT NO. 5 (Eastern Side) as at 20th March 1984	Anne Wheatley	3/84
W84/2021	1	FILTER CAKE DISPOSAL AREA - Locality Plan	Anne Wheatley	4/84
	2	FILTER CAKE DISPOSAL AREA - Showing Inspection Pits	Anne Wheatley	4/84
W84/4022		BENCH MARKS	Anne Wheatley	4/84
W84/4023		WHITES OVERBURDEN HEAP - Completion of Stage 2	Anne Wheatley	5/84
W84/4024		MINE SITE - FINAL CLEAN UP FOR STAGE 4	Anne Wheatley	5/84

DRAWING NO.	SHEET NO.	DESCRIPTION	DRAWN BY	DATE
W84/4025		PROPOSED BORROW AREA 6 - Plan for Mines Dept for Extract Licence	Anne Wheatley	5/84
W84/4026		PROJECT NOTICE BOARD - Thiess Contractors Stage III & II	Anne Wheatley	6/84
W84/4027		LOCALITY & SITE PLAN (1:20,000) OF MINE SITE (Overview Report, Fig 1)	Anne Wheatley	7/84
W84/4028	1 & 2	TYPICAL OVERBURDEN HEAP - TYPICAL CROSS SECTIONS (Overview Report, Fig 2)	Anne Wheatley	7/84
W84/4029		DYSONS OPEN CUT - TYPICAL CROSS SECTIONS (Overview Report, Fig 3)	Anne Wheatley	7/84
W84/4030		SCHEMATIC ARRANGEMENT WITH THE WATER TREATMENT PLANT (Overview Report, Fig 4)	Anne Wheatley	7/84
W84/4031		SEASONAL VARIATION IN THE COPPER LOAD CARRIED BY THE EAST BRANCH 1973-74	Anne Wheatley	7/84
W84/4032		REDUCTION WHITES OVERBURDEN HEAP - DESIGN DRAWING (W83/4017 3 of 24)	Anne Wheatley	8/84
W84/4033	1-13	RUM JUNGLE SPECIAL SERIES 1:1,000	Pike & Ptners	8/84
W84/4034	1	UPGRADING OF GRAVEL ROADS TO GAUGING STATIONS & CULVERT	Anne Wheatley	9/84
W84/4035	1	UPGRADING HAUL ROADS - Site Plan	Anne Wheatley	10/84
	2	PLAN & LONGITUDINAL SECTION - HAUL ROAD TO BORROW PIT 5	Anne Wheatley	10/84
	3	PLAN & LONGITUDINAL SECTION - HAUL ROAD TO BORROW PIT 5	Anne Wheatley	10/84
	4	PLAN & LONGITUDINAL SECTION - WATER TREATMENT PLANT ROAD	Anne Wheatley	10/84

DRAWING NO.	SHEET NO.	DESCRIPTION	DRAWN BY	DATE
W84/4036		MINE SITE - SITE OFFICES - DETAIL PLAN	Anne Wheatley	10/84
W84/4037	1	REHABILITATION MONITORING GAUGING STATION FOR WHITES O/B HEAP - Site & Locality Plans	G.H. & D.	11/84
	2	REHABILITATION MONITORING GAUGING STATION FOR WHITES O/B HEAP - Control Weir Details	G.H. & D.	11/84
	3	REHABILITATION MONITORING GAUGING STATION FOR WHITES O/B HEAP - Instrument Housing Station Details	G.H. & D.	11/84
W84/4038		PROPOSED BORROW AREA 7 - Plans for Mines Deptartment for Extract Licence	Anne Wheatley	10/84
W84/4039	2	Copper Heap Leach Pile - Site & Locality Plans, (levels & - Levels Taken After Completion of Works 15/11/84 (contours)	Anne Wheatley	11/84
W84/4040		WATER TREATMENT PLANT - DRAINAGE PLAN as at 1/11/84	Anne Wheatley	11/84
W84/4041		DYSONS OPEN CUT - DETAIL OF EASTERN DRAINS	Anne Wheatley	12/84
W84/4042		RUM JUNGLE REHABILITATION - STAGE 4.1	Cameron McNamara	12/84
	1	Locality Plan & Schedule of Drawings		
	2	Site Plan		
	3	Intermediate Heap - Setting Out, Levelling & Drainage Plan		
	4	Intermediate Heap - Details of Drains 7, 8 & 9		

DRAWING NO.	SHEET NO.	DESCRIPTION	DRAWN BY	DATE
W84/4042 cont'd		RUM JUNGLE REHABILITATION - STAGE 4.1	Cameron McNamara	12/84
	5	Intermediate Heap - Typical Section & Detail		
	6	Dysons Heap - Setting Out, Levelling & Drainage Plan		
	7	Dysons Heap - Drainage Sections & Details		
	8	Dysons Heap - Typical Sections & Details		
	9	Whites North Heap/Acid & Sweetwater Dams/Explosives Magazines - Extent of Work & Typical Sections		
	10	Borrow Pit 3 - Extent of Earthworks & Drainage		
	11	Old Treatment Plant/Old Stockpile Areas - Setting Out, Levelling & Drainage Plan		
	12	Old Treatment Plant/Old Stockpile Areas - Typical Sections & Details		
	13	Intermediate Heap & Whites Heap Environs - Extent of Work/Typical Detail		
	14	Intermediate Heap - Earthworks Sections E 717140 - E717160 - N8562700		
	15	Intermediate Heap - Earthworks Section E 717180		
	16	Intermediate Heap - Earthworks Section E 717200		
	17	Intermediate Heap - Earthworks Section E 717220		

DRAWING NO.	SHEET NO.	DESCRIPTION	DRAWN BY	DATE
W84/4042 cont'd		RUM JUNGLE REHABILITATION - STAGE 4.1	Cameron McNamara	12/84
	18	Intermediate Heap - Earthworks Section E 717240		
	19	Intermediate Heap - Earthworks Section E 717260		
	20	Intermediate Heap - Earthworks Section E 717280		
	21	Intermediate Heap - Earthworks Section E 717300		
	22	Intermediate Heap - Earthworks Section E 717320		
	23	Intermediate Heap - Earthworks Section E 717340		
	24	Intermediate Heap - Earthworks Section E 717360		
	25	Intermediate Heap - Earthworks Sections E 717380 - E 717400		
	26	Dysons Heap - Earthworks Section E 718960		
	27	Dysons Heap - Earthworks Sections E 718980, E 719000		
	28	Dysons Heap - Earthworks Sections E 719020, E 719040		
	29	Dysons Heap - Earthworks Sections E 719060, E 719080		
	30	Dysons Heap - Earthworks Sections E 719100, E 719120		
	31	Dysons Heap - Earthworks Sections E 719140, E 719160		
	32	Dysons Heap - Earthworks Sections E 719180, E 719200		

DRAWING NO.	SHEET NO.	DESCRIPTION	DRAWN BY	DATE
W84/4042 cont'd		RUM JUNGLE REHABILITATION - STAGE 4.1	Cameron McNamara	12/84
	33	Dysons Heap - Earthworks Section E 719220		
	34	Intermediate Heap - Revegetation Layout		
	35	Dysons Heap - Revegetation Layout		
	36	Whites North Heap/Acid & Sweetwater Dams/Explosives Magazines - Revegetation Layout		
	37	Borrow Pit 3 - Revegetation Layout		
	38	Old Treatment Plant/Old Stockpile Area - Revegetation Layout		
	39	Intermediate & Whites Heap Environs - Revegetation Layout		
	40	Revegetation - Typical Details		
W85/4043		OLD COPPER HEAP LEACH PILE AREA - PROPOSED RIPPING	Anne Wheatley	2/85
W85/4044		RUM JUNGLE MINE SITE - (Showing Sections & Mining Lease Boundaries)	Anne Wheatley	3/85
W85/4045	1	TAILINGS DAM - Final Levels After Rehabilitation Works (20m grid)	Anne Wheatley	3/85
	2	TAILINGS DAM - Final Levels After Rehabilitation Works (20m grid)	Anne Wheatley	3/85

DRAWING NO.	SHEET NO.	DESCRIPTION	DRAWN BY	DATE
W85/4046	1	TAILINGS DAM - Final Contours After Rehabilitation Works (½ m interval)	Anne Wheatley	3/85
W85/4047		STAGE 4.1 - TYPICAL 1200 X 450 R.C.B.C. DETAILS	Cameron McNamara	3/85
W85/4048	1	TAILINGS CREEK	Anne Wheatley	4/85
	2	TAILINGS DAM - Prior to Rehabilitation (Showing Monitoring Points)	Anne Wheatley	4/85
	3	TAILINGS DAM - After Rehabilitation (Showing Monitoring Points)	Anne Wheatley	4/85
	4 & 5	GAMMA DOSE RATES - Pre and Post Rehabilitation	Anne Wheatley	4/85
W85/4049		RUM JUNGLE REHABILITATION STAGE 4.2	Cameron McNamara	6/85
	1	Locality Plan & Schedule of Drawings		
	2	Site Plan		
	3	Whites Open Cut/Ablution, Washdown Facilities Area		
	4	Intermediate Open Cut/Copper Leach Area/Whites Open Cut		
	5	Whites Open Cut/Whites North Area/Sweetwater Dam		
	6	Intermediate Open Cut/Copper Leach Area		
	7	Borrow Pit 5		
	8	Whites & Intermediate Open Cuts/Hydraulic Structures		

DRAWING NO.	SHEET NO.	DESCRIPTION	DRAWN BY	DATE
W85/4049 cont'd		RUM JUNGLE REHABILITATION STAGE 4.2	Cameron McNamara	6/85
	9	Typical Sections & Details		
	10	Hydraulic Structure Details		
	11	Hydraulic Structure Details		
	12	Copper Leach Area - Revegetation		
	13	Copper Leach Area - Revegetation		
	14	Whites Open Cut Environs Revegetation		
	15	Whites Open Cut/East Finniss River Revegetation		
	16	Intermediate Open Cut Environs Revegetation		
	17	Borrow Area 5		
W85/4050	1	Tim Harrington's Final Report - R.J.T.D. All Personal Samples	Anne Wheatley	5/85
	2	Tim Harrington's Final Report - R.J.T.D. D6 "Swamp" Bulldozer	Anne Wheatley	5/85
	3	Tim Harrington's Final Report - R.J.T.D. All "Open" Samples	Anne Wheatley	5/85
	4	Tim Harrington's Final Report - RJTD All "Respirable" Samples	Anne Wheatley	5/85
	5	Tim Harrington's Final Report - Dysons Open Cut All "Spotters" "Open" Samples	Anne Wheatley	5/85

DRAWING NO.	SHEET NO.	DESCRIPTION	DRAWN BY	DATE
W85/4051		PROPOSED BORROW AREA - Plan for Mines for Extract Licence	Anne Wheatley	6/85
W85/4052		THIESS CONTRACTORS, Stages 4.1 & $.2 - PROGRAMME CHART	Anne Wheatley	6/85
W85/4053		DYSONS OVERBURDEN HEAP - Earthworks Levels taken 6/6/85	Anne Wheatley	6/85
W85/4054		DYSONS OVERBURDEN HEAP - New Design for Erosion Control Drains	Anne Wheatley	7/85
W85/4055		DYSONS OVERBURDEN HEAP - Final Earthworks Contours 18/6/85	Anne Wheatley	6/85
W85/4056	14 sh.	DYSONS OPEN CUT - Detail Survey (Dept. Lands)	Dept. Lands	7/85
W85/4057		INTERMEDIATE OVERBURDEN HEAP - Earthworks Levels taken 25/7/85	Anne Wheatley	8/85
W85/4058		INTERMEDIATE OVERBURDEN HEAP - Final Surface Levels taken 26/8	Anne Wheatley	9/85
W85/4059		INTERMEDIATE OVERBURDEN HEAP - Revised Design for Erosion Control Drains	Anne Wheatley	9/85
W85/4060		BORROW PIT 5 - Detail Survey (Dept. of Lands)	Dept. Lands	9/85
W85/4061		BORROW PIT 5 - Contour Plan 1:1000	Anne Wheatley	10/85
W85/4062	1	GROUNDWATER LEVELS - Dry Season 31/10/84 Deep Aquifer	Anne Wheatley	10/85
	2	GROUNDWATER LEVELS - Wet Season 25/3/85 Shallow Aquifer	Anne Wheatley	10/85
	3	GROUNDWATER LEVELS - Wet Season 25/3/85 Deep Aquifer	Anne Wheatley	10/85
W85/4063	3 sh.	PROPOSED REHABILITATION OF FILTER CAKE DISPOSAL SITES & Sheet 3 STOCK FENCE	Anne Wheatley	10/85

DRAWING NO.	SHEET NO.	DESCRIPTION	DRAWN BY	DATE
W86/4064	1	DYSONS OPEN CUT - CROSS SECTION COMPARISONS - of Main Drain	Anne Wheatley	1/86
	2	DYSONS OPEN CUT - CROSS SECTION COMPARISONS - 1 to 12	Anne Wheatley	1/86
	3	DYSONS OPEN CUT - CROSS SECTION COMPARISONS - 2 to 11	Anne Wheatley	1/86
	4	DYSONS OPEN CUT - CROSS SECTION COMPARISONS - 3 to 10	Anne Wheatley	1/86
	5	DYSONS OPEN CUT - CROSS SECTION COMPARISONS - 4 to 9	Anne Wheatley	1/86
	6	DYSONS OPEN CUT - CROSS SECTION COMPARISONS - 5 to 8, 6 to 7	Anne Wheatley	1/86
W86/4065	8 sh.	GROUNDWATER CONTOURS - for Monitoring Report, by R Salama	Anne Wheatley	1/86
W86/4066		CURRENT BORROW AREAS - November 1985	Anne Wheatley	11/85
W86/4067		GAUGING STATIONS - for Monitoring Report, by R Salama	Anne Wheatley	1/86
W86/4068		INTERMEDIATE OVERBURDEN HEAP - Final Survey Plan	Dept. Lands	1/86
W86/4069		DYSONS OVERBURDEN HEAP - Final Survey Plan	Dept. Lands	1/86
W86/4070		COPPER HEAP LEACH PILE AREA - Final Survey Plan	Dept. Lands	1/86
W86/4071		COPPER HEAP LEACH PILE AREA - Lands Computer Survey	Dept. Lands	1/86
W86/4072		DYSONS OVERBURDEN HEAP - Lands Computer Survey	Dept. Lands	1/86
W86/4073		INTERMEDIATE OVERBURDEN HEAP - Lands Computer Survey	Dept. Lands	7/85 8/85 1/86

DRAWING NO.	SHEET NO.	DESCRIPTION	DRAWN BY	DATE
W86/4074		TAILINGS DAM - Computer Sketches	Anne Wheatley	2/86
W86/4075	12 sh.	INTERMEDIATE HEAP - Final Survey Long Sections	Anne Wheatley	2/86
W86/4076	1	WHITES OVERBURDEN HEAP - DRAIN LONG SECTIONS - Drains A, Al & B	Anne Wheatley	3/86
	2	WHITES OVERBURDEN HEAP - DRAIN LONG SECTION - Drain C	Anne Wheatley	3/86
W86/4077		LOCALITY & SITE PLAN - FOR MINOR WORKS - BORROW PIT 5 & SURROUNDS OF WHITES OPEN CUT	Anne Wheatley	3/86
W86/4078		PROPOSED DROP STRUCTURE AT INTERMEDIATE OVERBURDEN HEAP	Anne Wheatley	3/86
W86/4079		RUM JUNGLE - SITE PLAN AFTER COMPLETION OF REHABILITATION	Anne Wheatley	4/86
W86/4080	7 sh.	GRAPHS FOR PETER RYAN'S REPORT	Anne Wheatley	4/86
W86/4081		SITE PLAN - Location of Demountables & Buildings	Anne Wheatley	4/86
W86/4082		SITE & LOCALITY PLAN - Location of Power Generation System & 2 Bores	Anne Wheatley	4/86
W86/4083	2	SWITCHBOARD DETAILS - W.T.P. Generators (for Tender Documents)	Powerlite	3/84
W86/4084	13	TAILINGS DAM - CROSS-SECTIONS - FINAL SURVEY	QASCO	10/84
W86/4085	12	INTERMEDIATE HEAP CROSS-SECTIONS - Final Surface Levels, SURVEY 26-8-85	Anne Wheatley	8/85
W86/4086	8	DYSONS HEAP CROSS-SECTIONS - Final Surface Levels, SURVEY 18-6-85	Anne Wheatley	6/85

DRAWING NO.	SHEET NO.	DESCRIPTION	DRAWN BY	DATE
W86/4087	5	COPPER HEAP LEACH PILE CROSS-SECTIONS - Surface Levels, SURVEY 15-11-84	Anne Wheatley	11/84
W86/4088	15	WHITES HEAP CROSS-SECTIONS - Surface Levels, SURVEY 29-9-84	QASCO	9/84
W86/4089	1	DYSONS OPEN CUT - Earthworks Interim Measure Up	Brazier & Motti	8/84
	2	TAILINGS DAM - Earthworks Interim Measure Up		
	3	TAILINGS DAM - Earthworks Interim Measure Up		
W86/4090		VEHICLE WASHDOWN AREA - Services Plan	P.J.O'D.	5/85
W86/4091	2	INTERMEDIATE OVERBURDEN HEAP - Typical Sections	M.P.E.S.	Undated
W86/4092	6	DYSONS OVERBURDEN HEAP - Typical Sections	M.P.E.S.	Undated
W86/4093	16	DYSONS HEAP - Generated Sections	Associated Surveys	Undated
W86/4094	9	WHITES OVERBURDEN HEAP - Generated Sections		
W86/4095	7	Overburden Heap Reductions (Dysons O/B, Whites O/B, Intermediate O/B, C.H.L.P., Dysons O/C)	Assorted	Assorted
W86/4096		RUM JUNGLE - SITE PLAN PRIOR TO REHABILITATION	Anne Wheatley	3/86
W86/4097	1	DYSONS OPEN CUT - After Completion of Rehabilitation	Anne Wheatley	4/86
	2	INTERMEDIATE OVERBURDEN HEAP - Prior to Rehabilitation	Anne Wheatley	4/86
	3	INTERMEDIATE OVERBURDEN HEAP - After Compl. of Rehabilitation	Anne Wheatley	4/86

DRAWING NO.	SHEET NO.	DESCRIPTION	DRAWN BY	DATE
W86/4097 cont'd	4	WHITES OVERBURDEN HEAP - After Completion of Rehabilitation	Anne Wheatley	4/86
	5	DYSONS OVERBURDEN HEAP - Prior to Rehabilitation	Anne Wheatley	4/86
	6	DYSONS OVERBURDEN HEAP - After Completion of Rehabilitation	Anne Wheatley	4/86
	7	OLD TAILINGS DAM - Prior to Rehabilitation	Anne Wheatley	4/86
	8	OLD TAILINGS DAM - After Completion of Rehabilitation	Anne Wheatley	4/86
W86/4098		WATER TREATMENT PLANT - General Arrangement	Anne Wheatley	4/86
W86/4099		TREATMENT OF INTERMEDIATE OPEN CUT	Anne Wheatley	4/86
W86/4100		REDIVERSION OF THE EAST BRANCH OF THE FINNISS RIVER	Anne Wheatley	4/86
W86/4101	1	C.H.L.P. Area - Prior to Rehabilitation	Anne Wheatley	6/86
	2	C.H.L.P. Area - After Completion of Rehabilitation	Anne Wheatley	6/86

TABLE F.2

BASE PLANS, CHARTS, SCHEDULES & LANDS PLANS REGISTER

DRAWING NO.	SHEET NO.	DESCRIPTION	DRAWN BY	DATE
1		SIGNS - Site Office	Anne Wheatley	6/83
2		SIGNS - Project	Anne Wheatley	6/83
3		EXPENDITURE CHART	R.R.H.	7/83
4		1:5,000 LANDS MAP 2.4	Dept. Lands	
5		1:500 PHOTO CONTROL - Whites North Overburden Heap	Dept. Lands	
6	1	1:1,000 PHOTO CONTROL - Sheet 1	Dept. Lands	
7	2	1:1,000 PHOTO CONTROL - Sheet 2	Dept. Lands	
8		1:500 RUM JUNGLE SPECIAL - Sheet 1	Dept. Lands	
9	1	1:1,000 RUM JUNGLE SPECIAL - Sheet 1	Dept. Lands	
10	2	1:1,000 RUM JUNGLE SPECIAL - Sheet 2	Dept. Lands	
11		1:5,000 LANDS BASE PLAN (Reduction of 1:2,500)	Dept. Lands	
12		M.P.E.S. 4 YEAR PROGRAMME CHART	M.P.E.S.	6/83
13		M.P.E.S. 4 YEAR PROGRAMME CHART - Revised 4/8/83	M.P.E.S.	8/83
14		4 YEAR PROGRAMME BASE CHART	R.R.H.	
15		MONTHLY REPORT COVERS	Anne Wheatley	12/83

DRAWING NO.	SHEET NO.	DESCRIPTION	DRAWN BY	DATE
16		PROJECT SCHEDULE BASE CHART	R.R.H.	
17		PROJECT SCHEDULES Dec 83, Feb 84, Oct 84, Jun 85	Anne Wheatley	12/83 2/84 10/84
18		M.P.E.S. CHART - Reduction of Water Treatment Plant Schedule	M.P.E.S.	2/84
19		PROJECT SCHEDULES - (Manila Envelope) - INDIVIDUAL PROJECTS	Anne Wheatley	1/84
20		1:5,000 BASE PLAN - MINE SITE	Anne Wheatley	12/83
21		1:12,500 BASE PLAN - MINE SITE	Anne Wheatley	12/83
22		1:20,000 BASE PLAN - MINE SITE	Anne Wheatley	12/83
23		PROJECT MANAGER'S REPORT COVERS	Anne Wheatley	3/84
24		MONITORING PROGRAMME & STRATEGY - REPORT COVERS	Anne Wheatley	3/84
25	18 sh.	BORE HYDROGRAPHS - Environmental Section	Anne Wheatley	3/84
26	7 sh.	CONSTANT DISCHARGE TESTS - Environmental Section	Anne Wheatley	3/84
27	42 sh.	WATER QUALITY DATA PLOTS - Environmental Section	Anne Wheatley	3/84
28		PROFORMA for BORE HYDROGRAPHS (Environmental Section) (Dr No 25)	Anne Wheatley	3/84
29		PROFORMA for WATER QUALITY DATA PLOTS (Env. Section) (Dr No 27)	Anne Wheatley	3/84
30		(REDUCTION) THIESS CONSTRUCTION PROGRAMME (Stage 3 & Completion of Stage 2)	Thiess	3/84

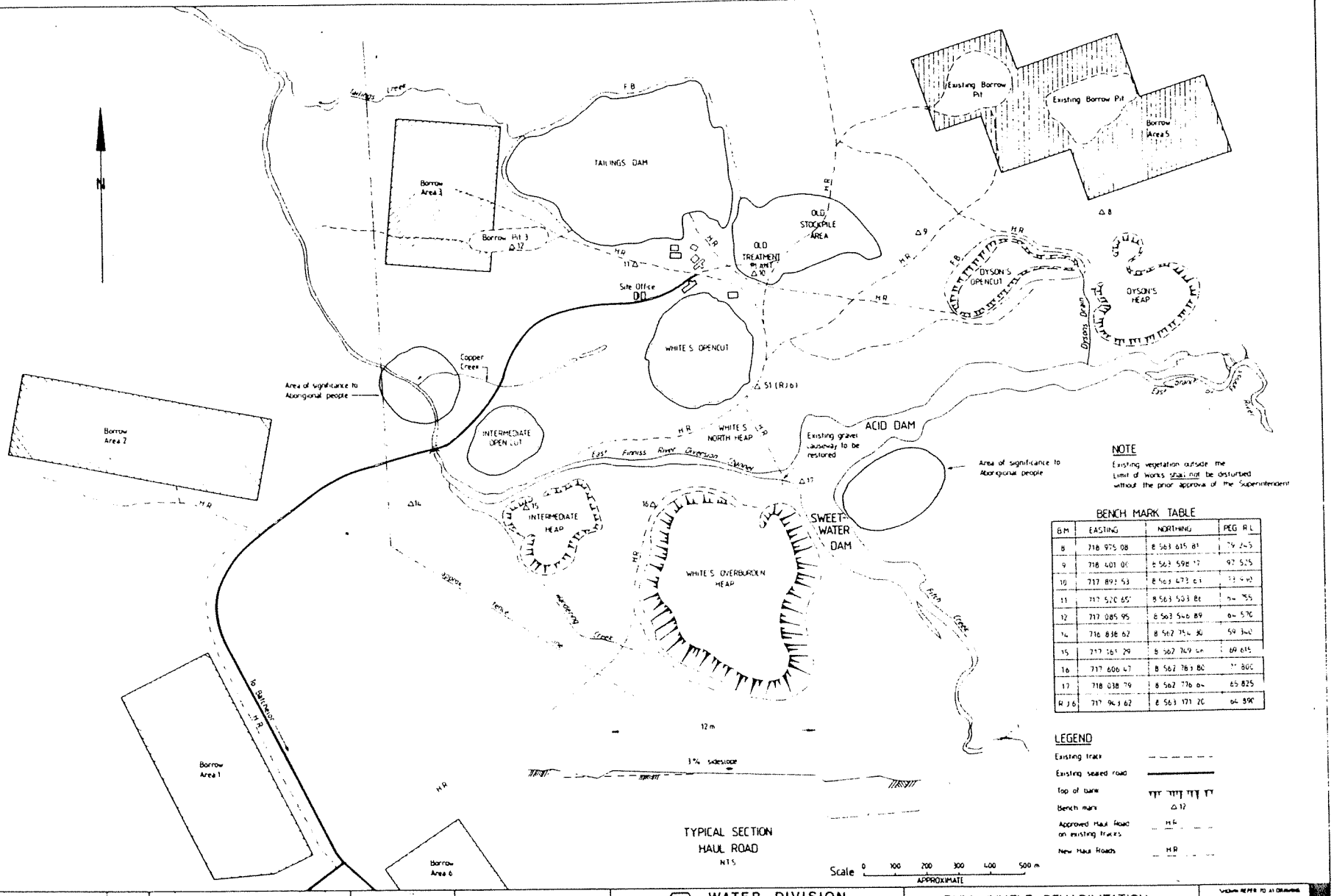
DRAWING NO.	SHEET NO.	DESCRIPTION	DRAWN BY	DATE
31		ENVIRONMENTAL MONITORING ACTIVITIES - Chart	Anne Wheatley	5/84
32		PROFORMA for CASH FLOW CHART - (Revised 22/3/84)	Anne Wheatley	5/84
33		PROFORMA for ".... 1984 REVIEW: ESTIMATES OF EXPENDITURE at .... 1984 LEVELS"	Anne Wheatley	5/84
34	19 sh.	May 1984 Review - ESTIMATES of EXPENDITURE	Anne Wheatley	5/84
35		COVERS - QUARTERLY STATEMENTS & COST ESCALATION	Anne Wheatley	6/84
36		PROPOSED FLOOR PLAN - 2nd Floor, Sasco House	Anne Wheatley	2/84
37		MINE SITE SHOWING BORROW AREAS (May Monthly Report - Fig. 1)	Anne Wheatley	6/84
38		WORK ON TAILINGS DAM (May Monthly Report - Fig. 2)	Anne Wheatley	6/84
39		BATCHELOR - Aerial Photo with SEWERAGE RETICULATION	Dept. Lands	8/75
40		DISPLAY BOARD & PROJECT SHEET ORIGINALS	Anne Wheatley	6/84
41		REPORT COVER "A Technical Overview" P F Loveday - August 1984	Anne Wheatley	8/84
42		1984/85 EXPENDITURE CHART	Anne Wheatley	8/84
43		SUPPLY OF HYDRATED LIME, RUM JUNGLE (Contract TW 28 of 83/84)	Anne Wheatley	9/84
44		IMPACT OF ESCALATION FORMULA - (Based upon Preliminary & Final Indices)	Anne Wheatley	9/84
45		WATER TREATMENT PLANT - WEEKLY PERFORMANCE SUMMARY	Anne Wheatley	9/84
46		WATER TREATMENT PLANT - Weekly & Cumulative Figures for Performance Summary Chart	Anne Wheatley	10/84

DRAWING NO.	SHEET NO.	DESCRIPTION	DRAWN BY	DATE
47		WATER DIVISION MONITORING CHART (September 1984)	Anne Wheatley	9/84
48		REPORT COVER - (September 1984)	Anne Wheatley	9/84
49		REPORT COVER - Project Manager's Report to Liaison Committee - October 1984	Anne Wheatley	9/84
50		IMPACT OF ESCALATION FORMULA - Base Rate & Award Rate	Anne Wheatley	10/84
51		POSTER - R.J.R.P. PROJECT SHEET - ORIGINAL ARTWORK	Anne Wheatley	10/84
52		WATER TREATMENT PLANT - TREATED WATER COMPARISON (per 1000m^3 of Treated Water Produced)	Anne Wheatley	11/84
53		WATER TREATMENT PLANT - OPERATING COSTS	Anne Wheatley	3/85
54		WATER TREATMENT PLANT - OPERATING COST SUMMARY	Anne Wheatley	3/85
55		GRAPHICS FOR SLIDES	Anne Wheatley	5/85
56		1982 TO 1986 EXPENDITURE CHART	Anne Wheatley	6/85
57		1985/1986 EXPENDITURE CHART	Anne Wheatley	8/85
58		WHITES OPEN CUT - Treatment Summary	Anne Wheatley	9/85
59		WHITES OPEN CUT - Graph of Treated Water Depth	Anne Wheatley	9/85
60		1:10,000 BASE MAP	Anne Wheatley	11/85
61	3 sh.	DARWIN REGIONAL - Uncontrolled Aerial Photo Mosaic - 1:50,00	Dept. Lands	7/78
62		FLOOR PLAN - MINERALS HOUSE	Anne Wheatley	1/86

DRAWING NO.	SHEET NO.	DESCRIPTION	DRAWN BY	DATE
63		BATCHELOR - Augmentation of Water Supply & Sewerage Services - Site Plan	T & W	5/80
64		BATCHELOR - Sewer Reticulation Compilation Plan	T & W	1971
65		BATCHELOR - Plan of Town, 1:2500	T & W	-
66		BATCHELOR - Zoning Map	Dept. Lands	8/82
67		FINNISS RIVER LAND CLAIM	Dept. Lands	1979
68		PART SECTION 2890 - ROAD & POWERLINE EASEMENT	Dept. Lands	9/72
69		HUNDRED OF GOYDER - COUNTY OF PALMERSTON	Dept. Lands	4/74
70		LANDS PLAN OF RUM JUNGLE AREA	Dept. Lands	8/53
71		1982/1986 EXPENDITURE - Comparison - Actual & Estimated (Jun 82)	Anne Wheatley	5/86
72		PROPOSED PROJECT SCHEDULE	Anne Wheatley	5/86
73		ACTUAL PROJECT SCHEDULE	Anne Wheatley	5/86

Appendix G

Arrangement Drawings



NOTE

Existing vegetation outside the Limit of Works shall not be disturbed without the prior approval of the Superintendent

BENCH MARK TABLE

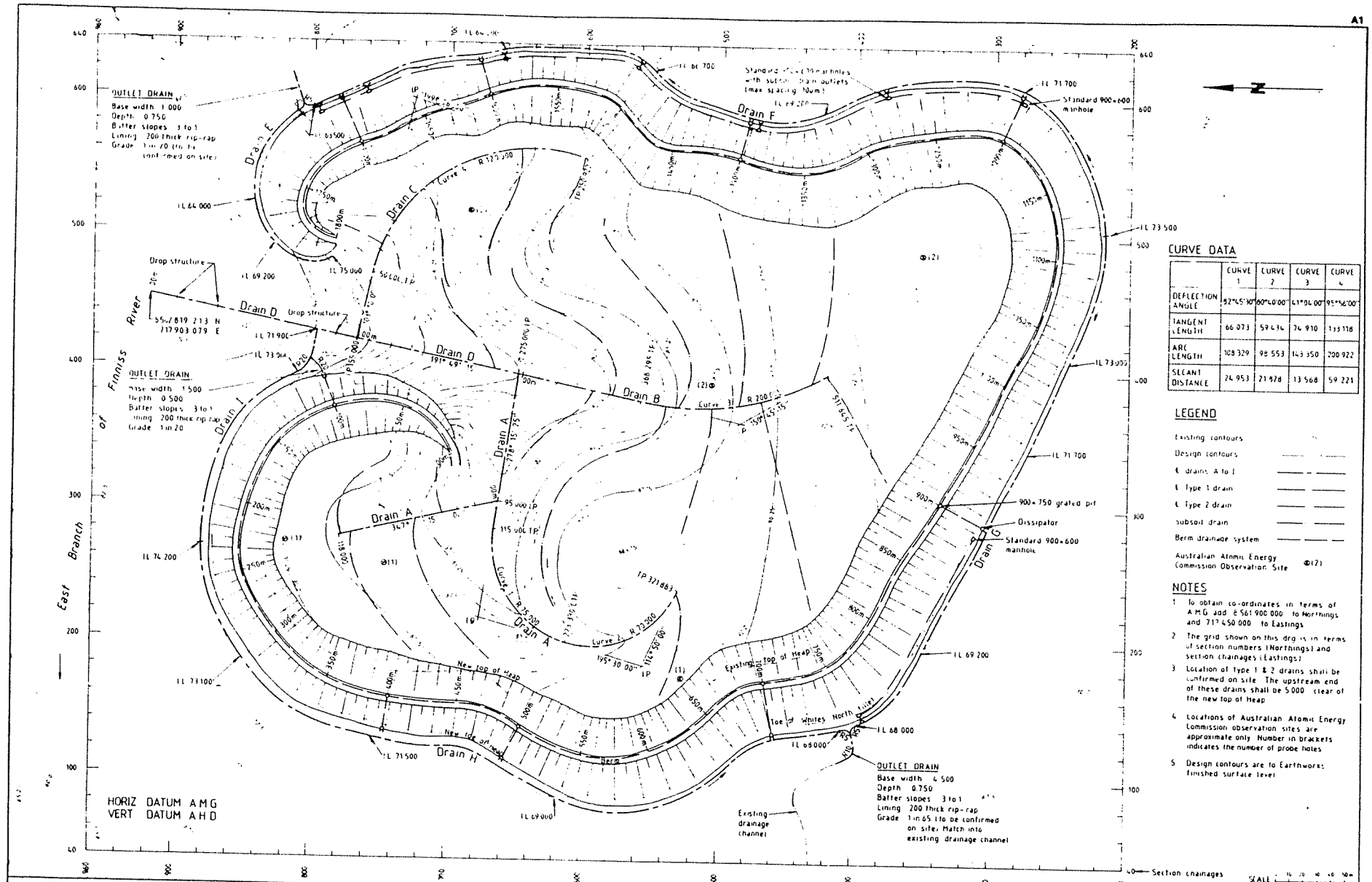
B.M	EASTING	NORTHING	PEG R.L
8	718 975 08	8 563 615 81	79 245
9	718 401 01	8 563 598 12	92 525
10	717 892 53	8 563 673 61	73 493
11	717 520 65	8 563 503 86	64 755
12	717 085 95	8 563 546 89	64 570
14	716 838 62	8 562 754 30	59 340
15	717 161 29	8 562 749 [illegible]	69 615
16	717 606 47	8 562 783 80	[illegible] 800
17	718 038 79	8 562 776 04	65 825
R J 6	717 943 62	8 563 171 20	64 890

LEGEND

Existing track
Existing sealed road
Top of bank
Bench mark △12
Approved Haul Road on existing tracks H.R.
New Haul Roads H.R.

			Cameron McNamara	WATER DIVISION DEPARTMENT OF TRANSPORT AND WORKS	RUM JUNGLE REHABILITATION STAGE 4 1 SITE PLAN
			84-4511	60932	W 85-4042 SHEET 2 OF 40 SHEETS

A1



CURVE DATA

	CURVE 1	CURVE 2	CURVE 3	CURVE 4
DEFLECTION ANGLE	92°45'30"	60°40'00"	41°04'00"	95°56'00"
TANGENT LENGTH	66 073	59 434	74 910	133 118
ARC LENGTH	108 329	98 553	143 350	200 922
SECANT DISTANCE	74 953	71 928	13 568	59 221

LEGEND

- Existing contours
- Design contours
- ℄ drains A to I
- ℄ Type 1 drain
- ℄ Type 2 drain
- subsoil drain
- Berm drainage system
- Australian Atomic Energy Commission Observation Site (12)

NOTES

1. To obtain co-ordinates in terms of AMG add E 561 900 000 to Northings and 717 450 000 to Eastings
2. The grid shown on this drg is in terms of section numbers (Northings) and section chainages (Eastings)
3. Location of Type 1 & 2 drains shall be confirmed on site The upstream end of these drains shall be 5 000 clear of the new top of heap
4. Locations of Australian Atomic Energy Commission observation sites are approximate only Number in brackets indicates the number of probe holes
5. Design contours are to Earthworks finished surface level

40 Section chainages
200 Section numbers

SCALE 1:5000 at A1

1	EARTHWORKS FINISHED SURFACE CONTOURS RAISED 0 250 BATTERS	5.81	JW
	AMENDED OUTLET DRAIN ADDED AT BERM CH 100m		

AMENDMENTS — AS-SHOWN ENCLOSURES

IN ASSOCIATION WITH
Dames & Moore
AND
Meehan Burgess & Yeates

Cameron McNamara

82-6029	60426	

NORTHERN TERRITORY OF AUSTRALIA
DEPARTMENT OF TRANSPORT AND WORKS

DESIGNED	JW
DRAWN	TR
CHECKED	IHB
PROJECT ENGINEER	
EXECUTIVE ENGINEER	
CHIEF ENGINEER	

TITLE
DARWIN – RUM JUNGLE REHABILITATION - STAGE 2
WHITES OVERBURDEN HEAP
SETTING OUT LEVELLING AND DRAINAGE PLAN

SHEET No.	CODE	SCALE	
3 of 23		DATE	
DRAWING No. DRR-1371		1	A1

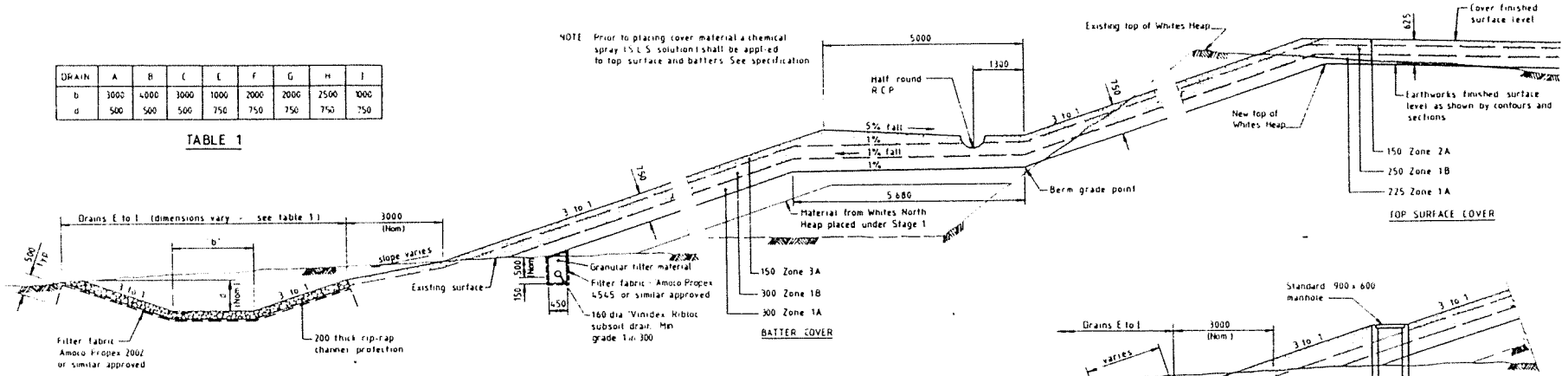
W83/400

A1

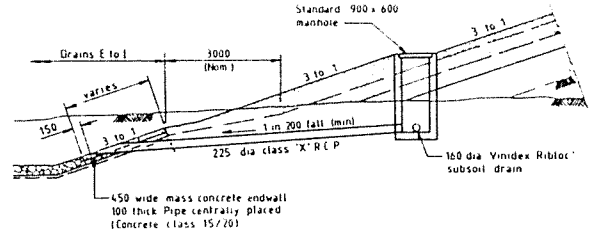
DRAIN	A	B	C	E	F	G	H	I
b	3000	4000	3000	1000	2000	2000	2500	1000
d	500	500	500	750	750	750	750	750

TABLE 1

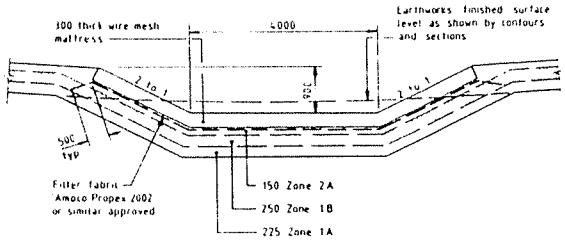
NOTE Prior to placing cover material a chemical spray (5% S.S. solution) shall be applied to top surface and batters. See specification



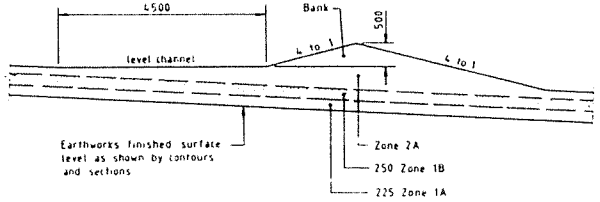
TYPICAL CROSS SECTION



SUBSOIL DRAIN OUTLET



TYPICAL CROSS SECTION DRAIN D

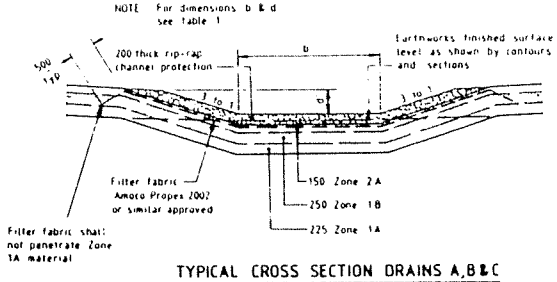


TYPE 1 DRAIN

TOTAL LENGTH OF DRAIN	GRADES			EROSION CONTROL FABRIC
	0m to 20m	20m to 40m	40m to end	
0m to 80m	1.5%	1.0%	1.0%	Refer drg
greater than 80m	2.0%	1.5%	1.0%	R83-1391

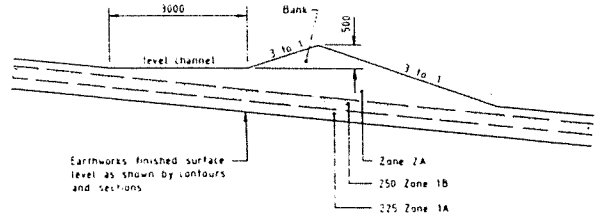
TABLE 2

NOTE All lengths of drains are measured upstream from junctions (from end of rip rap lining)

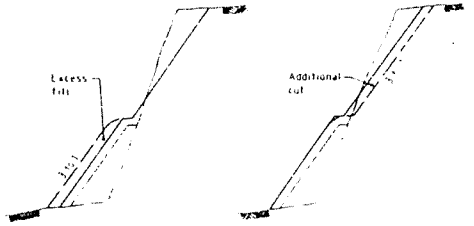


TYPICAL CROSS SECTION DRAINS A,B & C

NOTE For details of grading and lining of types 1 & 2 drains see table 2



TYPE 2 DRAIN



EXCESS OF FILL SHORTAGE OF FILL

TREATMENT FOR IMBALANCE OF EARTHWORKS

NTS SCALE

IN ASSOCIATION WITH
Damas & Moore
SPL
AND
Meehan Burgess & Yeates

Cameron McNamara

82-6029 | 60427

NORTHERN TERRITORY OF AUSTRALIA
DEPARTMENT OF TRANSPORT AND WORKS
DESIGNED JW
DRAWN TA
CHECKED JHB
EXECUTIVE ENGINEER

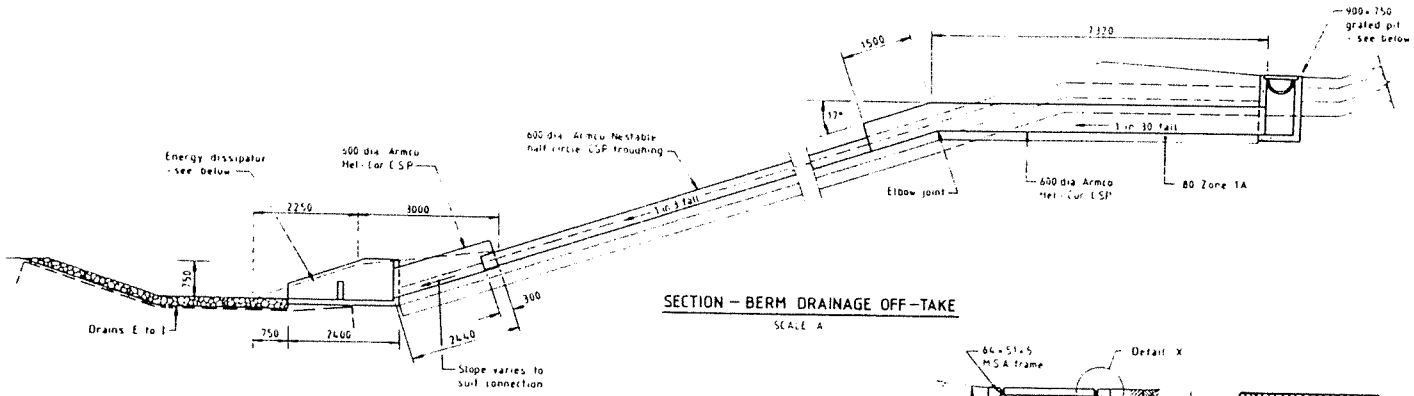
DARWIN - RUM JUNGLE REHABILITATION - STAGE 2
WHITES OVERBURDEN HEAP
TYPICAL CROSS SECTIONS

SHEET 4 of 23

DRAWING No R83-1372 A1

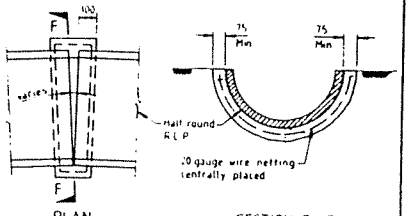
W83/4004

A1



SECTION – BERM DRAINAGE OFF-TAKE

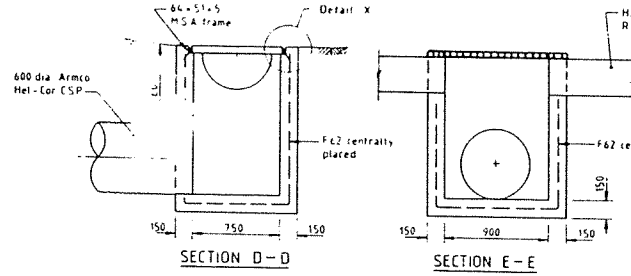
SCALE A



COLLAR JOINT DETAIL

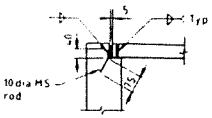
NTS

NOTE Collar joints shall be constructed where berm radius requires greater than 35mm deflection per 2440 pipe length 450 to 600 dia half round pipe joints shall be similar.



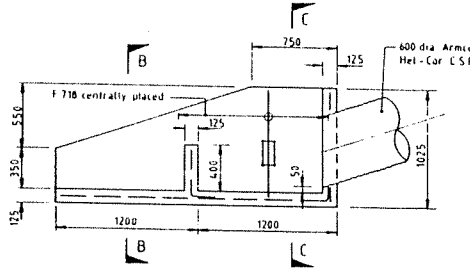
SECTION D-D

SECTION E-E

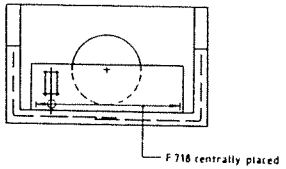


DETAIL 'X'

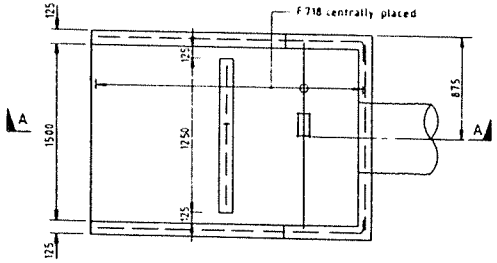
SCALE C



SECTIONAL ELEVATION A-A



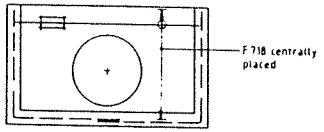
SECTION B-B



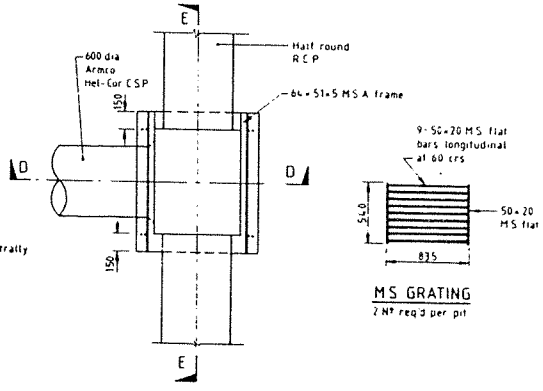
PLAN

ENERGY DISSIPATOR

SCALE B



SECTION C-C



PLAN

M S GRATING

2 Nº req'd per pit

900 x 750 GRATED PIT

SCALE B

NOTES

1. This drawing shall be read in conjunction with drg RB3 - 1372
2. Concrete shall comply with A S 1480 grade 25/20 shall be used with maximum slump of 80mm
3. Minimum cover to reinforcement shall be 50mm
4. Welded mesh reinforcement shall comply with A S 1304. Laps shall not be less than one complete mesh plus 25mm
5. Steelwork shall comply with A S 1250
6. Welds shall comply with A S 1554 part 1. All welds shall be 5mm continuous fillet welds unless otherwise shown. Butt welds shall be "Prequalified Incomplete Penetration" butt welds
7. Area beneath slabs on ground shall be cleared of all organic matter
8. All Corrugated Steel Pipe shall have 2.5mm wall thickness

SCALE C 0 0.5 1.0 1.5 2.0 2.5 m

SCALE B 0 1.0 2.0 m

SCALE A 0 0.5 1.0 1.5 2.0 2.5 m

IN ASSOCIATION WITH

Dames & Moore

AND

Meehan Burgess & Yeates

Cameron McNamara

82-6029

Drawing no 60428

NORTHERN TERRITORY OF AUSTRALIA

DEPARTMENT OF TRANSPORT AND WORKS

DESIGNED JW/MW

DRAWN TR

CHECKED JHB

PROJECT ENGINEER

EXECUTIVE ENGINEER

DIRECTOR

DARWIN – RUM JUNGLE REHABILITATION - STAGE 2

WHITES OVERBURDEN HEAP

BERM DRAINAGE OFF-TAKE ENERGY DISSIPATOR, GRATED PIT & COLLAR JOINT DETAILS

SHEET No 5 of 23

CODE

SCALE

DATE

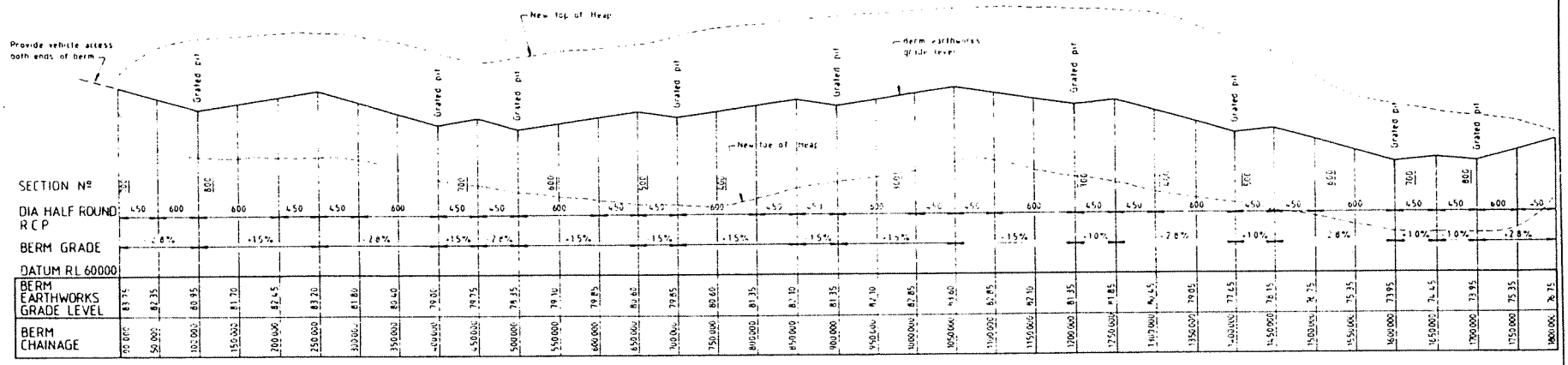
DRAWING No RB3-1373

REVISION

A1

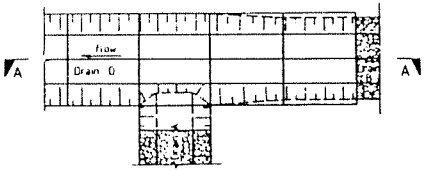
3740

A1

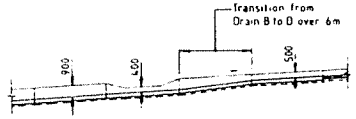


BERM LONGITUDINAL SECTION

SCALE



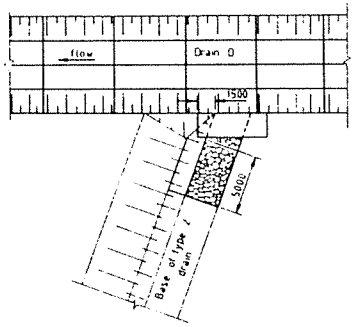
PLAN



SECTION A–A

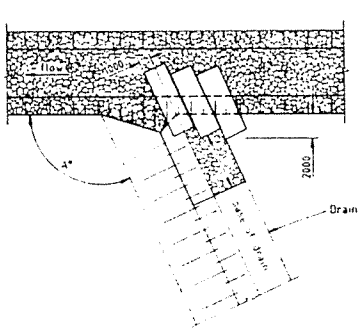
DRAIN JUNCTION A–D

SCALE

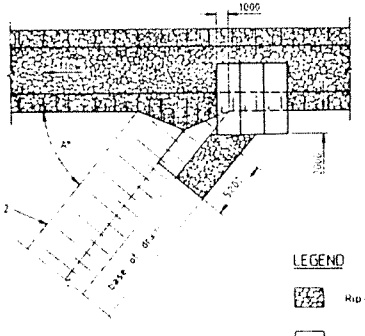


DRAIN JUNCTION – TYPE 2 WITH D

SCALE



A° GREATER THAN 90°



A° LESS THAN 90°

LEGEND

Rip-rap 200 thick

wire mesh mattresses

TYPICAL DRAIN JUNCTIONS – TYPE 1 OR 2 WITH A, B OR C

NTS

NOTES

1 Wire mesh mattresses shall be PVC coated and 6000 × 2000 × 300 unless otherwise shown
2 The contractor shall supply and locate mattresses as per specification
3 For placement of erosion control fabric see drg R83 - 1391

SECTION Nº 5 ADDED TO BERM LONGITUDINAL SECTION		IN ASSOCIATION WITH Dames & Moore AND Meehan Burgess & Yeates	Cameron McNamara	82–6029	60429	NORTHERN TERRITORY OF AUSTRALIA DEPARTMENT OF TRANSPORT AND WORKS	DARWIN – RUM JUNGLE REHABILITATION - STAGE 2 WHITES OVERBURDEN HEAP BERM LONGITUDINAL SECTION AND DRAIN JUNCTION DETAILS

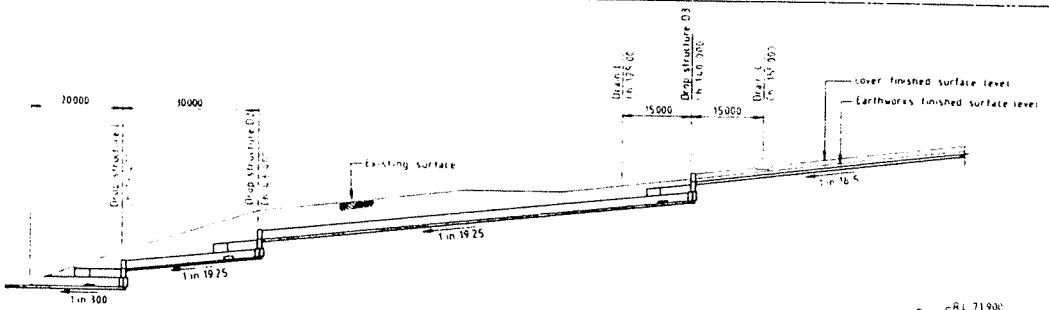
DESIGNED JW/DR · DRAWN TR · CHECKED JHB · PROJECT ENGINEER · EXECUTIVE ENGINEER · CHIEF DESIGN ENGINEER

SHEET No 6 of 23 · CODE · SCALE · DATE · FILE

DRAWING No R83-1374 · ISSUING 1 · A1

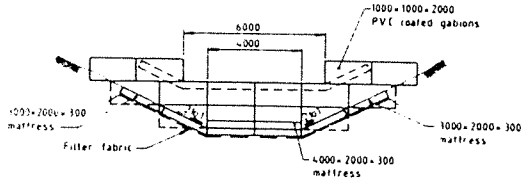
W83/4004

A1

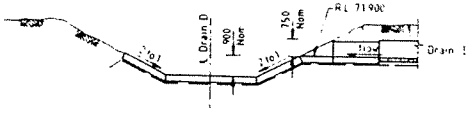


PART DRAIN D LONGITUDINAL SECTION

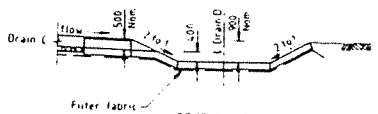
SCALE



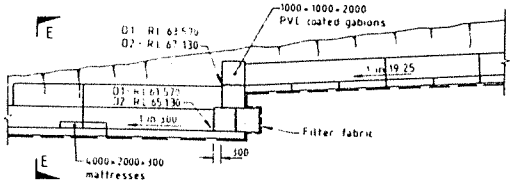
SECTION E-E



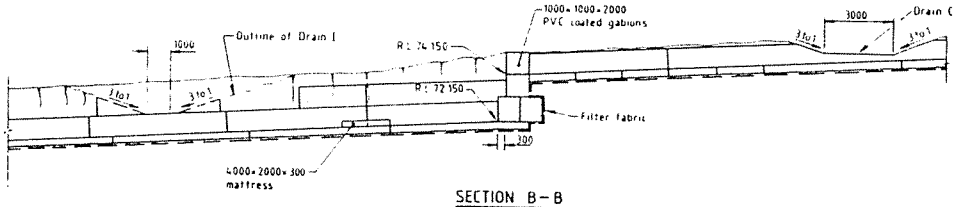
SECTION C-C



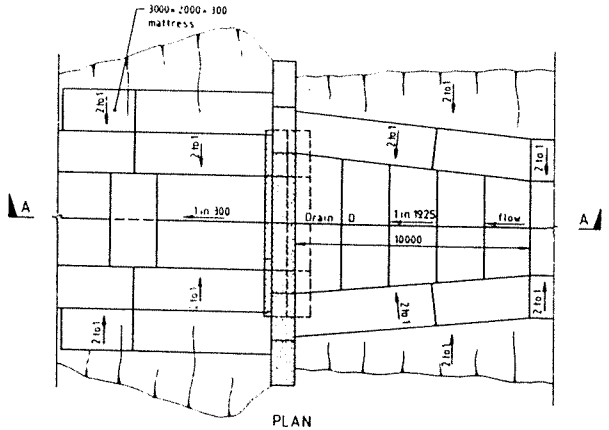
SECTION D-D



SECTION A-A



SECTION B-B

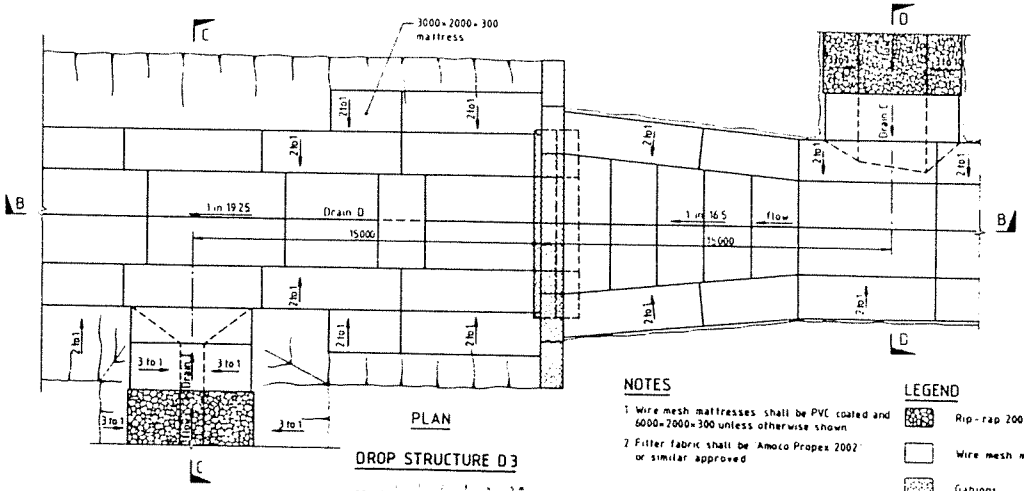


PLAN

DROP STRUCTURE D1

(Drop structure D2 similar)

SCALE



PLAN

DROP STRUCTURE D3

SCALE

NOTES

1 Wire mesh mattresses shall be PVC coated and 6000 x 2000 x 300 unless otherwise shown

2 Filter fabric shall be Amoco Propex 2002 or similar approved

LEGEND

Rip-rap 200 thick

Wire mesh mattresses

Gabions

1	D1 - D3 REGRADED				
	AMENDMENTS				

IN ASSOCIATION WITH

Dames & Moore

AND

Meehan Burgess & Yeates

Cameron McNamara

	82-6029	60430

NORTHERN TERRITORY OF AUSTRALIA
DEPARTMENT OF TRANSPORT AND WORKS

DESIGNER	M W	PROJECT ENGINEER	
DRAWN	T R	EXECUTIVE ENGINEER	
CHECKED	H B	CHIEF ENGINEER (ROADS)	

DARWIN - RUM JUNGLE REHABILITATION - STAGE 2
WHITES OVERBURDEN HEAP

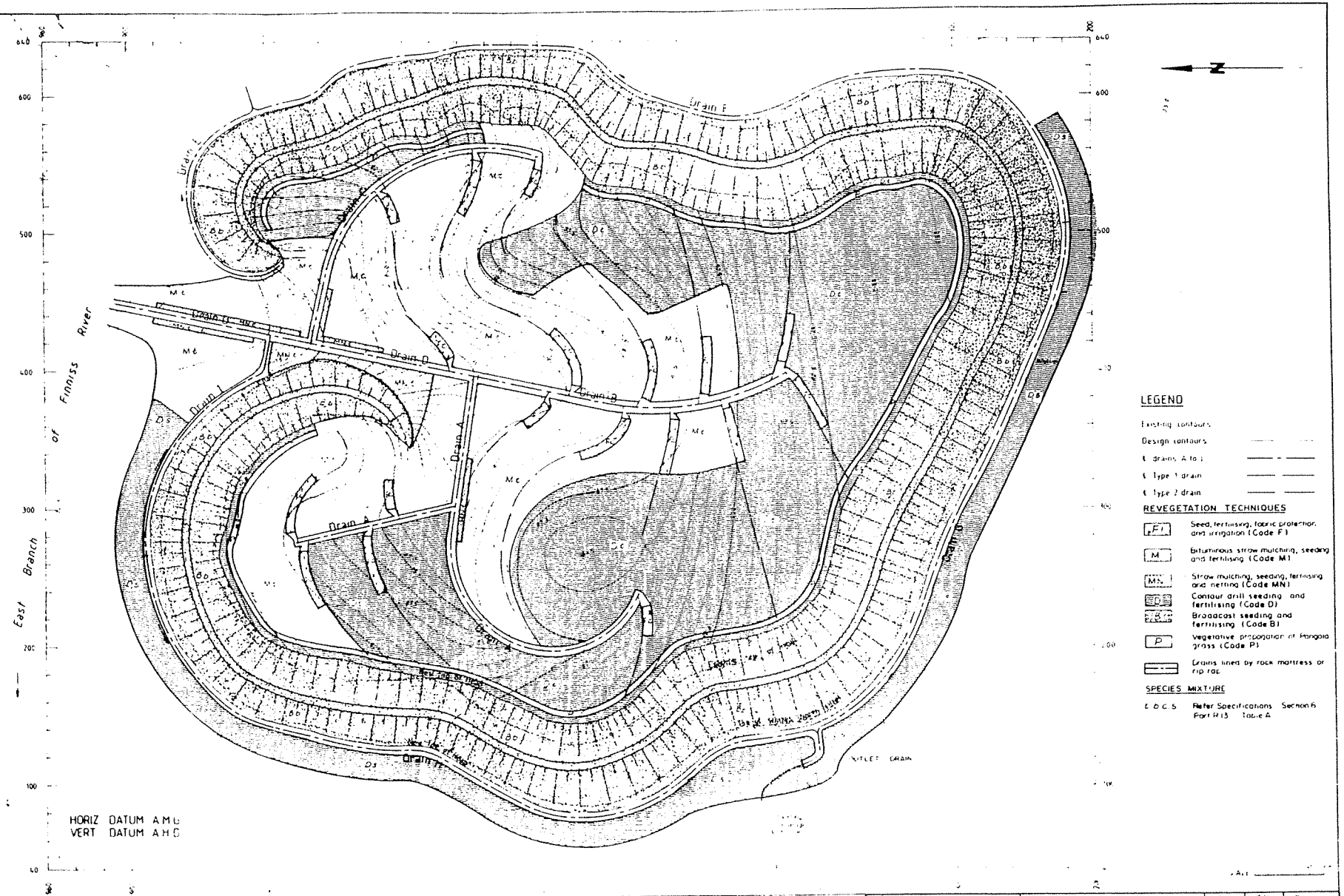
DROP STRUCTURES D1, D2 & D3

SHEET No.	7 of 23	CODE	SCALE
			DATE
			FILE

DRAWING No. DR3-1375 | ISSUE 1 | A1

W83/4004

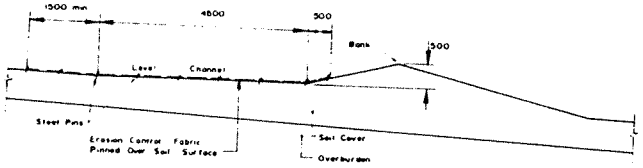
A1



	Darnes & Moore / Meehan Burgess & Yeates	Cameron McNamara	NORTHERN TERRITORY OF AUSTRALIA DEPARTMENT OF TRANSPORT AND WORKS	DARWIN – RUM JUNGLE REHABILITATION - STAGE 2 WHITES OVERBURDEN HEAP REVEGETATION LAYOUT OF TECHNIQUES	22 of 24 R83-1390 A1

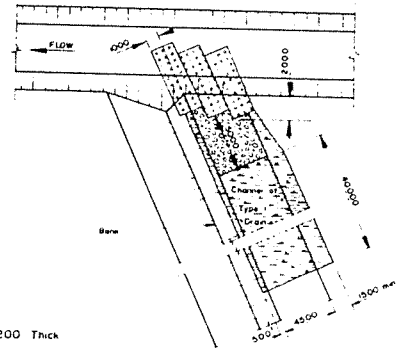
W83/4004

TYPICAL LAYING OF EROSION CONTROL FABRIC IN DRAINS



SECTION

TYPE I DRAIN



LEGEND

Rip-rap 200 Thick

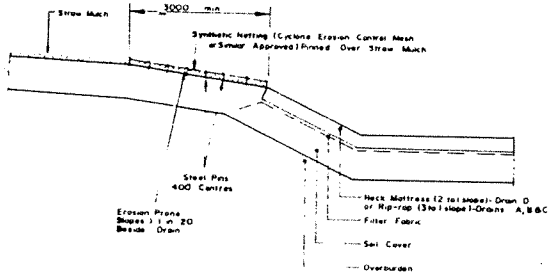
Reno Mattress or Similar Approved

Erosion Control Fabric

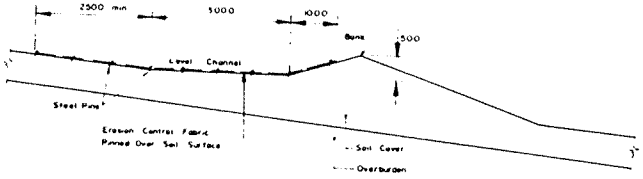
PLAN

TYPE I. DRAIN

TYPICAL LAYING OF NETTING OVER STRAW MULCH ON EROSION PRONE SLOPES.

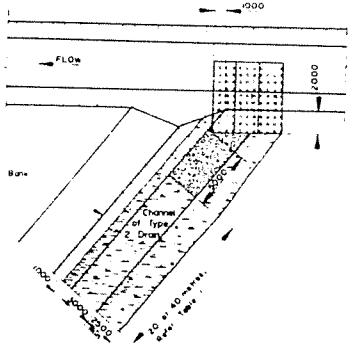


Note See drg R83-1390 for locations of respective treatments



SECTION

TYPE 2. DRAIN



PLAN

TYPE 2. DRAIN

TOTAL LENGTH OF DRAIN	DRAIN			EROSION CONTROL FABRIC LINED
	0m to 20m	20m to 40m	40m to End	
0m to 80m	15%	10%	10%	0m to 20m
Greater Than 80m	20%	15%	10%	0m to 40m

TABLE 1.

Note: All lengths of drains are measured upstream from junctions, from end of rip rap lining

IN ASSOCIATION WITH

Barnes & Moore

AND

Meehan Burgess & Yeates

Cameron McNamara

82-6029 | 60446

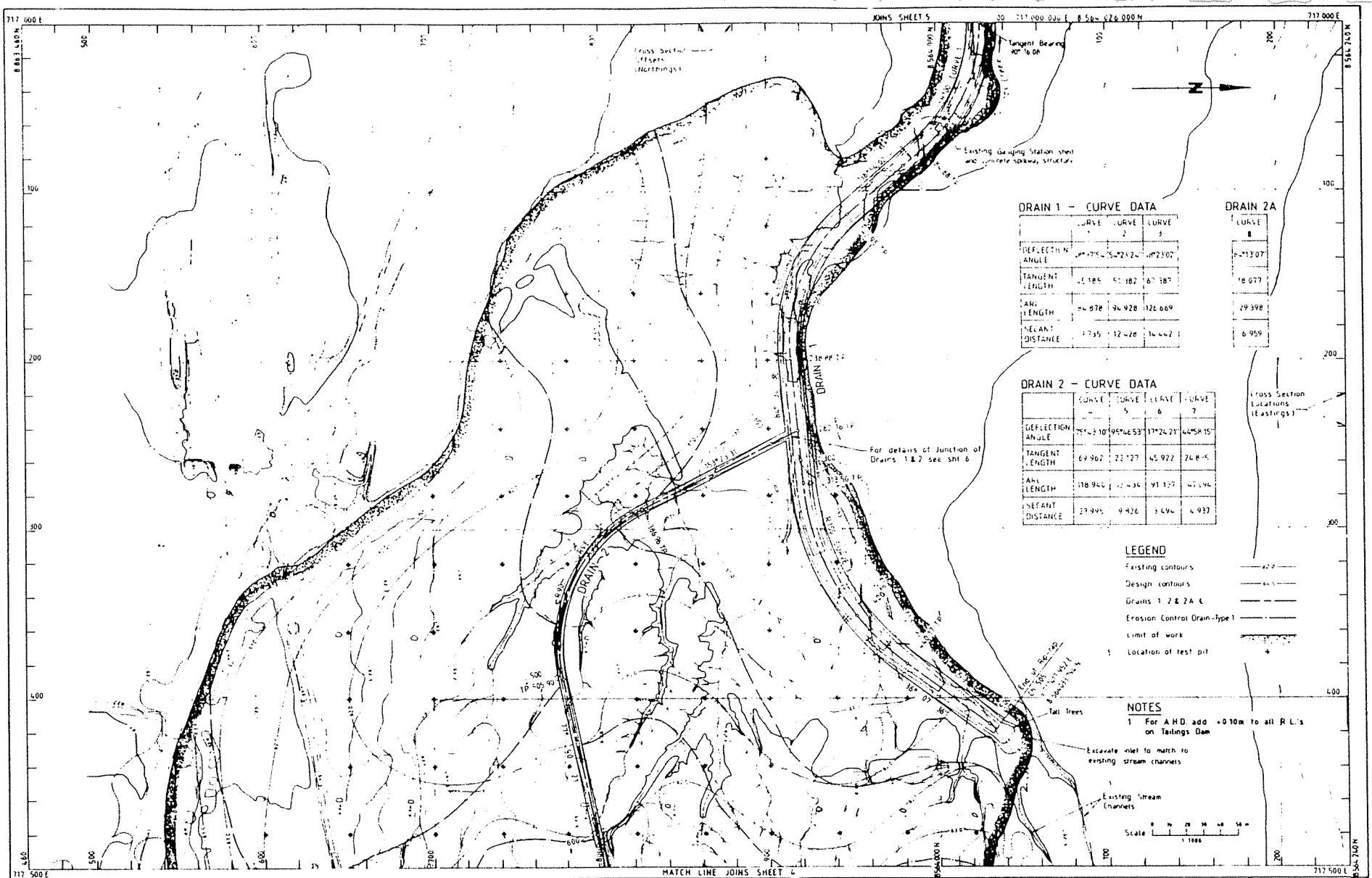
NORTHERN TERRITORY OF AUSTRALIA
DEPARTMENT OF TRANSPORT AND WORKS

DARWIN - RUM JUNGLE REHABILITATION - STAGE 2
WHITES OVERBURDEN HEAP
REVEGETATION CROSS SECTIONS AND PLAN

23 of 23

1391

WD374004



DRAIN 1 – CURVE DATA

	CURVE 1	CURVE 2	CURVE 3
DEFLECTION ANGLE	39°47'54"	76°24'24"	39°23'07"
TANGENT LENGTH	45.185	55.182	67.387
ARC LENGTH	84.878	94.928	126.669
SECANT DISTANCE	37.35	12.428	14.442

DRAIN 2A

CURVE 8
39°23'07"
18.077
29.398
6.959

DRAIN 2 – CURVE DATA

	CURVE 4	CURVE 5	CURVE 6	CURVE 7
DEFLECTION ANGLE	75°43'10"	95°46'53"	17°24'21"	44°58'15"
TANGENT LENGTH	69.962	23.727	45.922	26.8[illegible]
ARC LENGTH	118.946	[illegible]	91.139	47.[illegible]
SECANT DISTANCE	29.995	9.426	3.694	6.937

LEGEND

- Existing contours
- Design contours
- Drains 1, 2 & 2A ℄
- Erosion Control Drain-Type 1
- Limit of work
- Location of test pit

NOTES

1 For A.H.D. add +0.10m to all R.L.'s on Tailings Dam

DATUM VERTICAL	A.H.D.
HORIZONTAL	A.M.G.

Cameron McNamara

WATER DIVISION
DEPARTMENT OF TRANSPORT AND WORKS
NORTHERN TERRITORY OF AUSTRALIA

JOB No.	83-4521
DRAWING No.	60543

DRAWN: Brazier & Mott 12.83
DES: R 2.84
CHK: C.R.J.W 2.84
CHKD: J.M.B 2.84

DARWIN – RUM JUNGLE
REHABILITATION - STAGE 3
TAILINGS DAM

SETTING OUT, LEVELLING AND DRAINAGE PLAN – SHEET 1 OF 2

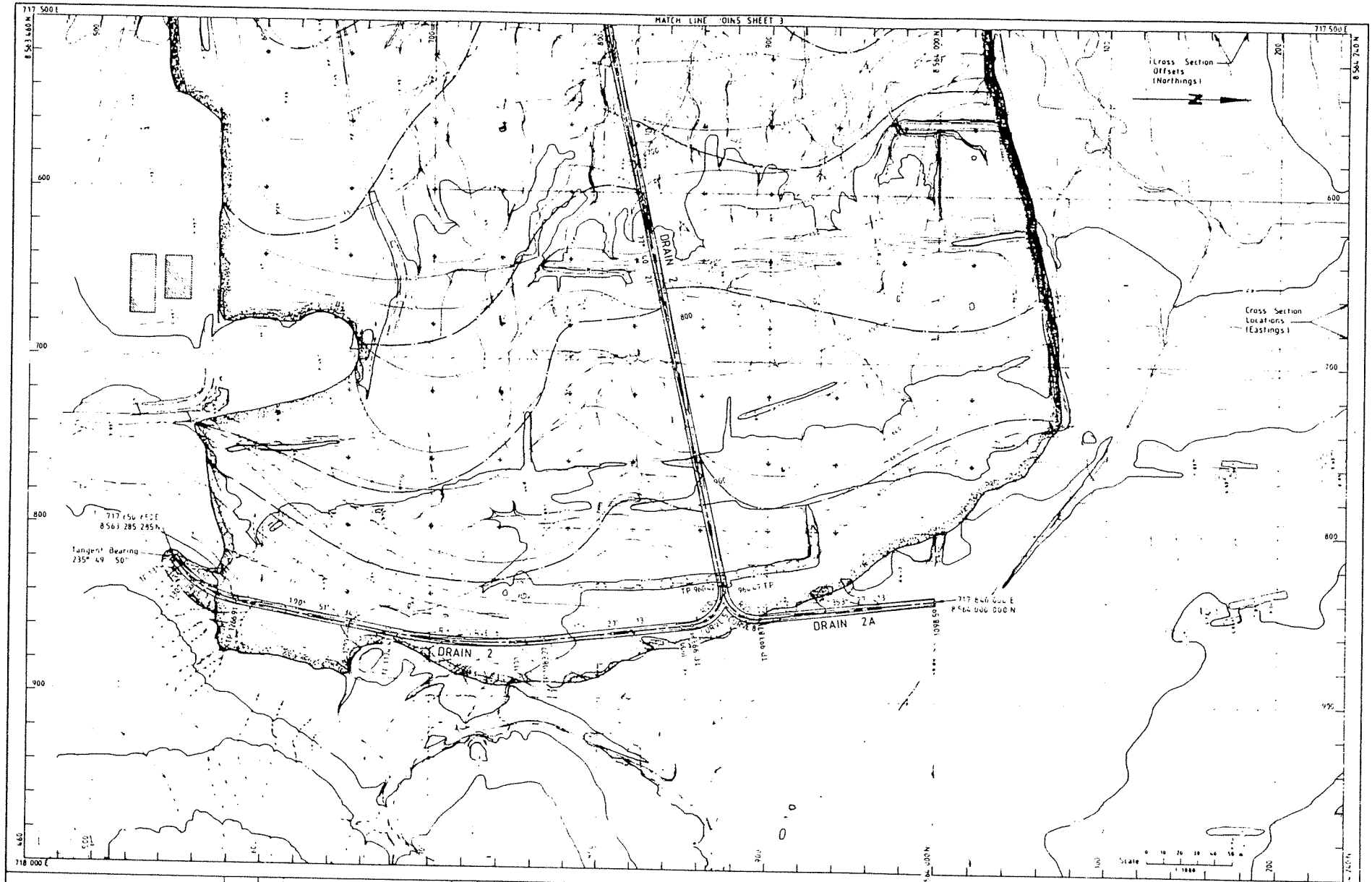
W(C)83-4005

SHEET 3 OF 43 SHEETS

ASSOCIATED DRAWINGS

AMENDMENTS

1 CURVE NO'S AMENDED



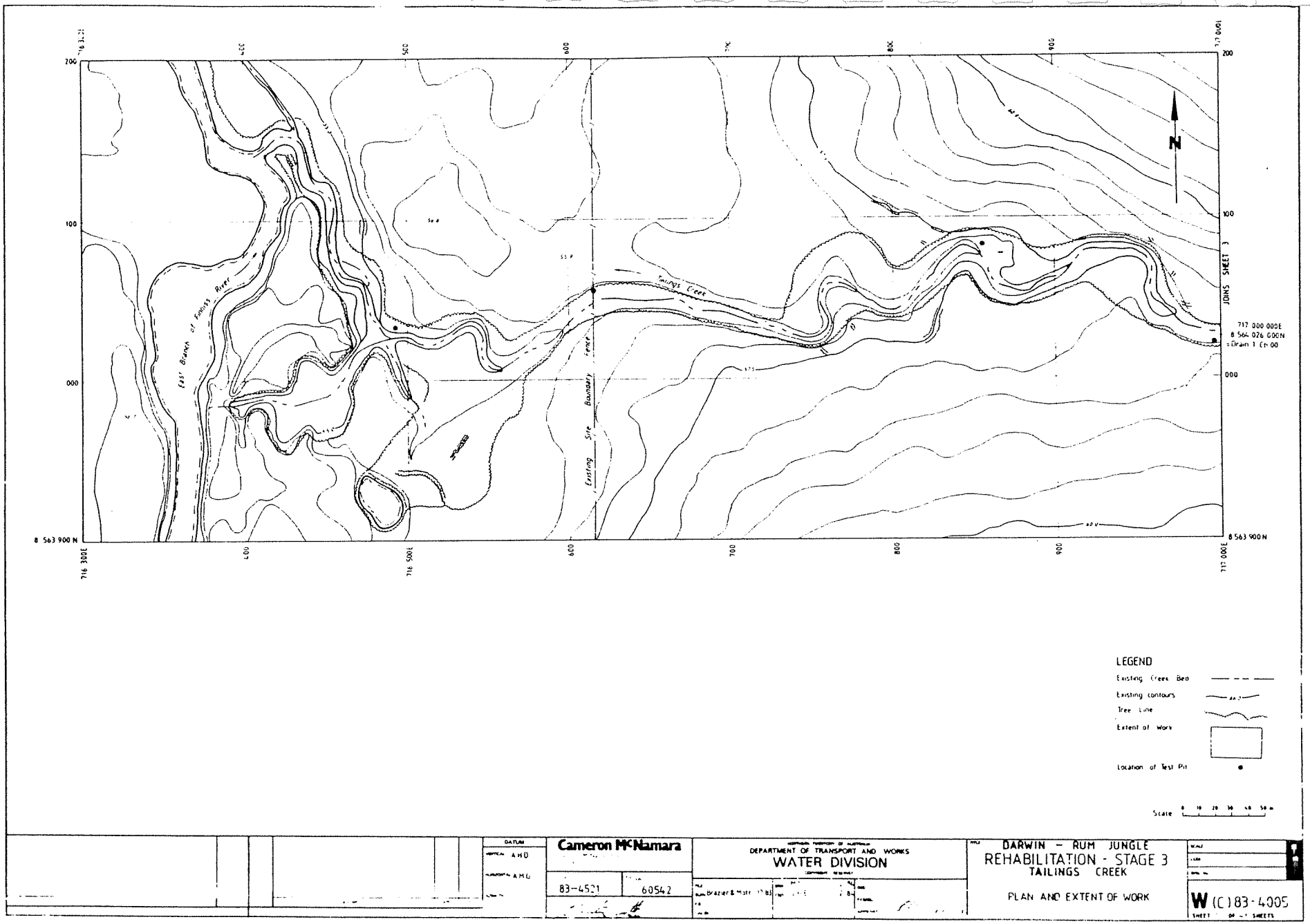
Cameron McNamara

WATER DIVISION
DEPARTMENT OF TRANSPORT AND WORKS

83-4521 | 60544

DARWIN - RUM JUNGLE
REHABILITATION - STAGE 3
TAILINGS DAM
SETTING OUT LEVELLING AND DRAINAGE PLAN - SHEET 2 OF 3

W(C)83-4005



DATUM
VERTICAL AHD
HORIZONTAL AMG

Cameron McNamara

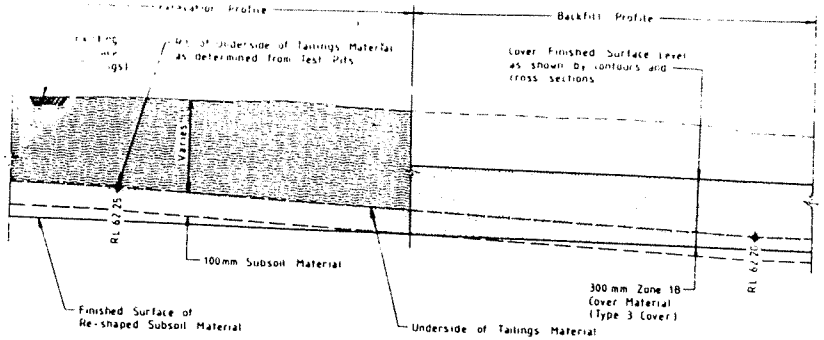
83-4521 | 60542

DEPARTMENT OF TRANSPORT AND WORKS
WATER DIVISION

DARWIN – RUM JUNGLE
REHABILITATION - STAGE 3
TAILINGS CREEK

PLAN AND EXTENT OF WORK

W (C) 83-4005

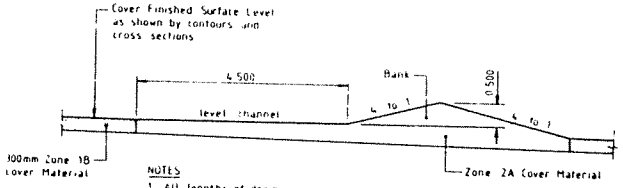


EXCAVATION

BACKFILL

TAILINGS DAM – TYPICAL DETAILS

NTS



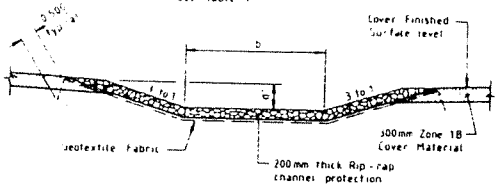
NOTES

1 All lengths of drains are measured upstream from junctions (from end of rip-rap lining)
2 For details of drain grades see Table 2
3 For erosion control fabric details see sht 43

GRADES		
0m to 20m	20m to 50m	50m to end
1.5%	1.0 %	0.5 %

TABLE 2

NOTE For dimensions b & d See Table 1

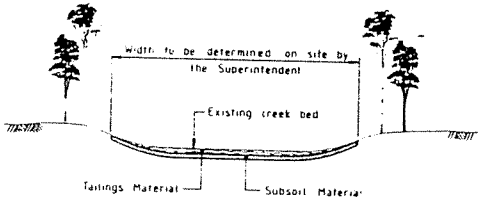


DRAIN	1	2	2A
'b'	7 000	1 000	1 000
'd'	1 200	1 200	1 200

TABLE 1

TYPICAL CROSS SECTIONS DRAINS 1, 2 & 2A

Scale



NOTES

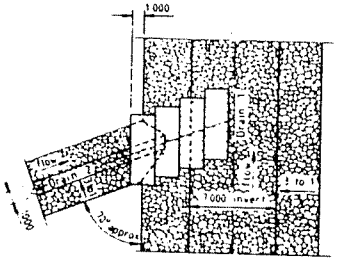
1 Depths of Tailings and Subsoil Materials to be excavated to be determined on site by the Superintendent
2 Re-shaping at downstream end to be determined on site by the Superintendent

TAILINGS CREEK TYPICAL CROSS SECTION

NTS

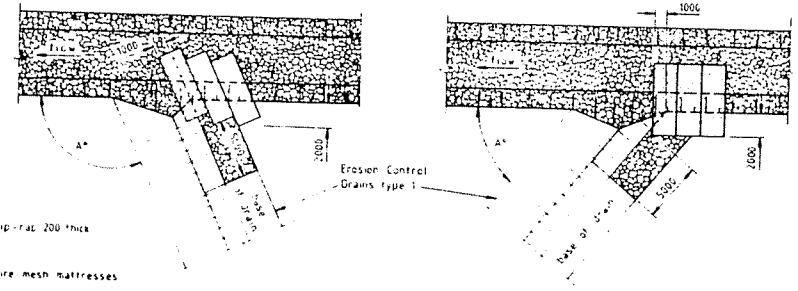
EROSION CONTROL DRAIN – TYPE 1

Scale



JUNCTION DRAINS 1 & 2

Scale



LEGEND

Rip-rap 200 thick

Wire mesh mattresses

NOTES

1 Wire mesh mattresses to be PVC coated and 6000 x 2000 x 300 unless otherwise shown
2 The contractor shall supply and locate mattresses as per specification
3 For placement of erosion control fabric see sht 43
4 Top of mattresses to coincide with finished surface level of adjacent rip-rap

TYPICAL DETAILS – EROSION CONTROL / MAIN DRAIN JUNCTIONS

NTS

GENERAL NOTES

1 TAILINGS MATERIAL — EXCAVATE, HAUL AND SPREAD PORTION OF DYSON'S GREEN C

2 SUBSOILS — EXCAVATE 100 mm AVERAGE AND SPREAD IN LAYERS

3 RESHAPING — RESHAPE REMAINING BE... BELOW COVER FINISHES SU... EXCAVATE DRAIN... AN...

4 COVER (TAILINGS DAM ONLY) — PLACE 300 mm THICK LAYER OF MATERIAL (TYPE 3 COVER

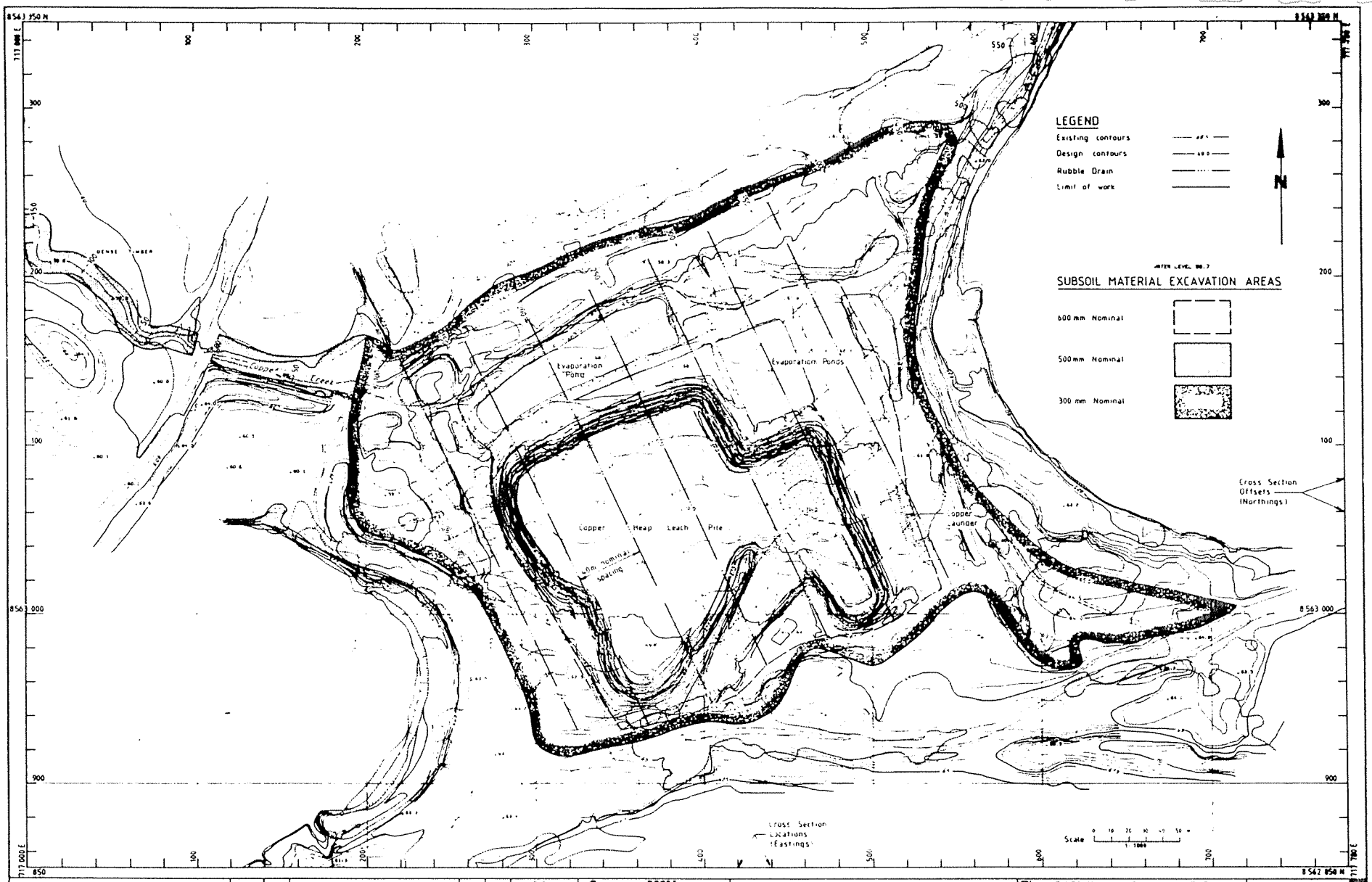
Cameron McNamara

DEPARTMENT OF TRANSPORT AND WORKS
WATER DIVISION

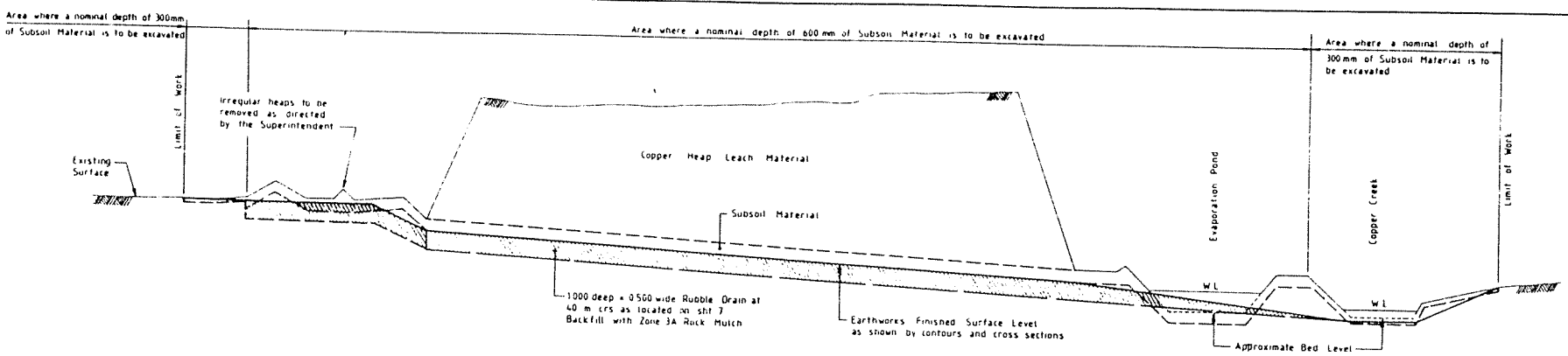
83-452 | 605-46

DARWIN – RUM JUNGLE
REHABILITATION - STAGE 3
TAILINGS DAM AND TAILINGS CREEK
TYPICAL CROSS SECTIONS

(1)8 ...05

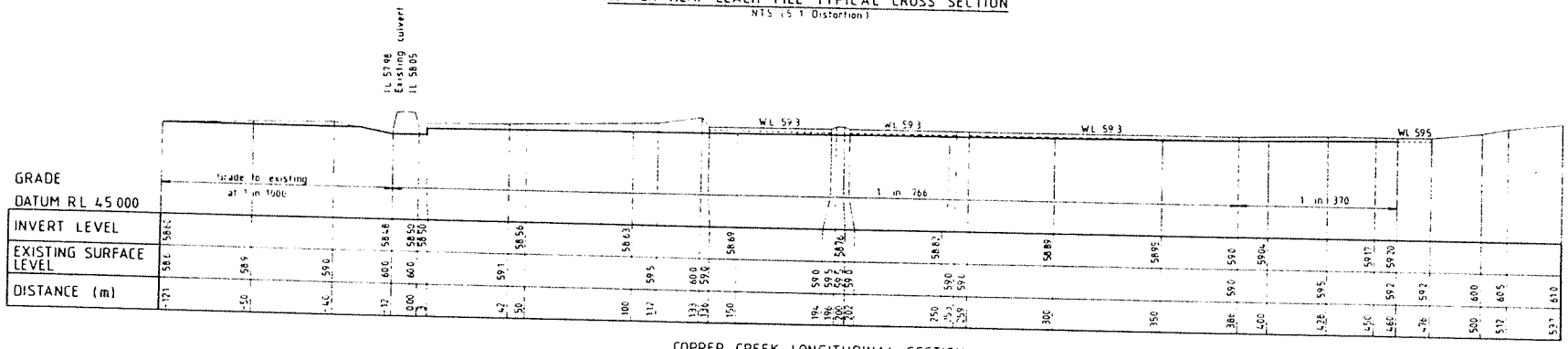


DATUM: AHD / AMG	Cameron McNamara	WATER DIVISION, Department of Transport and Works, Northern Territory of Australia	DARWIN – RUM JUNGLE REHABILITATION - STAGE 3 COPPER HEAP LEACH PILE
	83-4521 / 60547	Drawn: MKM 7.84; Design: JMM 7.84; Check: JMB 7.84	SETTING OUT LEVELLING AND DRAINAGE PLAN
			W(C)83-4005 SHEET 7 OF 43 SHEETS



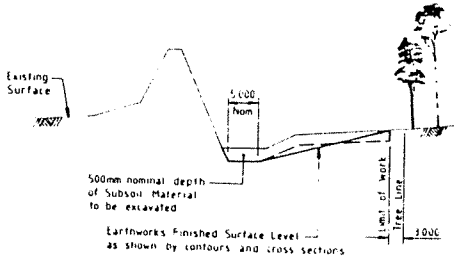
COPPER HEAP LEACH PILE TYPICAL CROSS SECTION

NTS (5:1 Distortion)



COPPER CREEK LONGITUDINAL SECTION

Scale



COPPER CREEK – TYPICAL CROSS SECTION

Scale

GENERAL NOTES

5. RESHAPING

RESHAPE REMAINING SUB-SOIL

6. COVER

PLACE A VARIABLE THICKNESS LAYER OF ZONE 2A MATERIAL (TYPE 4 COVER) TO EFFECT SATISFACTORY DRAINAGE

EXCAVATE, HAUL, SPREAD AND COMPACT IN DYSON'S OPEN CUT AS IN C ABOVE

(A) 600 mm BENEATH COPPER HEAP EVAPORATION PONDS AND COPPER LAUNDER.

(B) 900 mm FROM SURROUNDING AREA PRESERVING HEALTHY STANDS OF TREE

(C) 500 mm FROM TA[illegible]

						DATUM	
						VERTICAL AHD	
						HORIZONTAL AMG	
TITLE							
ABBOCIATED DRAWINGS	DRG. No.	ISSUE	DESCRIPTION / AMENDMENTS	INT.	DATE		

Cameron McNamara

JOB No.	DRAWING No.
83-4521	60548

DEPARTMENT OF TRANSPORT AND WORKS
WATER DIVISION

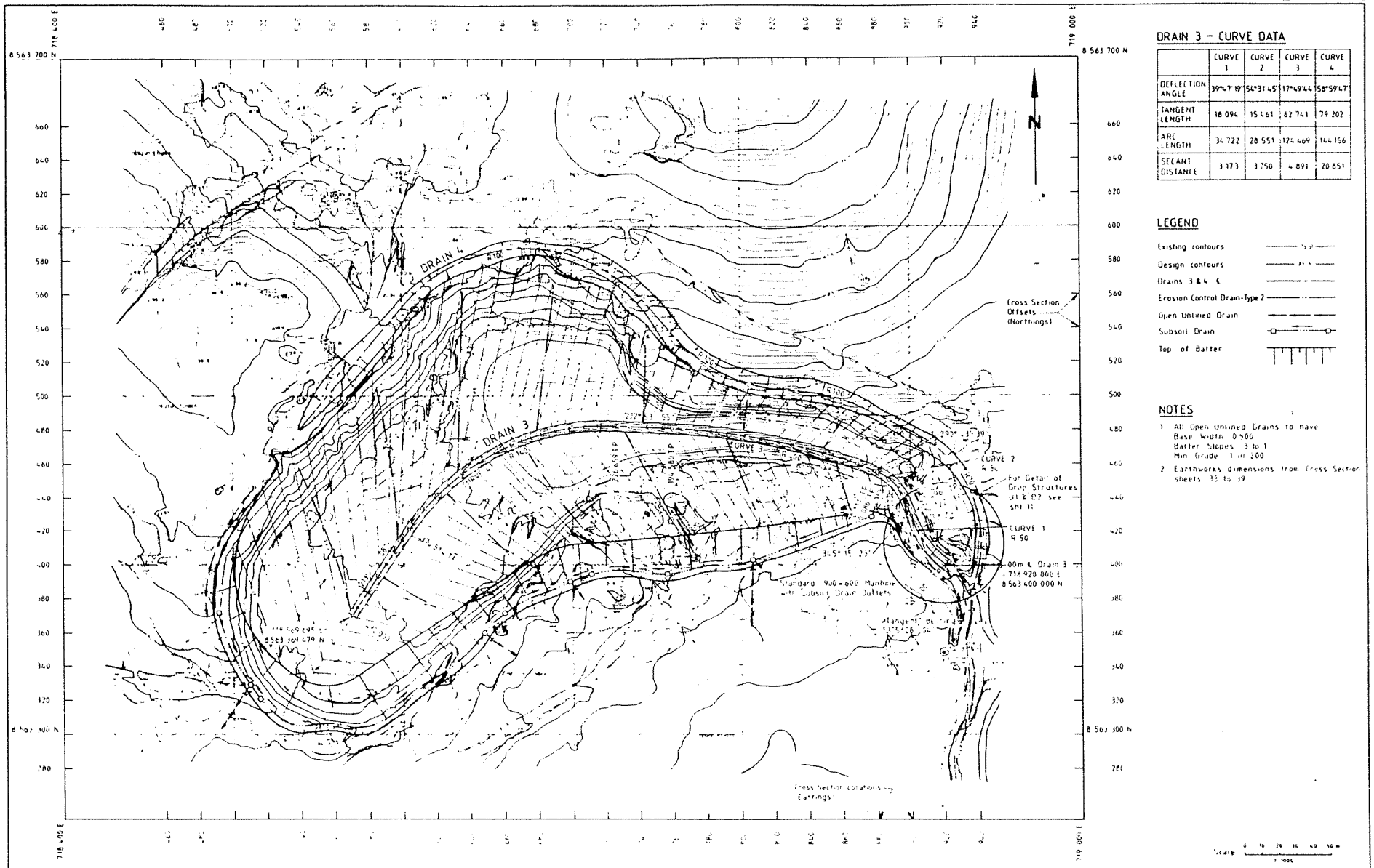
DES.	Brazier & Motti 12.83	DRN.	J W 12.84
CHK.		CHK.	J H B 2.84

TITLE
DARWIN – RUM JUNGLE
REHABILITATION - STAGE 3
COPPER HEAP LEACH PILE & COPPER CK
TYPICAL CROSS SECTIONS AND
COPPER [illegible] LONGI[illegible]L SEC

SCALE
CONT
DRG. No.

[illegible] (C) [illegible]005

SHEET 8 OF 13 SHEETS



DRAIN 3 – CURVE DATA

	CURVE 1	CURVE 2	CURVE 3	CURVE 4
DEFLECTION ANGLE	39°47'19"	54°31'45"	117°49'44"	158°59'47"
TANGENT LENGTH	18.094	15.461	62.741	79.202
ARC LENGTH	34.722	28.551	124.469	144.156
SECANT DISTANCE	3.173	3.750	4.891	20.851

LEGEND

- Existing contours
- Design contours
- Drains 3 & 4 ℄
- Erosion Control Drain-Type 2
- Open Unlined Drain
- Subsoil Drain
- Top of Batter

NOTES

1. All Open Unlined Drains to have
   Base Width 0.500
   Batter Slopes 3 to 1
   Min Grade 1 in 200
2. Earthworks dimensions from Cross Section sheets 33 to 39

Scale 0 10 20 30 40 50 m
1:1000

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83-4521 | 60544

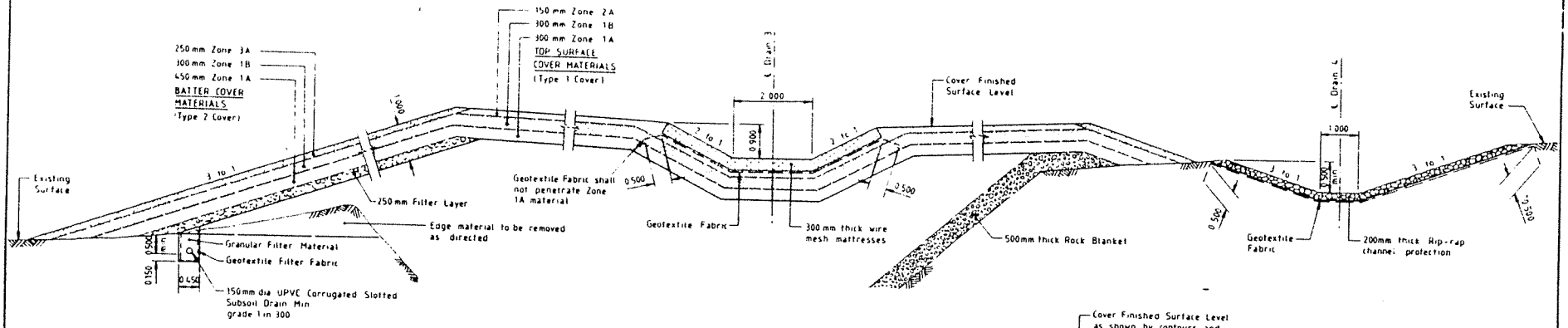
WATER DIVISION
DEPARTMENT OF TRANSPORT AND WORKS
NORTHERN TERRITORY OF AUSTRALIA

DARWIN – RUM JUNGLE
REHABILITATION - STAGE 3
OYSON'S OPENCUT

SETTING OUT LEVELLING AND DRAINAGE

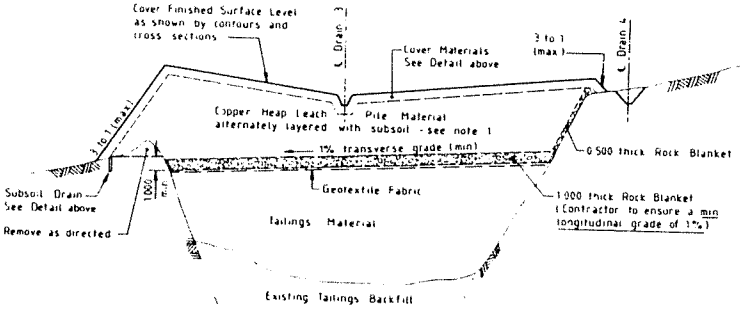
W(C)83-4005

SHEET ... OF ... SHEETS



COVER AND DRAINS 3 & 4 TYPICAL DETAILS

Scale

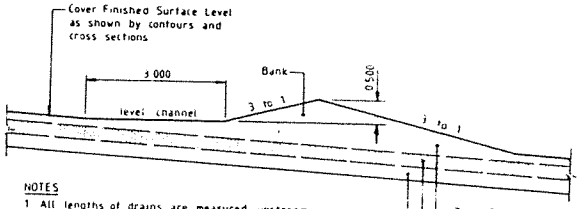


TYPICAL CROSS SECTION

Scale

TOTAL LENGTH OF DRAIN	GRADES		
	0m to 20m	20m to 40m	40m to end
0m to 80m	1.5%	1.0%	1.0%
greater than 80m	2.0%	1.5%	1.0%

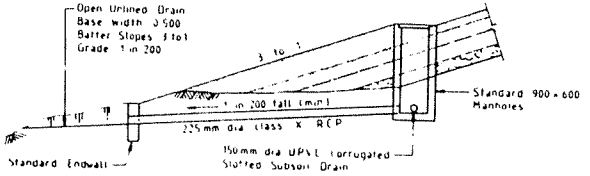
TABLE 1



NOTES
1 All lengths of drains are measured upstream from junctions (from end of rip-rap lining)
2 For details of drain grades see Table 1
3 For erosion control fabric details see Sheet

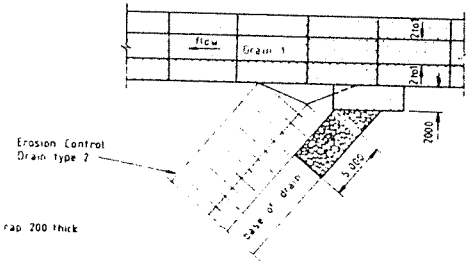
EROSION CONTROL DRAIN - TYPE 2

Scale



SUBSOIL DRAIN OUTLET

Scale



LEGEND

Rip-rap 200 thick

Wire mesh mattresses

NOTES
1 Wire mesh mattresses to be PVC coated and 6000 x 2000 x 300 unless otherwise
2 The contractor shall supply and locate mattresses as per specification
3 For placement of erosion control fabric see sht 42
4 Top of mattresses to coincide with finished surface level of adjacent rip-rap

TYPICAL DETAIL - EROSION CONTROL / MAIN DRAIN JUNCTIONS

N.T.S.

DATUM
VERTICAL AHD
HORIZONTAL AMG

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DEPARTMENT OF TRANSPORT AND WORKS
WATER DIVISION

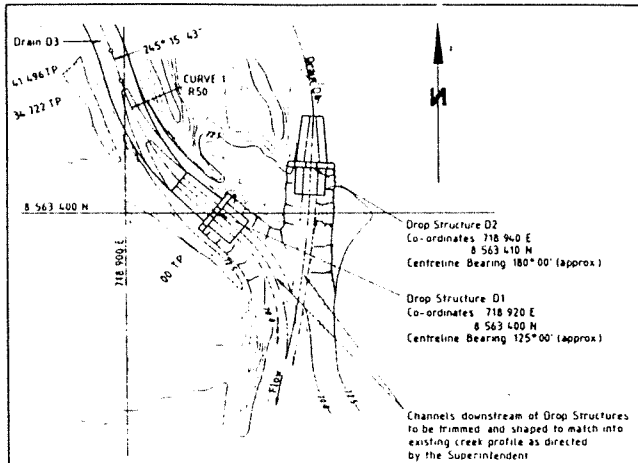
Job No. 83-4521
Drawing No. 60550

Brazier & Motti 128.3

DARWIN - RUM JUNGLE
REHABILITATION - STAGE 3
DYSON'S OPENCUT

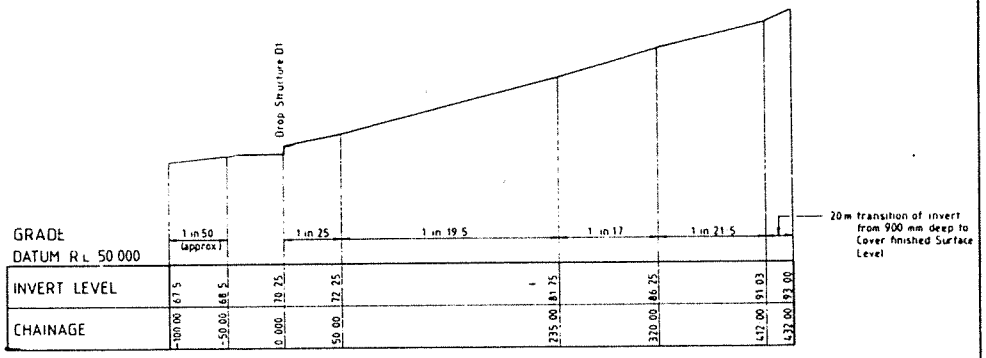
TYPICAL CROSS SECTIONS
0 DET

SHEET



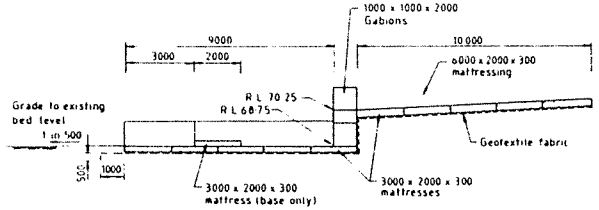
SITE PLAN

Scale 0 5 10 15 20 25 m

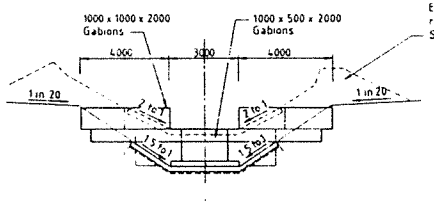


DRAIN 3 LONGITUDINAL SECTION

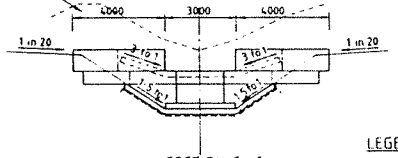
Scale VERT 0 4 8 12 16 20 m HORIZ 0 20 40 60 80 100 m



SECTION A-A



SECTION B-B



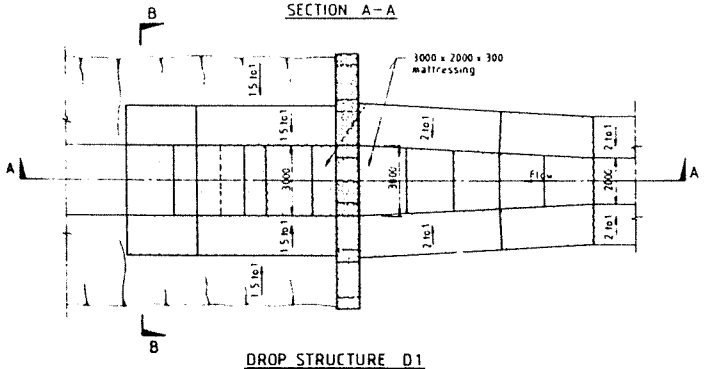
SECTION C-C

LEGEND

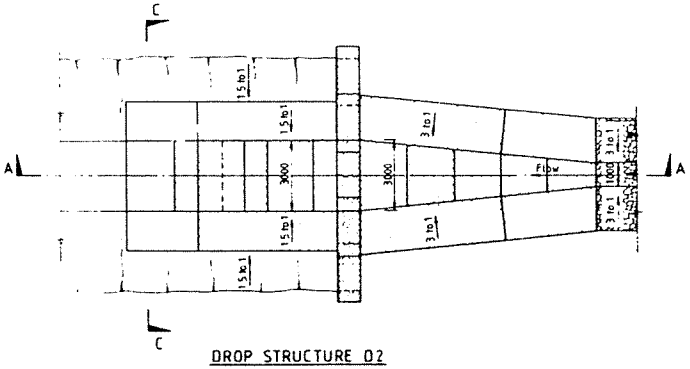
- Rip-rap 200 thick
- Wire Mesh Mattresses
- Gabions

NOTES

1. All levels to be checked on site prior to commencement of work
2. The existing ground surface in the vicinity of the Drop Structure is to be levelled as shown and as directed by the Superintendent
3. Wire mesh Mattresses shall be P V C coated General size to be 6000 x 2000 x 300 unless otherwise shown



DROP STRUCTURE D1



DROP STRUCTURE D2

DATUM VERTICAL A M G HORIZONTAL A M G

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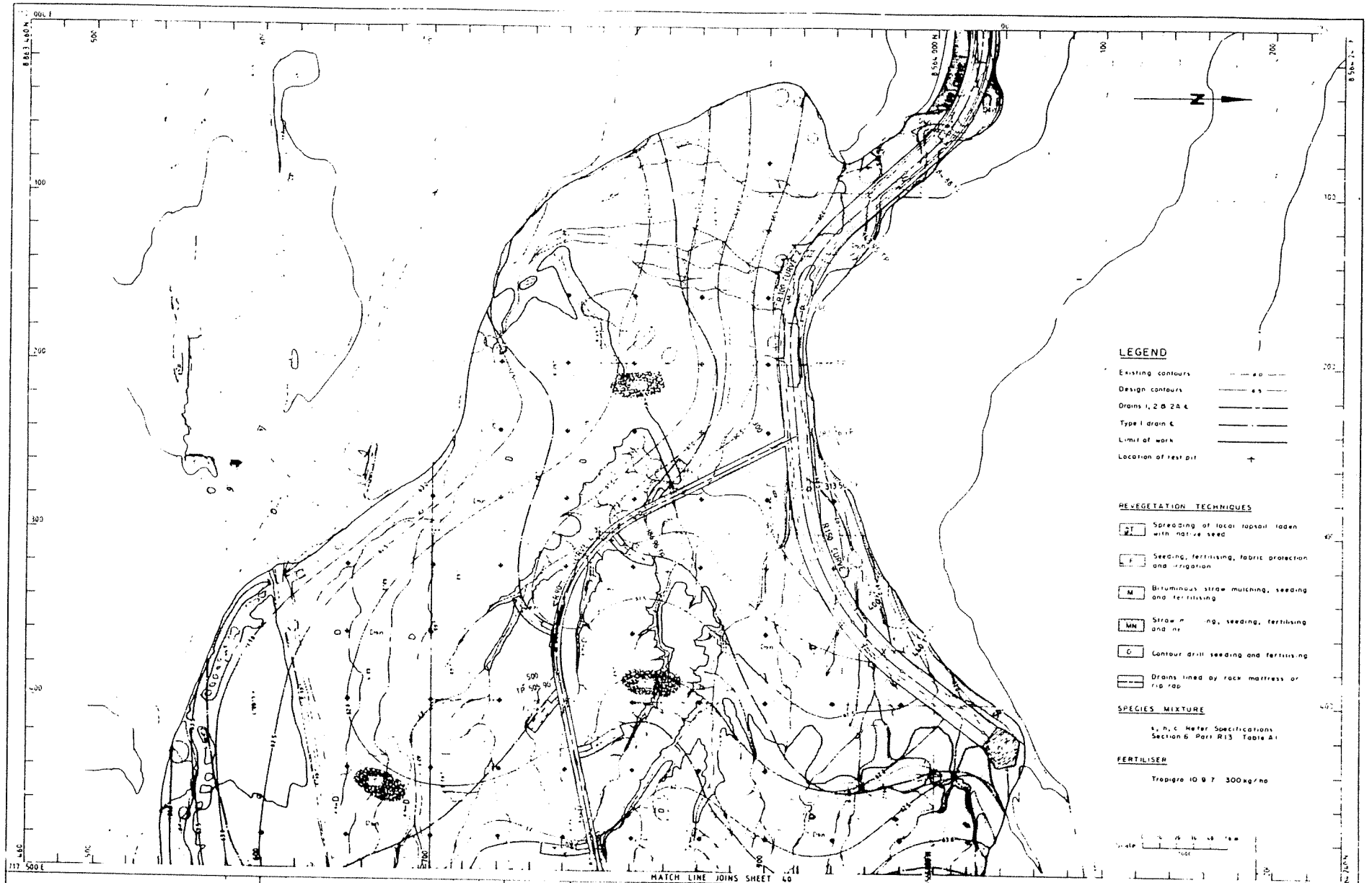
83 - 4527 | 60551

WATER DIVISION
DEPARTMENT OF TRANSPORT AND WORKS
NORTHERN TERRITORY OF AUSTRALIA

Drawn Brazier & Morris 12.83 | M W 2.84 | B W 2.84 | 2.84

DARWIN - RUM JUNGLE
REHABILITATION - STAGE 3
DYSON'S OPEN CUT
DRAIN 3 LONGITUDINAL SECTION AND DROP STRUCTURES D1 & D2 DETAILS

W(C)83-4005



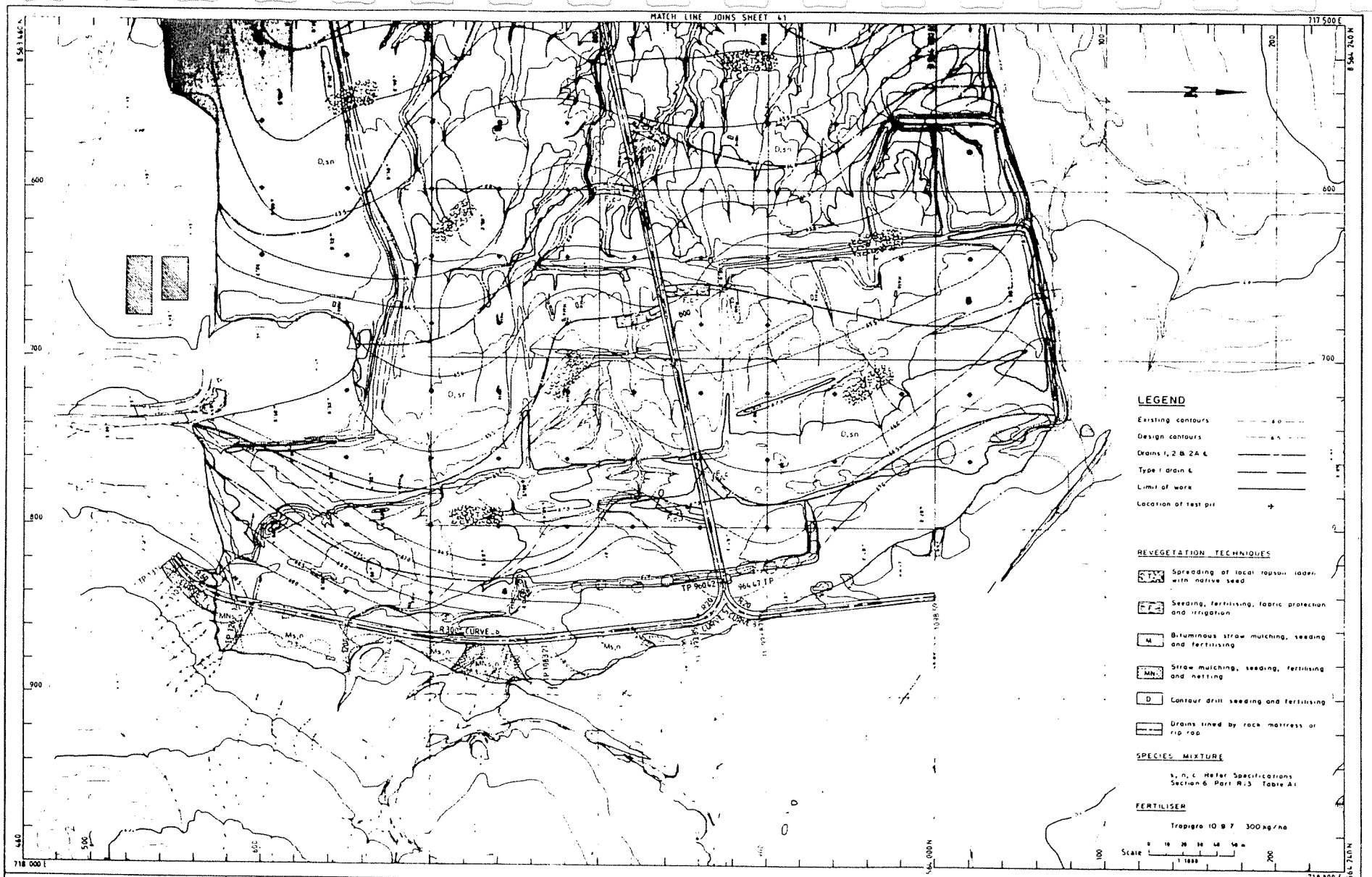
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WATER DIVISION
DEPARTMENT OF TRANSPORT AND WORKS

DARWIN – RUM JUNGLE
REHABILITATION - STAGE 3
TAILINGS DAM
REVEGETATION – LAYOUT OF TECHNIQUES
SHEET 1

60580

W(C)[illegible]005



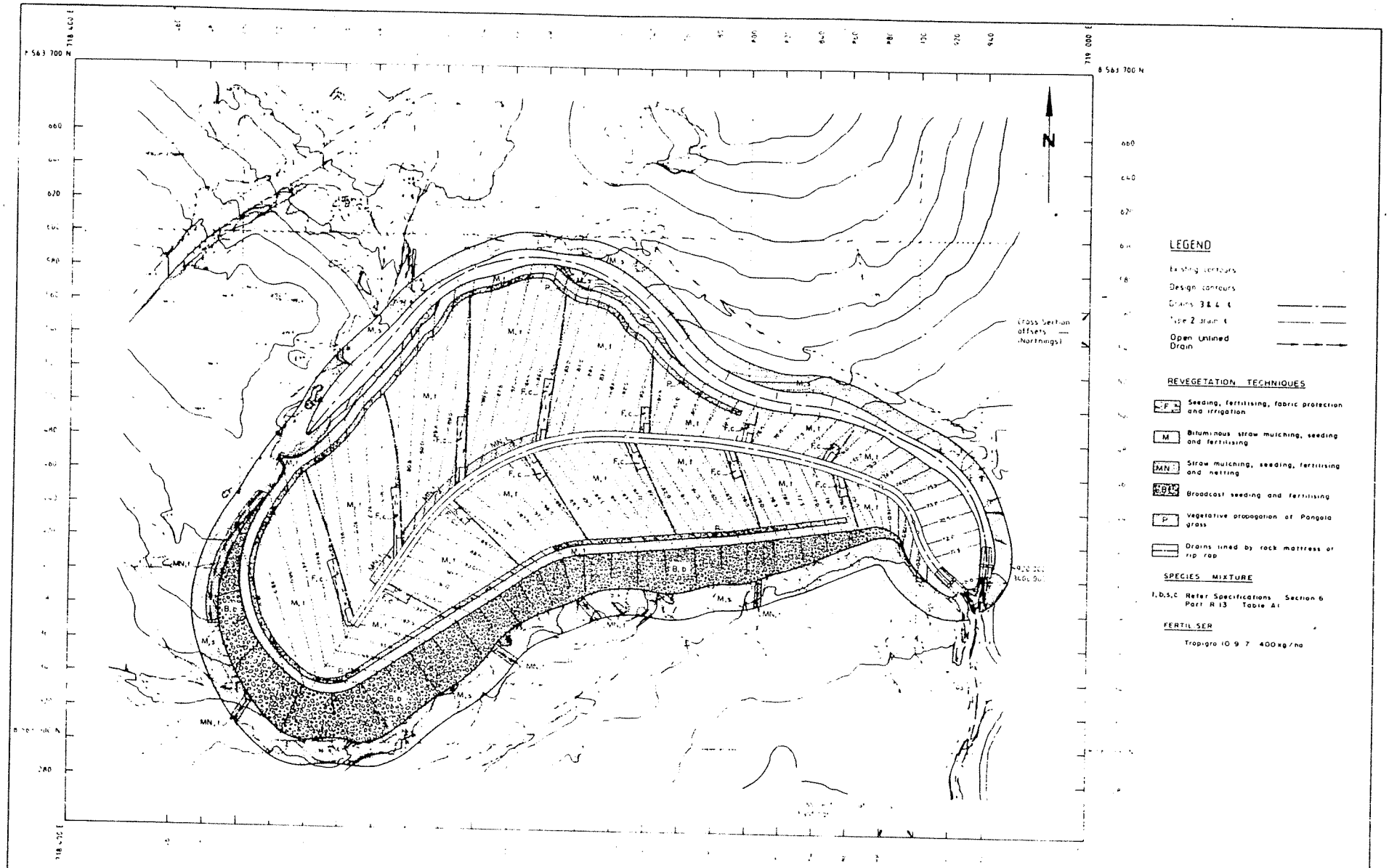
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83-4521 | 60581

WATER DIVISION
DEPARTMENT OF TRANSPORT AND WORKS
NORTHERN TERRITORY OF AUSTRALIA

DARWIN – RUM JUNGLE
REHABILITATION - STAGE 3
TAILINGS DAM
REVEGETATION – LAYOUT OF TECHNIQUES
SHEET 2 OF 2

W(C)83-4005
SHEET 41 OF 43 SHEETS



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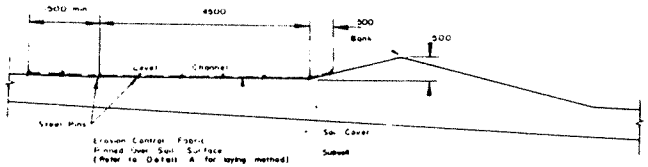
83 - 4521 | 60582

WATER DIVISION
DEPARTMENT OF TRANSPORT AND WORKS

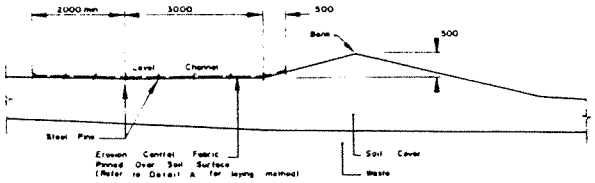
DARWIN - RUM JUNGLE
REHABILITATION - STAGE 3
DYSON'S OPENCUT
REVEGETATION
LAYOUT OF TECHNIQUES

W(C)83-4005
SHEET 42 SHEETS

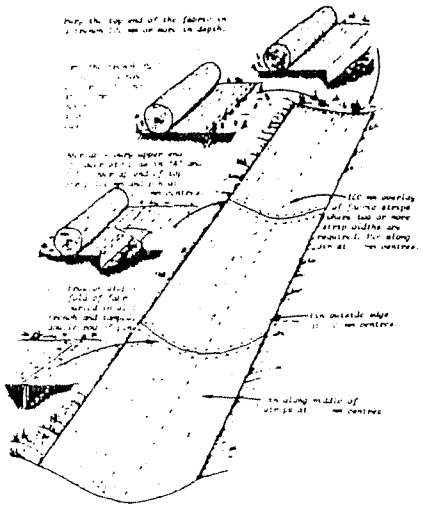
TYPICAL LAYING OF EROSION CONTROL FABRIC IN DRAINS



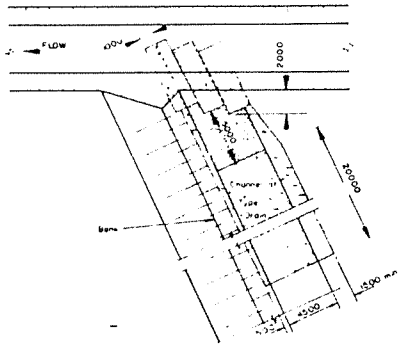
SECTION
TAILINGS DAM
(Type 1.)



SECTION
DYSONS
(Type 2.)



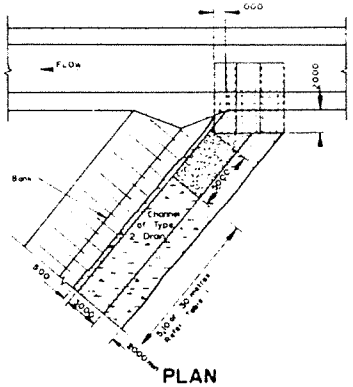
DETAIL A — LAYING EROSION CONTROL FABRIC ALONG DRAINS



PLAN
TAILINGS DAM

LEGEND

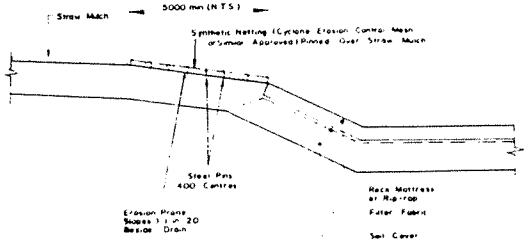
- Rip-rap 200 Thick
- Reno Mattress or Similar Approved
- Erosion Control Fabric



PLAN
DYSONS

Table 1.

TOTAL LENGTH OF DRAIN	LENGTH LINED WITH EROSION CONTROL FABRIC
TAILINGS DAM All Drains	0 — 20 m
DYSONS OPEN CUT Less Than 30 m 30 to 65 m Greater Than 65 m	0 — 5 m 0 — 10 m 0 — 30 m



TYPICAL LAYING OF NETTING OVER STRAW MULCH ON EROSION PRONE SLOPES

DATUM
VERTICAL AHD
HORIZONTAL AMG

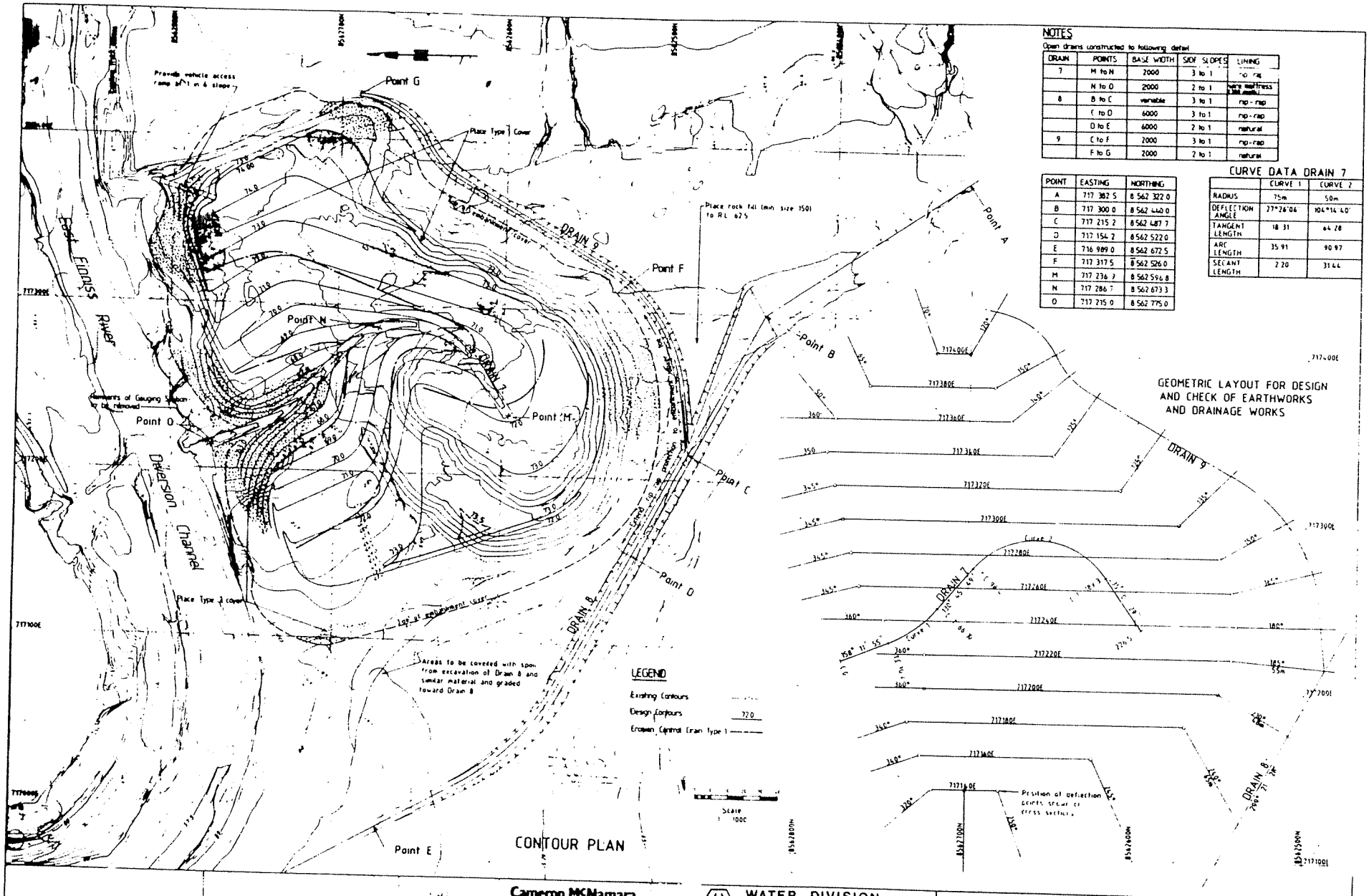
Cameron McNamara

WATER DIVISION
DEPARTMENT OF TRANSPORT AND WORKS
NORTHERN TERRITORY OF AUSTRALIA

DARWIN — RUM JUNGLE
REHABILITATION - STAGE 3
TAILINGS DAM AND DYSON'S OPENCUT
REVEGETATION
CROSS SECTION
AND PLAN VIEWS

Job No. 83-4521
Drawing No. 60583
DES. BF
DRN. MC
CHK. JEC

W(C) 83-4005
SHEET 43 OF 43 SHEETS



NOTES

Open drains constructed to following detail

DRAIN	POINTS	BASE WIDTH	SIDE SLOPES	LINING
7	M to N	2000	3 to 1	no rip
	N to O	2000	2 to 1	rock mattress 300 mm thick
8	B to C	variable	3 to 1	rip - rap
	C to D	6000	3 to 1	rip - rap
	D to E	6000	2 to 1	natural
9	C to F	2000	3 to 1	rip - rap
	F to G	2000	2 to 1	natural

POINT	EASTING	NORTHING
A	717 382 5	8 562 322 0
B	717 300 0	8 562 440 0
C	717 215 2	8 562 487 7
D	717 154 2	8 562 522 0
E	716 989 0	8 562 672 5
F	717 317 5	8 562 526 0
M	717 236 2	8 562 596 8
N	717 286 7	8 562 673 3
O	717 215 0	8 562 775 0

CURVE DATA DRAIN 7

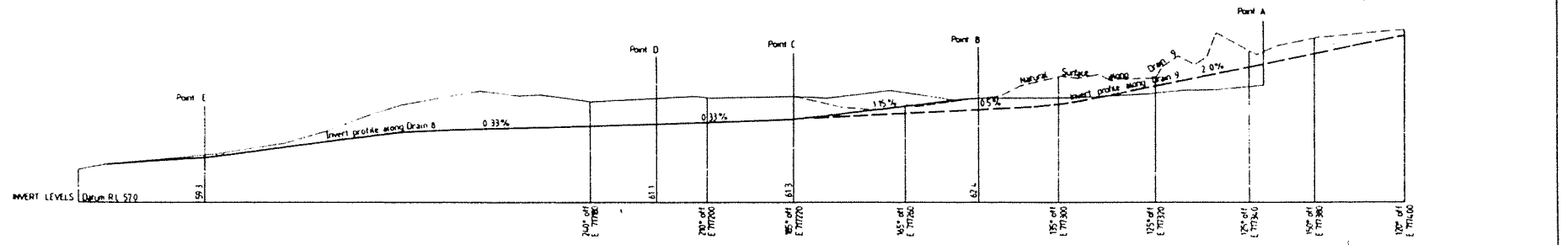
	CURVE 1	CURVE 2
RADIUS	75m	50m
DEFLECTION ANGLE	77°26'06	104°14'40"
TANGENT LENGTH	18 31	64 28
ARC LENGTH	35 91	90 97
SECANT LENGTH	2 20	31 44

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WATER DIVISION
DEPARTMENT OF TRANSPORT AND WORKS

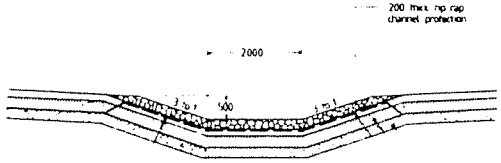
RUM JUNGLE REHABILITATION
STAGE 4.1
INTERMEDIATE HEAP
SE UT. LE AND
DRAINAGE PLAN

W 93-40-42



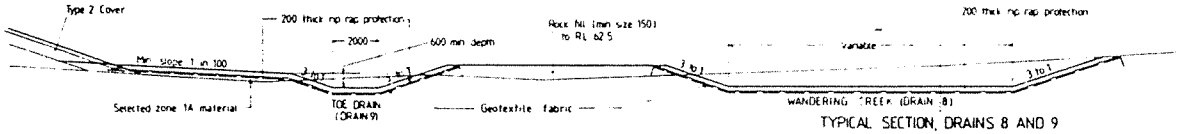
SECTION ALONG WANDERING CREEK DIVERSION DRAIN 8 (AND DRAIN 9)

Scale VERT 1:100 HORIZ 1:1000



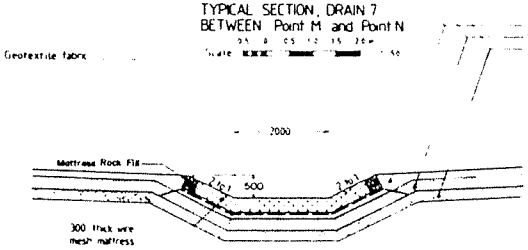
TYPICAL SECTION, DRAIN 7
BETWEEN Point M and Point N

Scale 0.5 0 0.5 1.0 1.5 2.0m 1:50



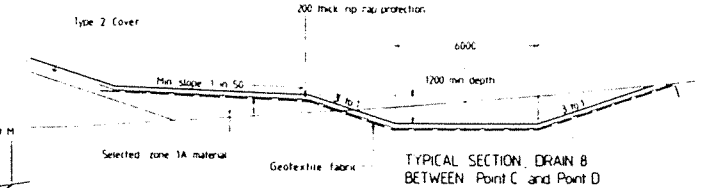
TYPICAL SECTION, DRAINS 8 AND 9
BETWEEN Point B and Point C

Scale 2 0 2 4 6 8 10m 1:100



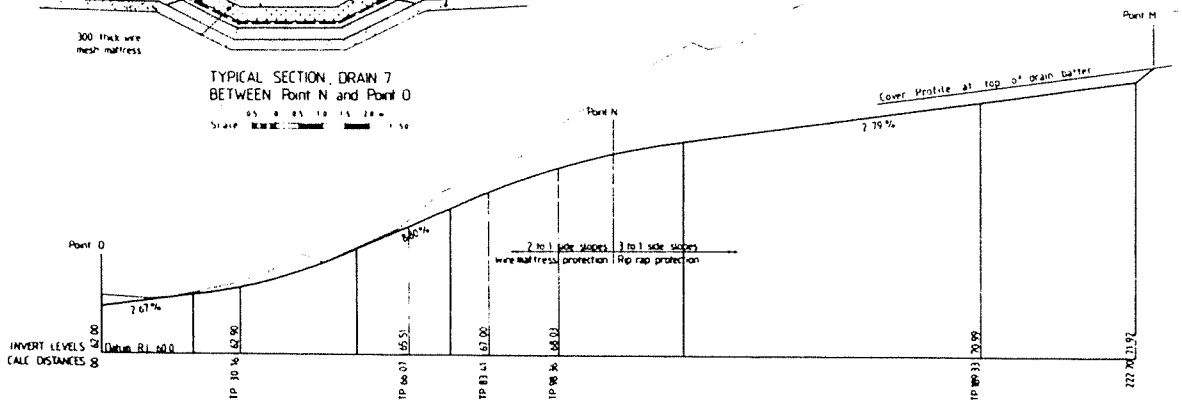
TYPICAL SECTION, DRAIN 7
BETWEEN Point N and Point O

Scale 0.5 0 0.5 1.0 1.5 2.0m 1:50



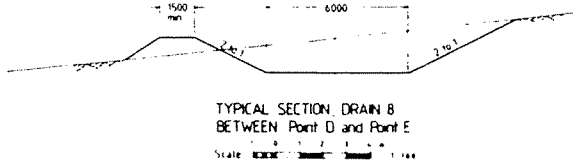
TYPICAL SECTION, DRAIN 8
BETWEEN Point C and Point D

Scale 0 1 2 3 4 5m 1:100



SECTION ALONG INTERMEDIATE HEAP MAIN DRAIN (DRAIN 7)

Scale VERT 1:100 HORIZ 1:1000



TYPICAL SECTION, DRAIN 8
BETWEEN Point D and Point E

Scale 0 1 2 3 4 5m 1:100

		1	Addition of Mattress Rock Fill to Drain 7 (Between Points N & O) & Alterations to Turndown of Geotextile Points to Drain 7 (Points M to N)				
ASSOCIATED DRAWINGS		NO.	AMENDMENTS				

AHD
AMG

Cameron McNamara

84-4511 | 60934

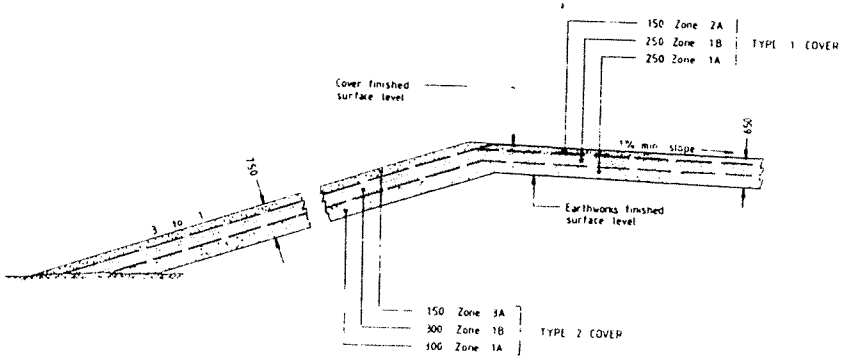
WATER DIVISION
DEPARTMENT OF TRANSPORT AND WORKS
NORTHERN TERRITORY GOVERNMENT

DES. BRAZIER & HOTH '84
DRN. P.T.L 12.84
CHD. B.F.G 12.84

RUM JUNGLE REHABILITATION
STAGE 4.1
INTERMEDIATE HEAP
DETAIL OF DRAINS 7 8 and 9

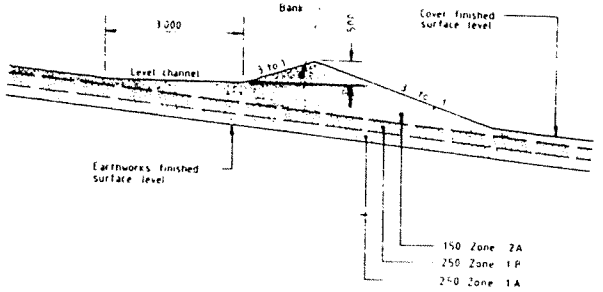
W 85-4042
SHEET 4 OF 40 SHEETS

A1



COVER DETAILS

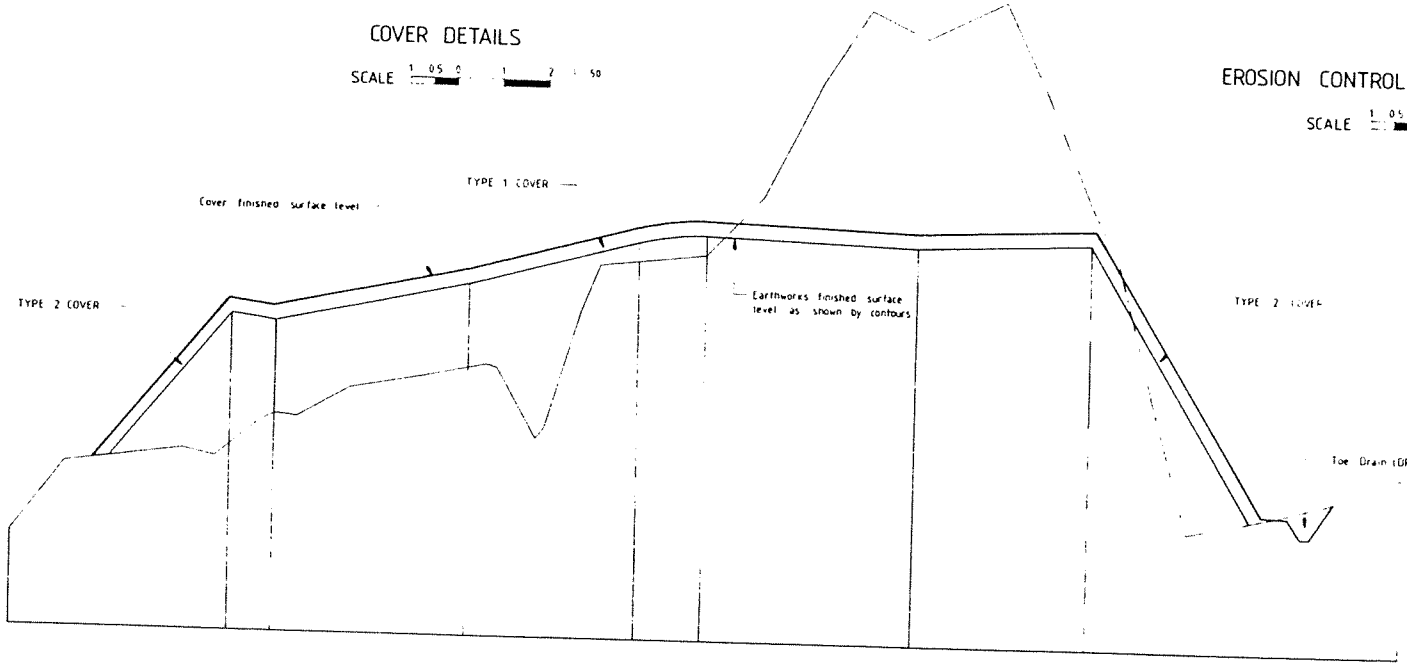
SCALE 1 0.5 0 1 2 1 : 50



EROSION CONTROL DRAIN DETAILS

SCALE 1 0.5 0 1 2 1 : 50

GRADES FOR EROSION CONTROL DRAINS	
0m to 20m	20m to end
1.5%	1.0%

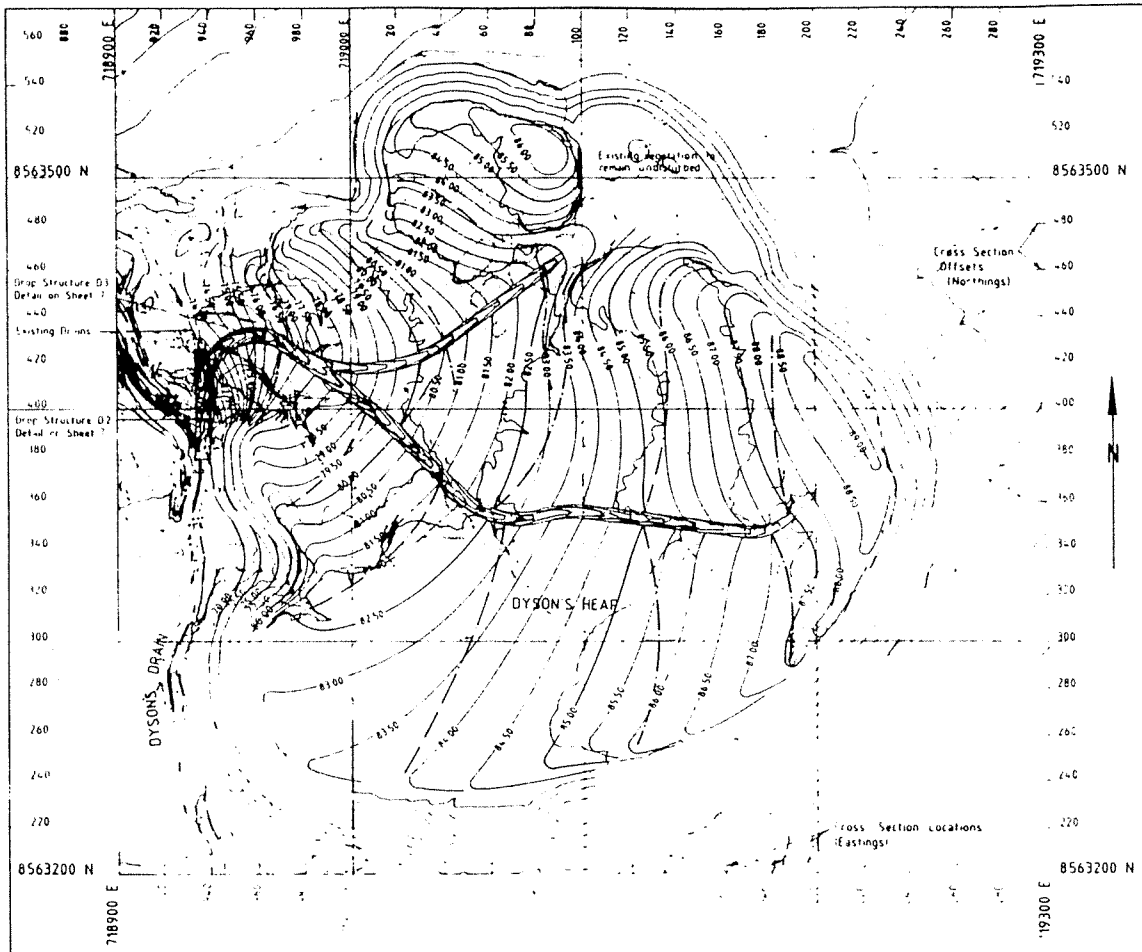


TYPICAL CROSS SECTION

SCALE VERT 1 0 1 2 3 4 5 1 in 100
HORIZ 0 5 10 15 20 25 1 in 500

		A.H.D. A.M.G.	Cameron McNamara	WATER DIVISION, DEPARTMENT OF TRANSPORT AND WORKS	RUM JUNGLE REHABILITATION STAGE 4.1 INTERMEDIATE HEAP TYPICAL SECTION AND ...
			84-4511	60935	W 85-4042

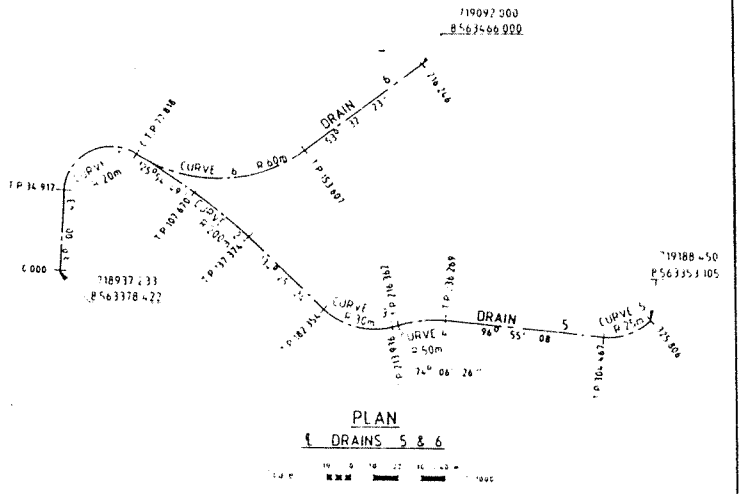
A1



CONTOUR PLAN

CURVE DATA

	DRAIN 5					DRAIN 6
	CURVE 1	CURVE 2	CURVE 3	CURVE 4	CURVE 5	CURVE 6
DEFLECTION ANGLE	122° 54 03	8° 30 35	60° 18 59	22° 48 42"	48° 54 22	72° 22 26
TANGENT LENGTH	30 760	14 880	17 431	10 087	11 368	43 892
ARC LENGTH	42 900	29 705	31 582	19 907	21 339	75 790
SECANT LENGTH	21 848	0 553	4 696	1 007	2 464	14 341



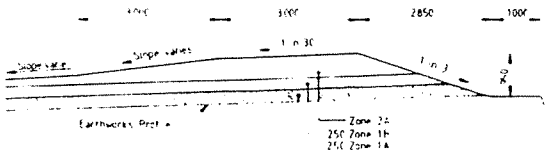
PLAN
DRAINS 5 & 6

LEGEND

- Existing Contours
- Design Contours
- Drains 5 & 6 ℄
- Erosion Control Drains

NOTES

1. Drain 5:
   Ch 34 917 to 200 construct with 4000 x 2000 x 300 wire Mattresses, Base 2000 wide
   Batter slopes 2 to 1
   Drain 6 & Drain 5 Ch 200 to 325 806 construct with Rip-Rap, Base 2000 wide
   Batter slopes 3 to 1
   Drain 5 Ch 00 to 34 917 Refer Detail, Sheet 7
2. Earthworks dimensions from Cross Section sheets 26 to 41
3. Location of Drains 5 & 6 shall be confirmed on the site
4. Design Contours are to Earthworks finished surface level



TYPICAL EDGE TREATMENT

Cameron McNamara

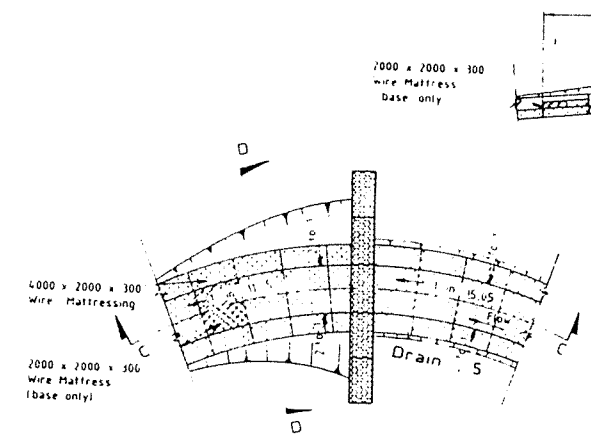
WATER DIVISION
DEPARTMENT OF TRANSPORT AND WORKS

RUM JUNGLE REHABILITATION
STAGE 4.1
DYSON'S HEAP
SETTING OUT, LEVELLING AND DRAINAGE PLAN

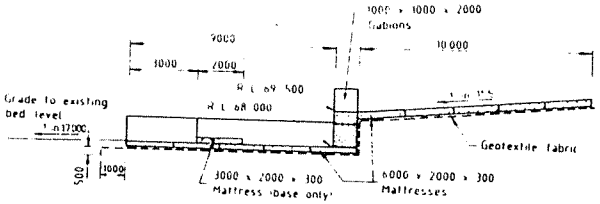
84 4511 | 60936

W 85-4042
SHEET 6 OF 40 SHEETS

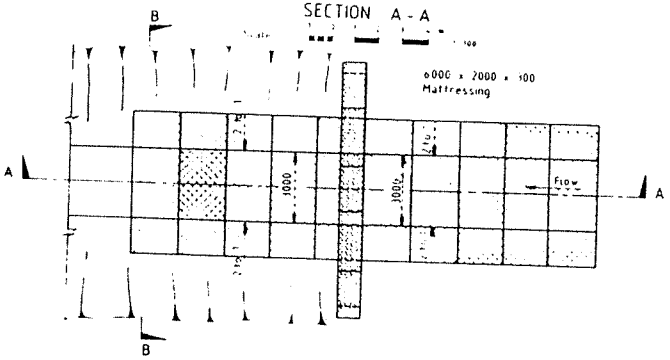
A1



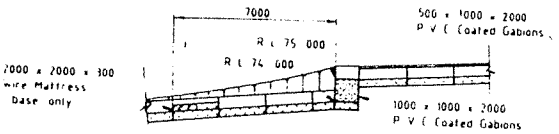
DROP STRUCTURE D3



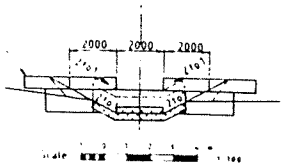
SECTION A - A



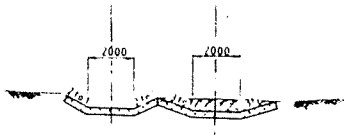
DROP STRUCTURE D2



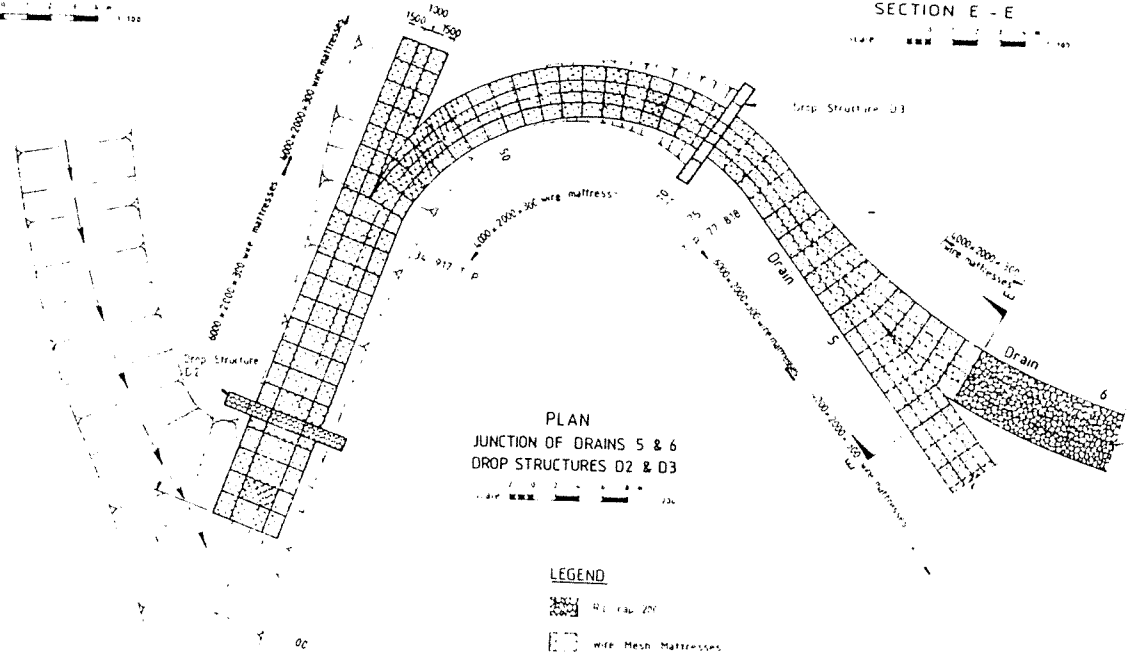
SECTION C-C



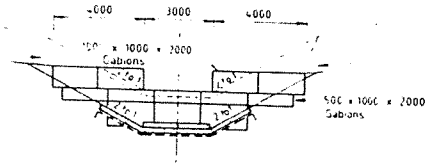
SECTION D-D



SECTION E - E



PLAN
JUNCTION OF DRAINS 5 & 6
DROP STRUCTURES D2 & D3



SECTION B - B

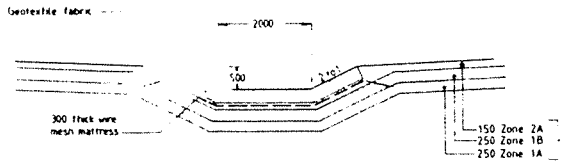
LEGEND

- R L rail 20
- wire Mesh Mattresses
- Gabions

NOTES

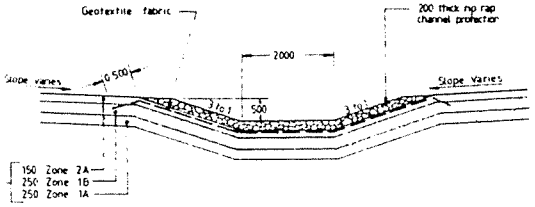
1. All levels to be checked on site prior to commencement of work
2. The existing ground surface in the vicinity of the [illegible] structure is to be levelled as shown and as directed by the Superintendent
3. Wire Mesh Mattresses shall be P.V.C. coated. General sizes to be 6000 x 2000 x 300 and 6000 x 2000 x 300 unless otherwise shown

Cameron McNamara	WATER DIVISION, DEPARTMENT OF TRANSPORT AND WORKS	RUM JUNGLE REHABILITATION STAGE 4.1 DYSONS HEAP DRAINAGE		
84-4511	60937			W 85 1042



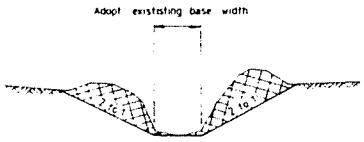
TYPICAL SECTION
WIRE MATTRESS PROTECTION

SCALE 0.5 0 0.5 1.0 1.5 2.0 m

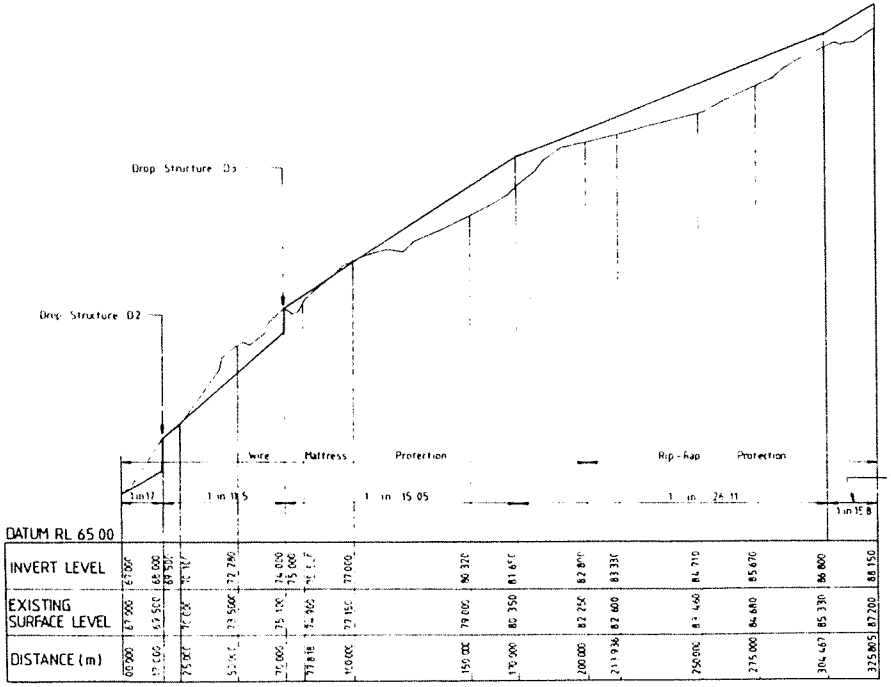


TYPICAL SECTION
RIP-RAP PROTECTION

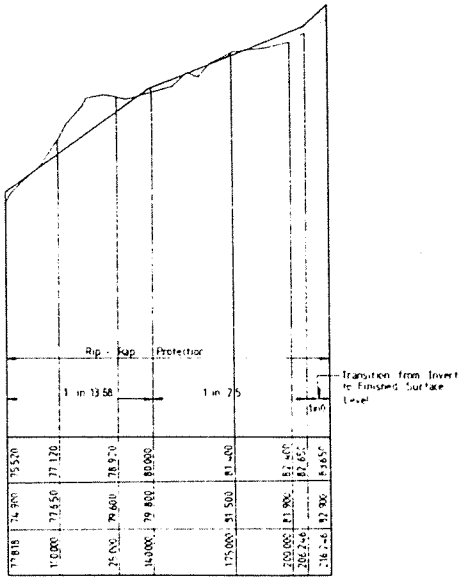
SCALE 0.5 0 0.5 1.0 1.5 2.0 m



TYPICAL DETAIL
EXCAVATION TO DYSONS DRAIN
NTS



DRAIN 5

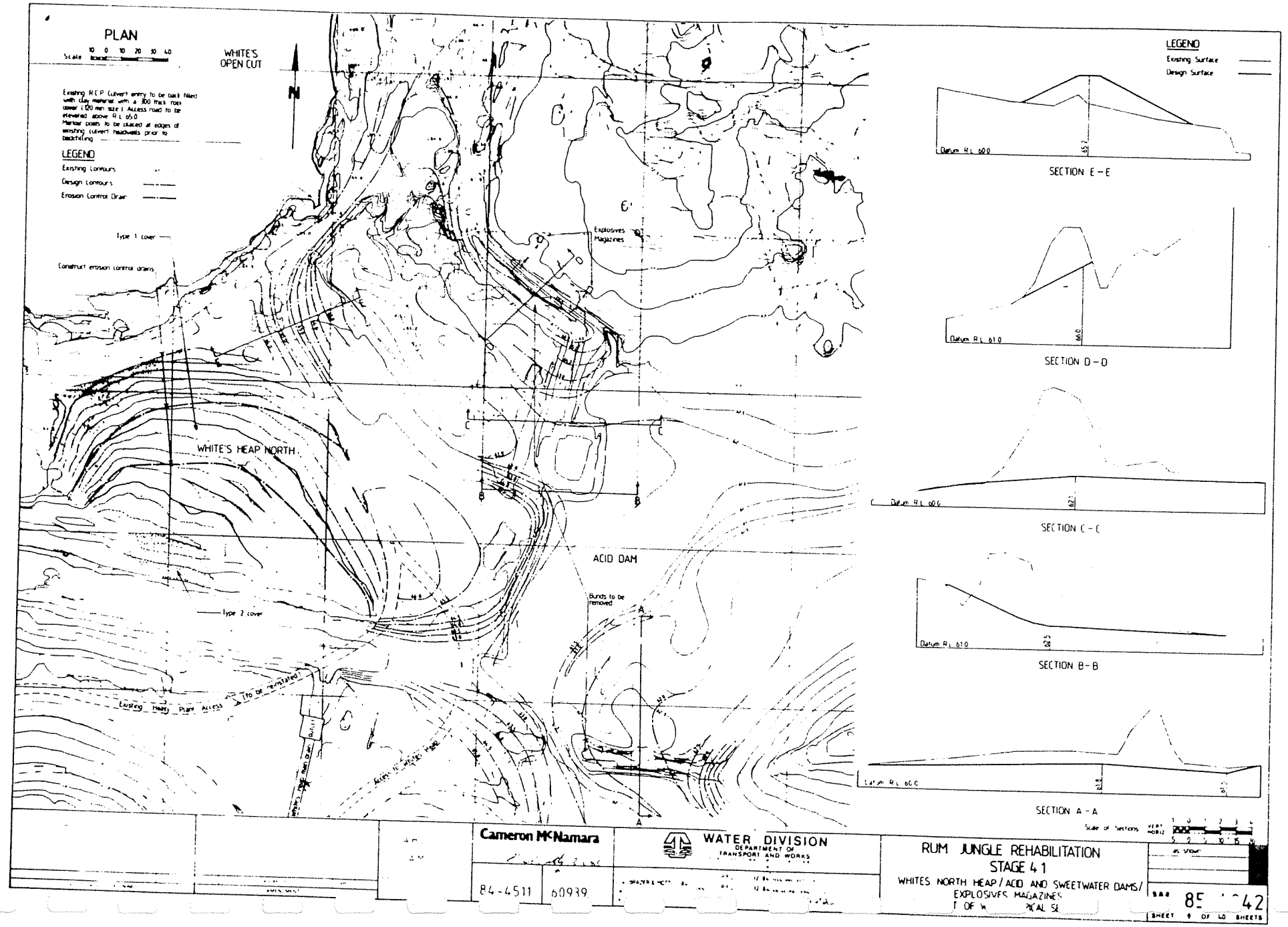


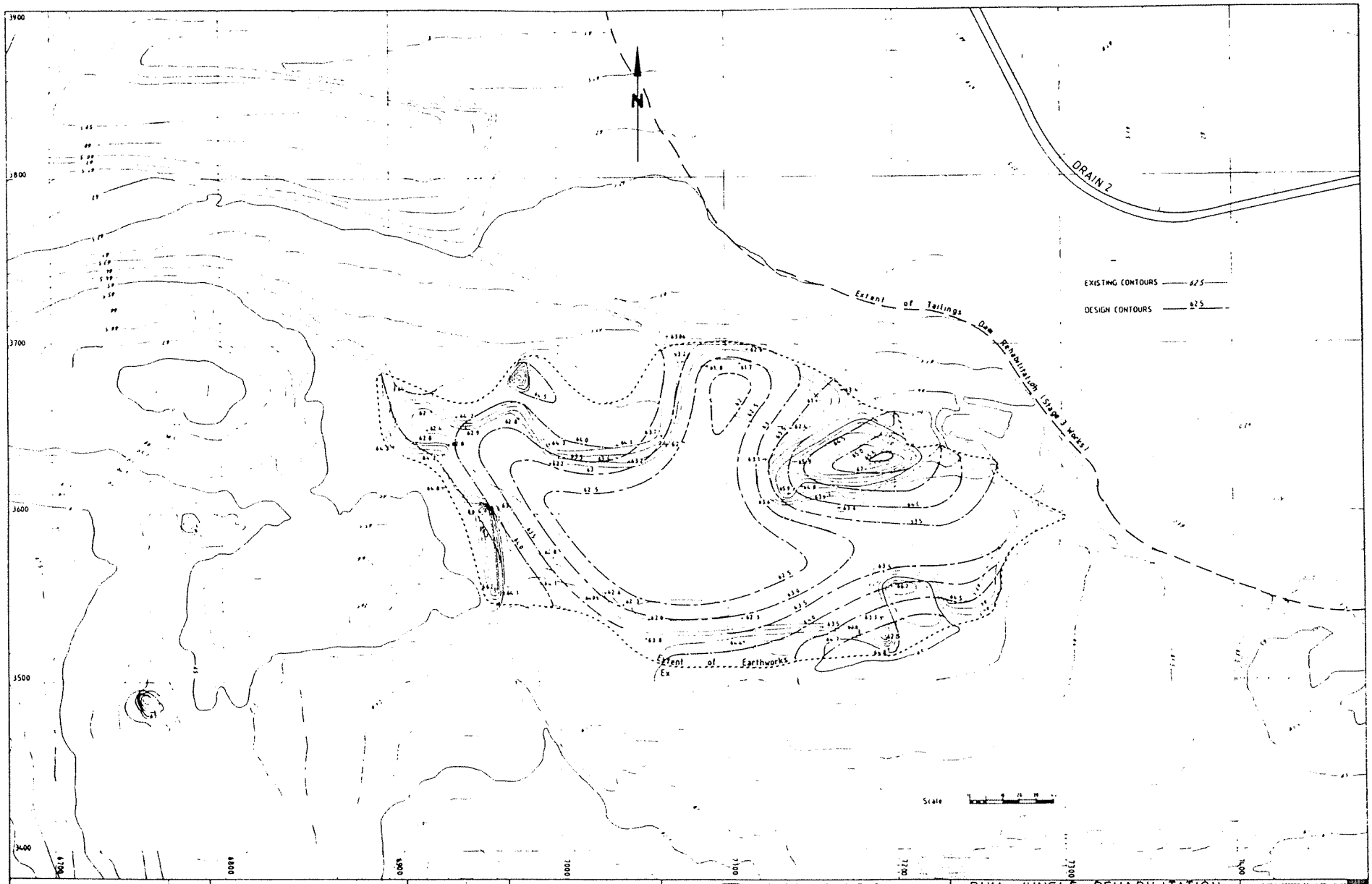
DRAIN 6

LONGITUDINAL SECTIONS

SCALE HORIZ 1:500 VERT 1:50

Cameron McNamara	WATER DIVISION	RUM JUNGLE REHABILITATION STAGE 4.1 DYSONS HEAP TYPICAL SECTIONS AND DETAILS
84-4511	60938	W 85-4042


PLAN
Scale
WHITE'S OPEN CUT
N
LEGEND
Existing Contours
Design Contours
Erosion Control Drain
Type 1 cover
Construct erosion control drains
Explosives Magazines
WHITE'S HEAP NORTH
ACID DAM
Bunds to be removed
Type 2 cover
Existing Heap Plant Access (To be reinstated)
LEGEND
Existing Surface
Design Surface
SECTION E-E
SECTION D-D
SECTION C-C
SECTION B-B
SECTION A-A
Cameron McNamara
WATER DIVISION
DEPARTMENT OF TRANSPORT AND WORKS
84-4511
60939
RUM JUNGLE REHABILITATION
STAGE 4.1
WHITES NORTH HEAP/ACID AND SWEETWATER DAMS/
EXPLOSIVES MAGAZINES
SHEET 9 OF 40 SHEETS

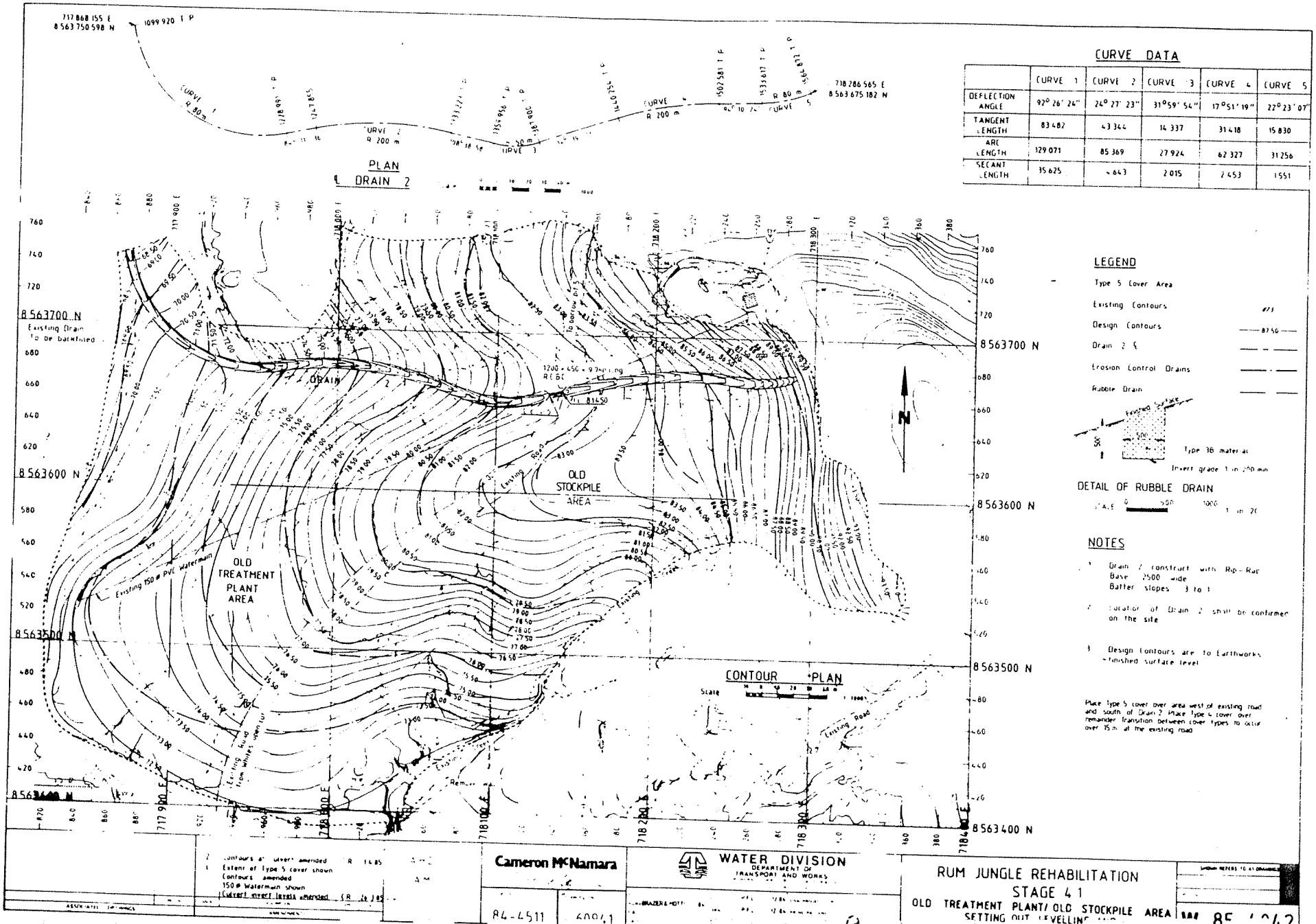


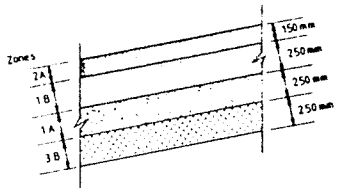
		AMD AMG	Cameron McNamara	WATER DIVISION DEPARTMENT OF TRANSPORT AND WORKS	RUM JUNGLE REHABILITATION STAGE 4.1 BORROW PIT 3 EXTENT OF EARTHWORKS & DRAINAGE
			84-4511	60940	PFL 2.85 BFG 2.85 JHB 2.85

W 85-4042

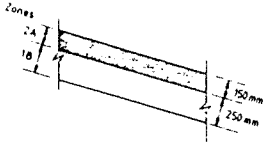
SHEET 10 OF 40 SHEETS

A1

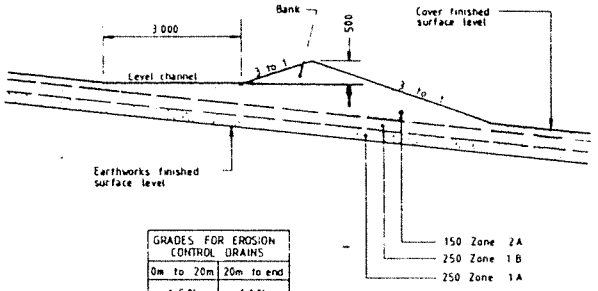

717 868 155 E
8 563 750 598 N
1099 920 T P
718 286 565 E
8 563 675 182 N
CURVE 1 R 80 m
CURVE 2 R 200 m
CURVE 3 R 30 m
CURVE 4 R 200 m
CURVE 5 R 80 m
PLAN
℄ DRAIN 2
CURVE DATA
CURVE 1
CURVE 2
CURVE 3
CURVE 4
CURVE 5
DEFLECTION ANGLE
92° 26' 24"
24° 27' 23"
31° 59' 54"
17° 51' 19"
22° 23' 07"
TANGENT LENGTH
83 482
43 344
14 337
31 418
15 830
ARC LENGTH
129 071
85 369
27 924
62 327
31 256
SECANT LENGTH
35 625
4 643
2 015
2 453
1 551
8563700 N
Existing Drain To be Backfilled
DRAIN 2
OLD TREATMENT PLANT AREA
OLD STOCKPILE AREA
Existing 150 ø PVC watermain
Existing Road
8563600 N
8563500 N
8563400 N
717 900 E
718 000 E
718 100 E
718 200 E
718 300 E
718 400 E
CONTOUR PLAN
Scale
LEGEND
Type 5 Cover Area
Existing Contours
Design Contours
Drain 2 ℄
Erosion Control Drains
Rubble Drain
Type 3B material
Invert grade 1 in 200 min
DETAIL OF RUBBLE DRAIN
SCALE
1 in 20
NOTES
1 Drain 2 construct with Rip-Rap Base 2500 wide Batter slopes 3 to 1
2 Location of Drain 2 shall be confirmed on the site
3 Design Contours are to Earthworks Finished surface level
Place Type 5 cover over area west of existing road and south of Drain 2 Place Type 4 cover over remainder transition between cover types to occur over 15 m at the existing road
Cameron McNamara
WATER DIVISION
DEPARTMENT OF TRANSPORT AND WORKS
RUM JUNGLE REHABILITATION
STAGE 4 1
OLD TREATMENT PLANT/ OLD STOCKPILE AREA
SETTING OUT LEVELLING
PLAN
84-4511
600/1
85 1042
SHEET 11 OF 40 SHEETS



TYPE 5 COVER



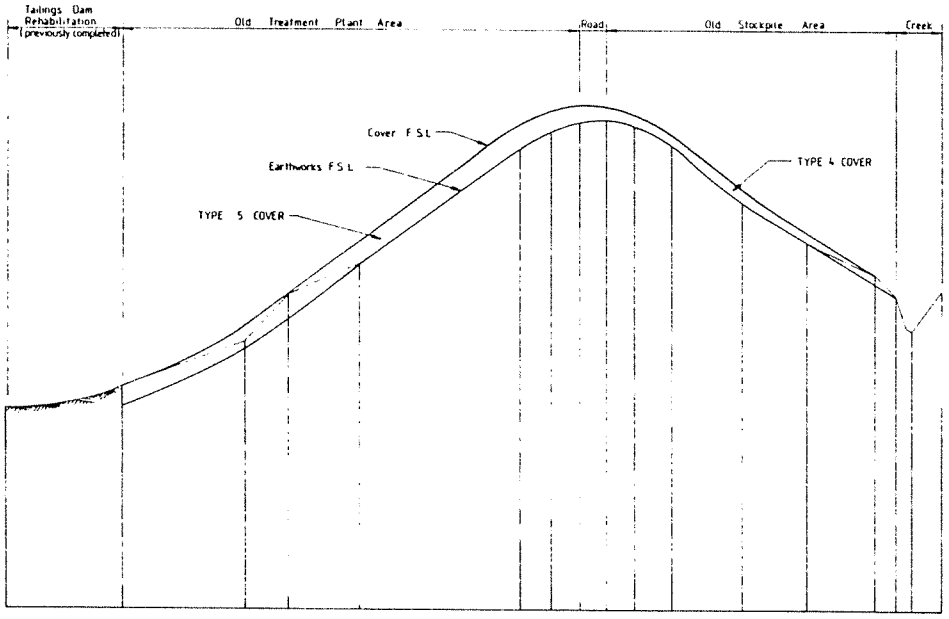
TYPE 4 COVER



GRADES FOR EROSION CONTROL DRAINS	
0m to 20m	20m to end
1.5%	1.0%

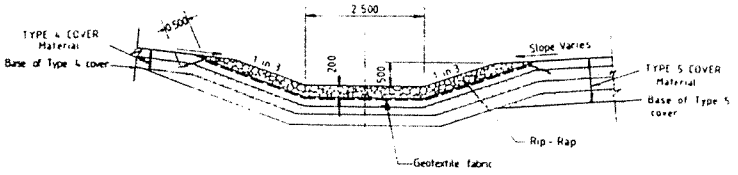
EROSION CONTROL DRAIN DETAILS

SCALE 1 0.5 0 1 2 1 50



TYPICAL SECTION

SCALE VERT 1 0 1 2 3 4 5 1 100
HORIZ 5 0 5 10 15 20 25 1 500

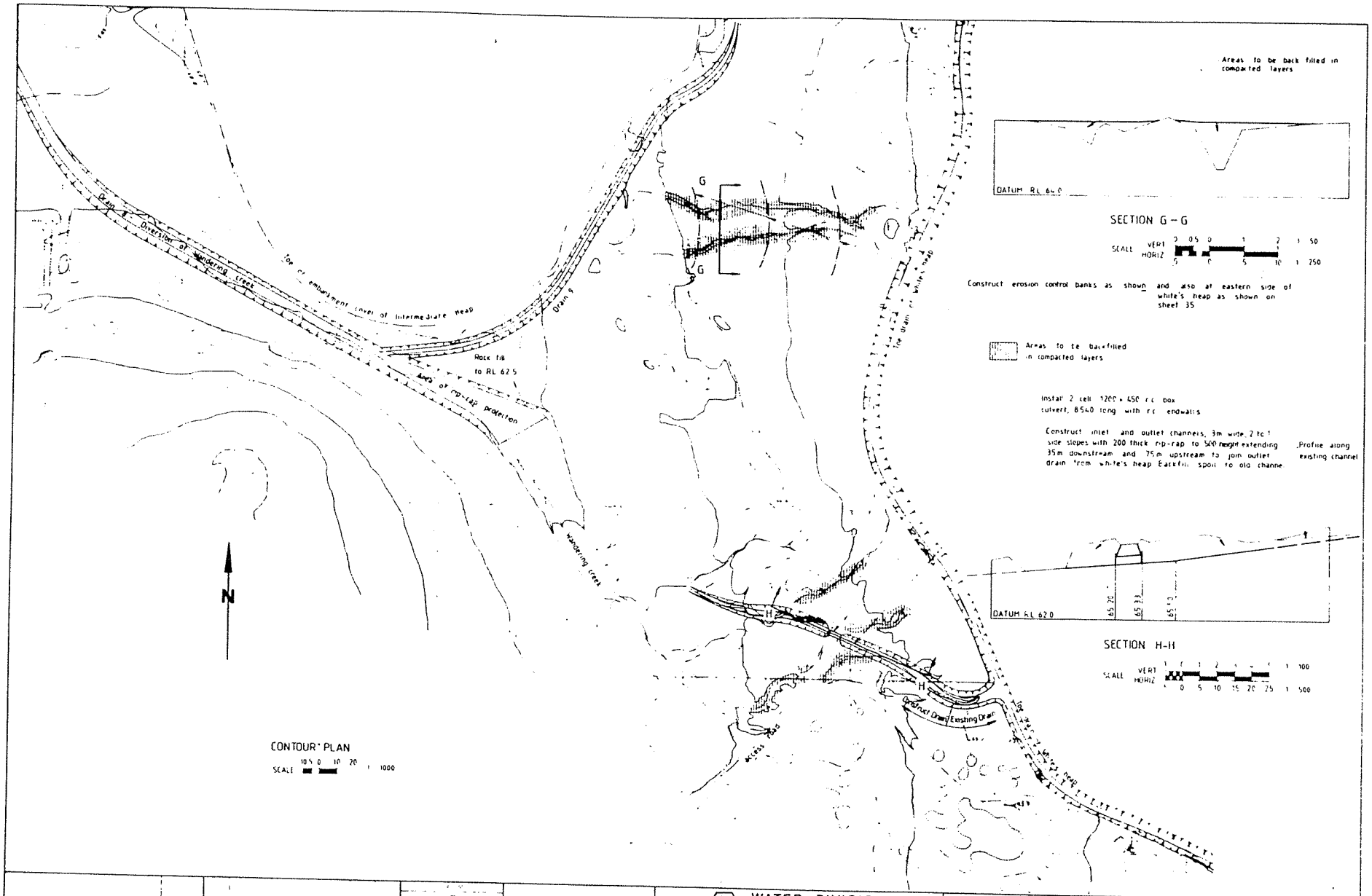


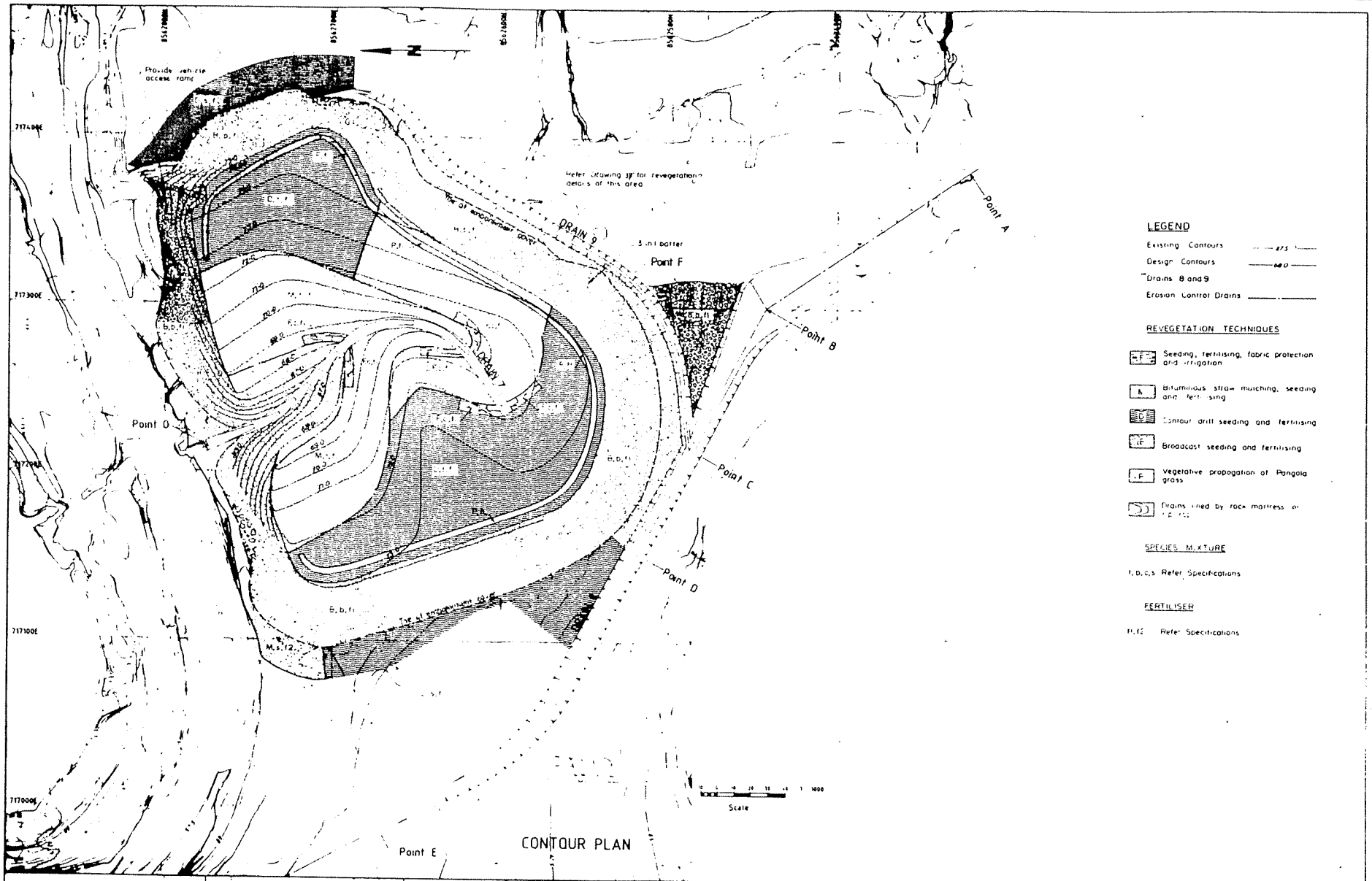
TYPICAL SECTION DRAIN 2

SCALE 1 0.5 0 1 2

	1 Typical section Drain 2 Amended (R 25-3-85)	AHD AMG	Cameron McNamara	WATER DIVISION DEPARTMENT OF TRANSPORT AND WORKS	RUM JUNGLE REHABILITATION STAGE 4.1 OLD TREATMENT PLANT/OLD STOCKPILE AREAS TYPICAL SECTIONS & DETAILS	W 85-4042
			84-4511	60942		SHEET 12 OF 40 SHEETS

A1


Areas to be back filled in compacted layers
DATUM RL 64.0
SECTION G-G
SCALE VERT HORIZ
Construct erosion control banks as shown and also at eastern side of white's heap as shown on sheet 35
Areas to be backfilled in compacted layers
Install 2 cell 1200 x 450 rc box culvert, 8540 long with rc endwalls
Construct inlet and outlet channels, 3m wide, 2 to 1 side slopes with 200 thick rip-rap to 500 height extending 35m downstream and 75m upstream to join outlet drain from white's heap Backfill spoil to old channe
Profile along existing channel
DATUM RL 62.0
SECTION H-H
SCALE VERT HORIZ
Rock fill to RL 62.5
Toe of embankment cover of intermediate heap
Drain 9
Diversion of Wandering Creek
Wandering Creek
Toe drain of white's heap
Outlet Drain Existing Drain
CONTOUR PLAN
SCALE
N
AMENDMENT 1 SECTION G-G CORRECTED
AMD
AML
Cameron McNamara
84-4511
60943
WATER DIVISION
DEPARTMENT OF TRANSPORT AND WORKS
RUM JUNGLE REHABILITATION
STAGE 4.1
INTERMEDIATE HEAP AND WHITES HEAP ENVIRONS
W 85 1242
SHEET 13 OF 40 SHEETS



LEGEND

Existing Contours

Design Contours

Drains 8 and 9

Erosion Control Drains

REVEGETATION TECHNIQUES

Seeding, fertilising, fabric protection and irrigation

Bituminous straw mulching, seeding and fertilising

Contour drill seeding and fertilising

Broadcast seeding and fertilising

Vegetative propagation of Pangola grass

Drains lined by rock mattress or

SPECIES MIXTURE

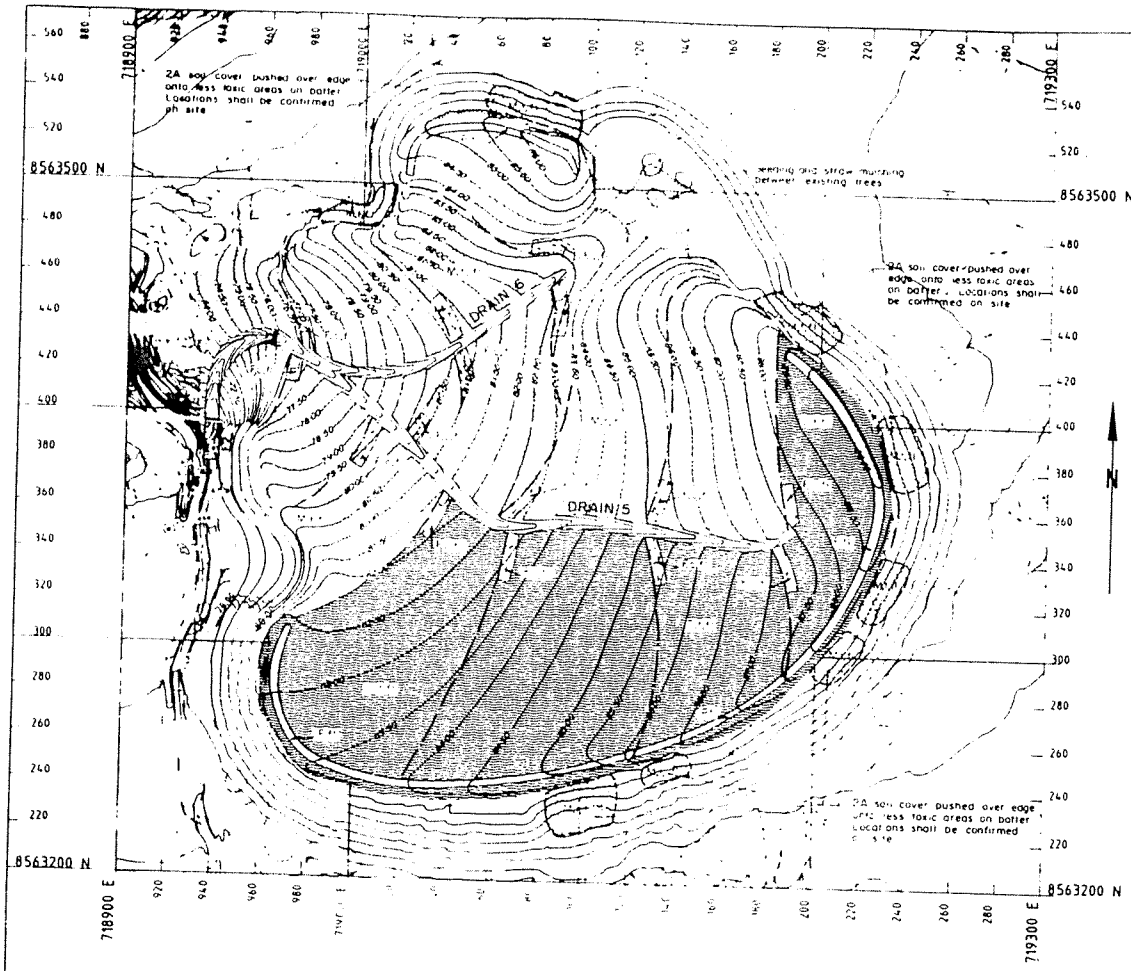
Refer Specifications

FERTILISER

Refer Specifications

		A.M.C. A.M.C.	Cameron McNamara	WATER DIVISION DEPARTMENT OF TRANSPORT AND WORKS	RUM JUNGLE REHABILITATION STAGE 4 1 INTERMEDIATE HEAP REVEGETATION LAYOUT	W 85-4042 SHEET 34 OF 48 SHEETS
			JOB NO. 84-4511	DRAWING NO. 60964	DRAZER & HOTH	DRN B.A.F. 30 1 85 DES M.D.C. 1 2 85 CHD P.A.R. 4 2 85

A1



CONTOUR PLAN

LEGEND

Existing Contours ——— 875 ———

Design Contours ——— 875 ———

Drains 5 and 6

Erosion Control Drains ———·———

REVEGETATION TECHNIQUES

F Seeding, fertilising, fabric protection and irrigation

M Bituminous straw mulching, seeding and fertilising

MN Straw mulching, seeding, fertilising and netting

Contour drill seeding and fertilising

P Vegetative propagation of Pangola grass

Protected by rock mattress or

REFER SPECIFICATIONS

Refer Specifications

FERTILISER

Refer Specifications

Cameron McNamara

WATER DIVISION
DEPARTMENT OF TRANSPORT AND WORKS

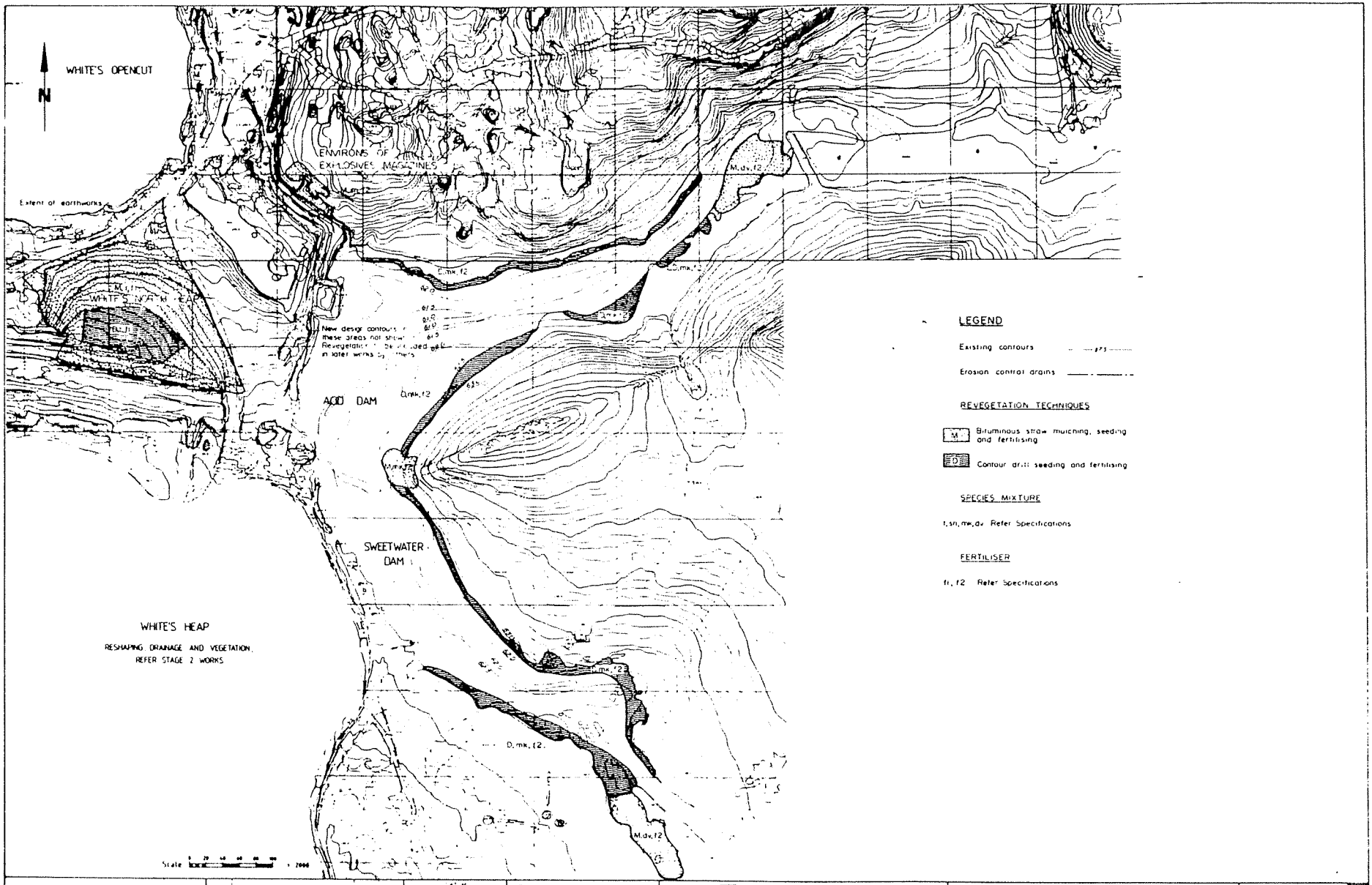
BRAZER & HOTH

RUM JUNGLE REHABILITATION
STAGE 4 1
DYSON'S HEAP
REVEGETATION LAYOUT

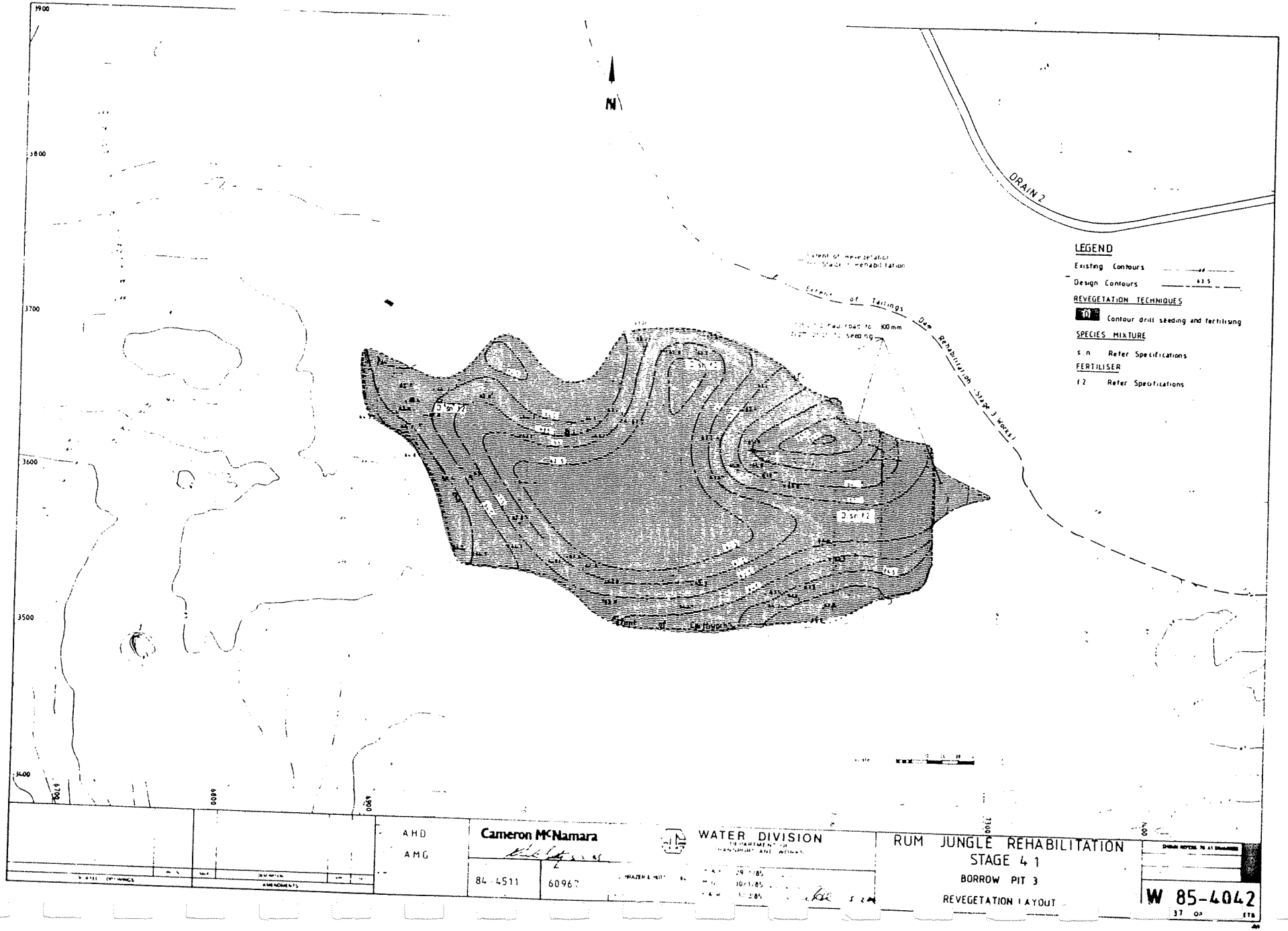
84 — 4511

60965

W 85. 10/2



		AHD AMG	Cameron McNamara	WATER DIVISION, DEPARTMENT OF TRANSPORT AND WORKS	RUM JUNGLE REHABILITATION STAGE 4.1
			Job No. 84-4511	Drawing No. 609	WHITE'S NORTH HEAP/ACID AND SWEETWATER DAMS/ EXPLOSIVES MAGAZINES REVEGETATION LAYOUT
				BRAZIER & MOTTI	W 85-4042
					SHEET 16 OF 40 SHEETS
ASSOCIATED CONSULTANTS	DESCRIPTION AMENDMENTS				A1



AHD
AMG

Cameron McNamara

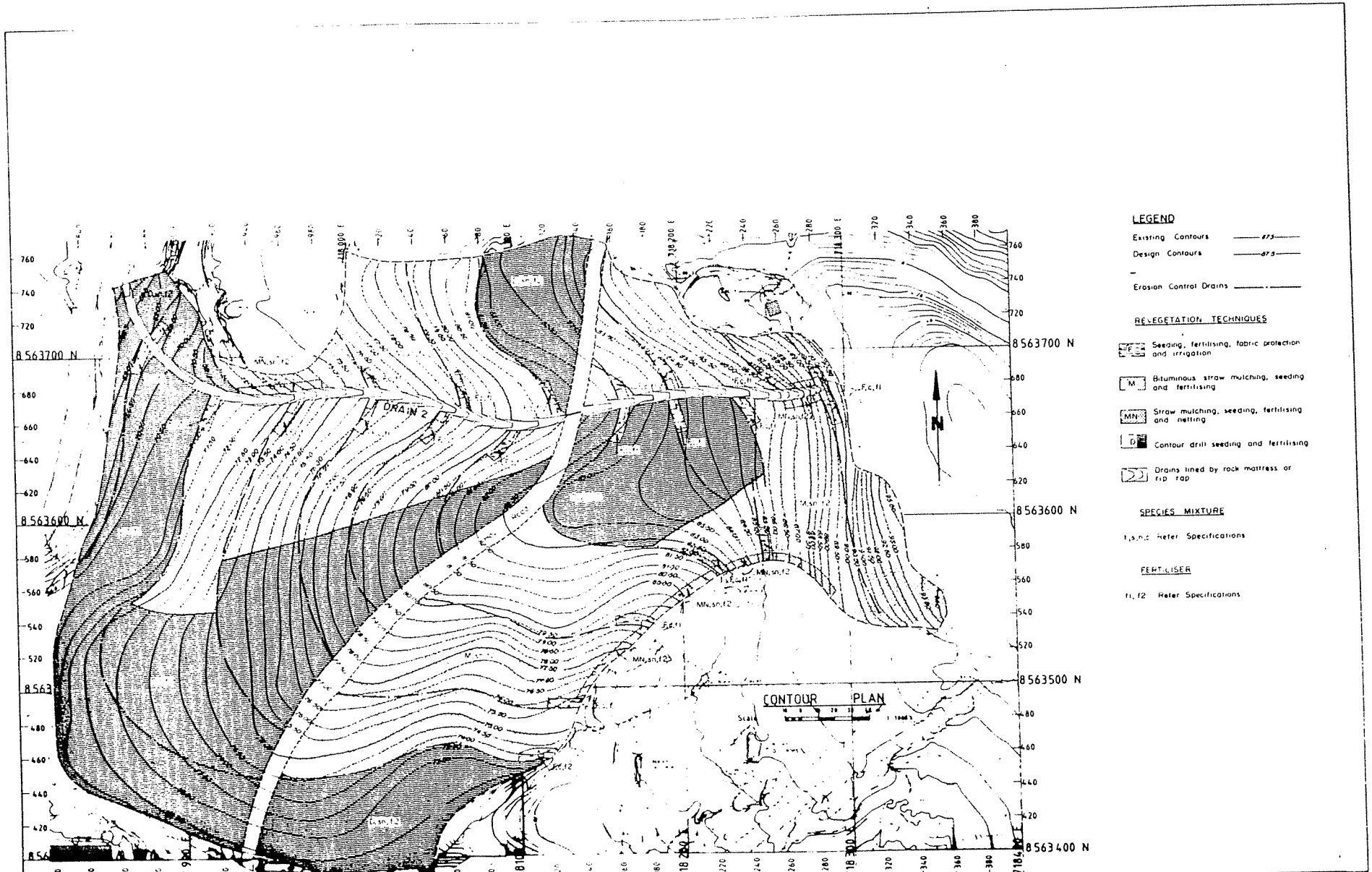
WATER DIVISION

84-4511

60967

RUM JUNGLE REHABILITATION
STAGE 4.1
BORROW PIT 3
REVEGETATION LAYOUT

W 85-4042



Cameron McNamara

WATER DIVISION
DEPARTMENT OF TRANSPORT AND WORKS
NORTHERN TERRITORY OF AUSTRALIA

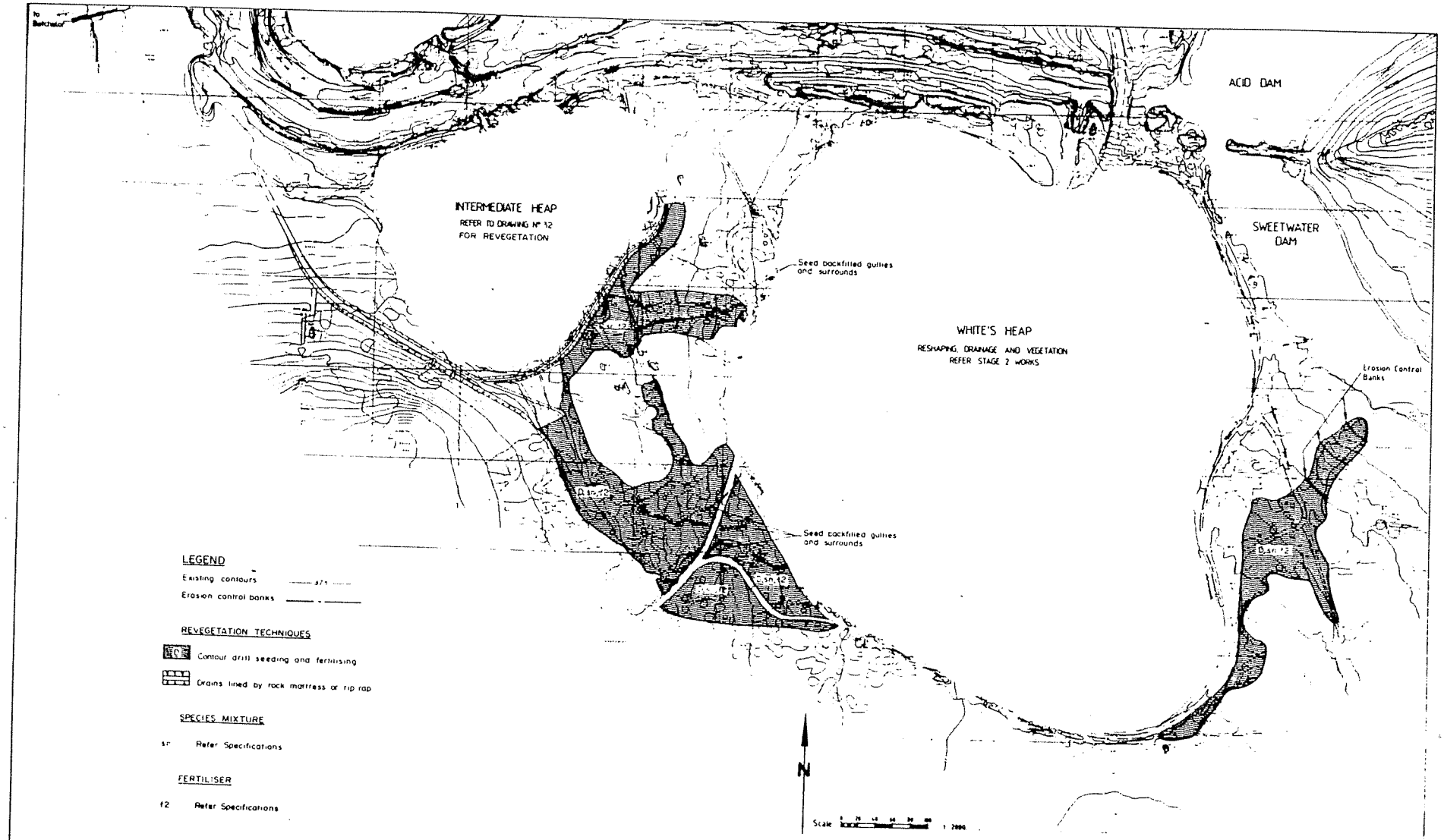
BRAZIER & MOTH

84-4511

60968

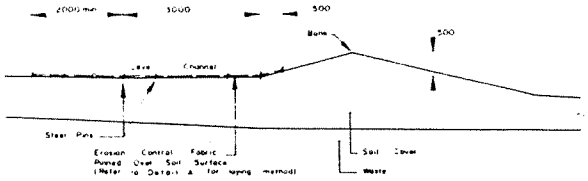
RUM JUNGLE REHABILITATION
STAGE 4 1
OLD TREATMENT PLANT/OLD STOCKPILE AREA
REVEGETATION LAYOUT

W 85-4042
SHEET 38 OF 40 SHEETS

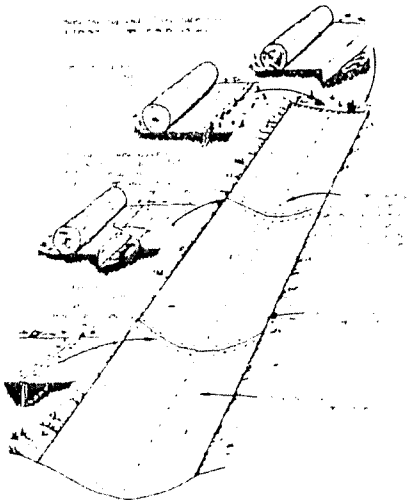


				AHD	Cameron McNamara Consultants	WATER DIVISION DEPARTMENT OF TRANSPORT AND WORKS	RUM JUNGLE REHABILITATION STAGE 4.1
				AMG	Job No. 84-4511	Drawing No. 60969	INTERMEDIATE AND WHITE'S HEAPS ENVIRONS REVEGETATION LAYOUT
ASSOCIATED DRAWINGS		AMENDMENTS			FRAZER & MOTTI	BAF 4 2 85 MDC 4 2 85 PAR 4 2 85	W 85-4042

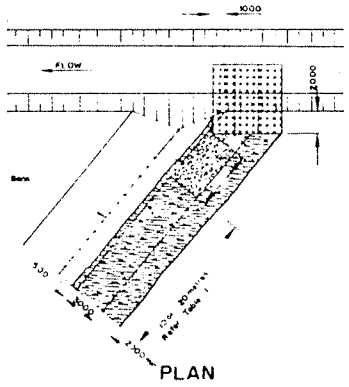
TYPICAL LAYING OF EROSION CONTROL FABRIC IN DRAINS



SECTION



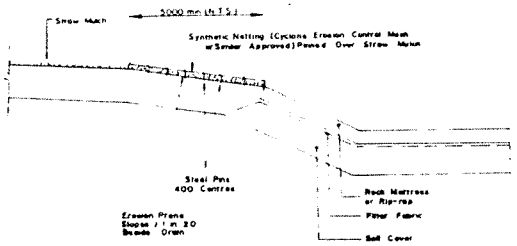
DETAIL A — LAYING EROSION CONTROL FABRIC ALONG DRAINS



PLAN

LEGEND

- Rip-rap 200 Thks
- Reno Mattress or Similar Approved
- Erosion Control Fabric



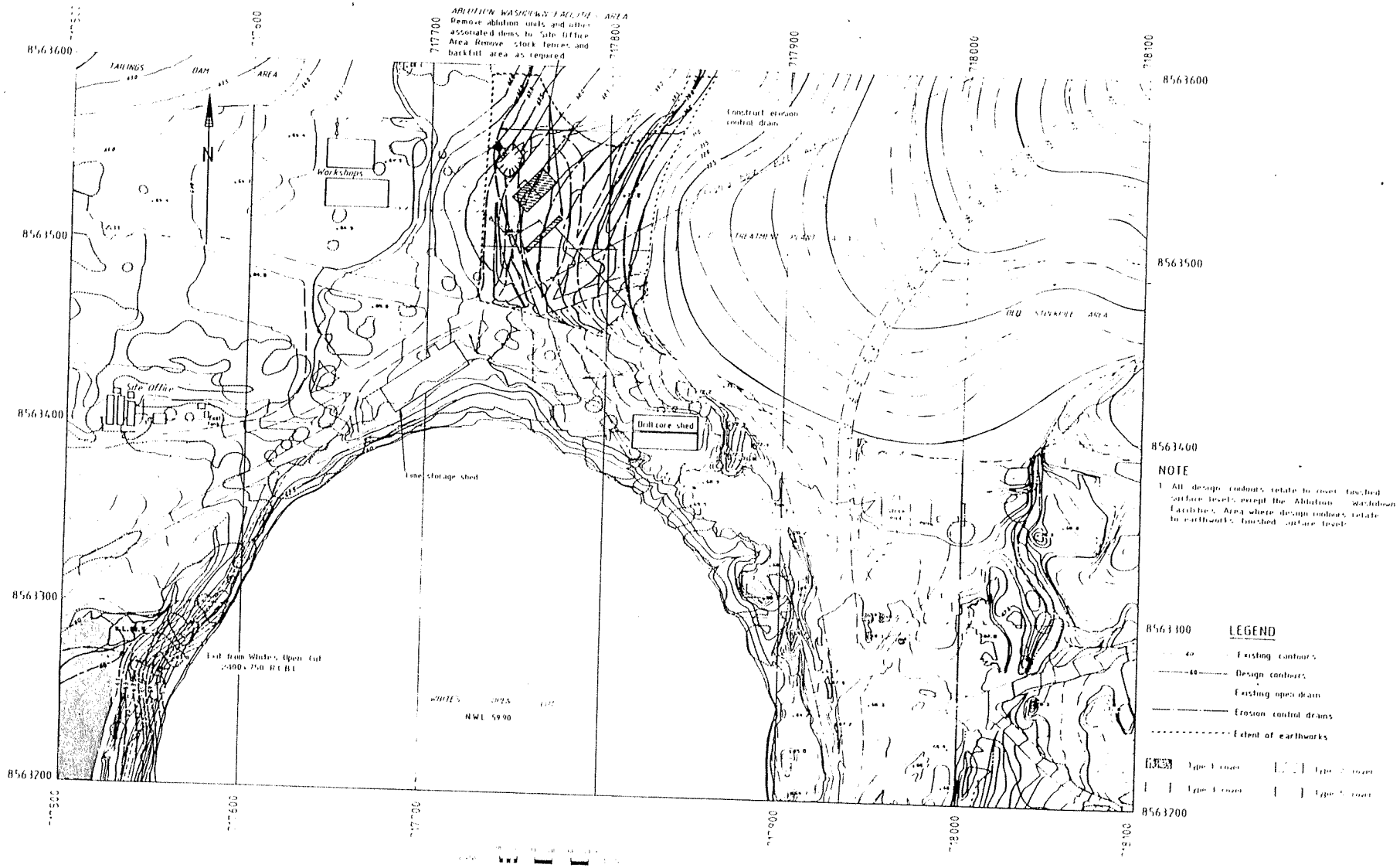
TYPICAL LAYING OF NETTING OVER STRAW MULCH ON EROSION PRONE SLOPES

Table I.

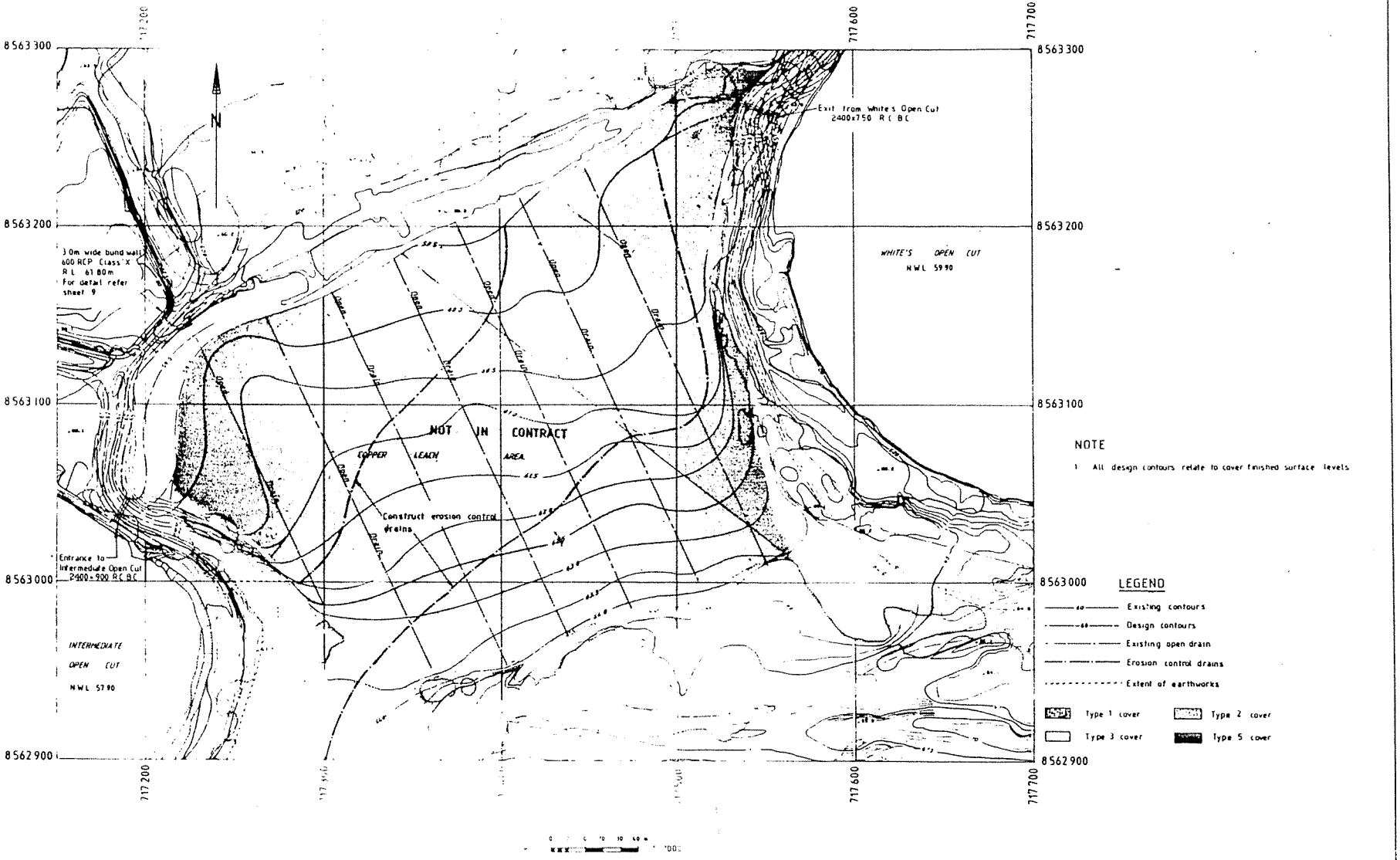
TOTAL LENGTH OF DRAIN	LENGTH LINED WITH EROSION CONTROL FABRIC
Less than 40 m	0 - 10m
Greater than 40 m	0 - 20m

ASSOCIATED DRAWINGS		AMENDMENTS		DATUM AHD / AMG	Cameron McNamara	WATER DIVISION DEPARTMENT OF TRANSPORT AND WORKS NORTHERN TERRITORY OF AUSTRALIA	RUM JUNGLE REHABILITATION STAGE 4.1 REVEGETATION TYPICAL DETAILS
					84-4511 / 60970	DES BF 4.2.85 / DRN KB 4.2.85 / CHD PAR 4.2.85	W 85-4042 SHEET 48 OF 48 SHEETS

A1



1	Extent of Works Amended				
		A.H.D.	Cameron McNamara	WATER DIVISION DEPARTMENT OF TRANSPORT AND WORKS	RUM JUNGLE REHABILITATION STAGE 4.2 WHITE'S OPEN CUT / ABLUTION WASHDOWN FACILITIES AREA
		A.M.G.	84-4511 71104		W85-401.9



Cameron McNamara

WATER DIVISION
DEPARTMENT OF TRANSPORT AND WORKS

71105

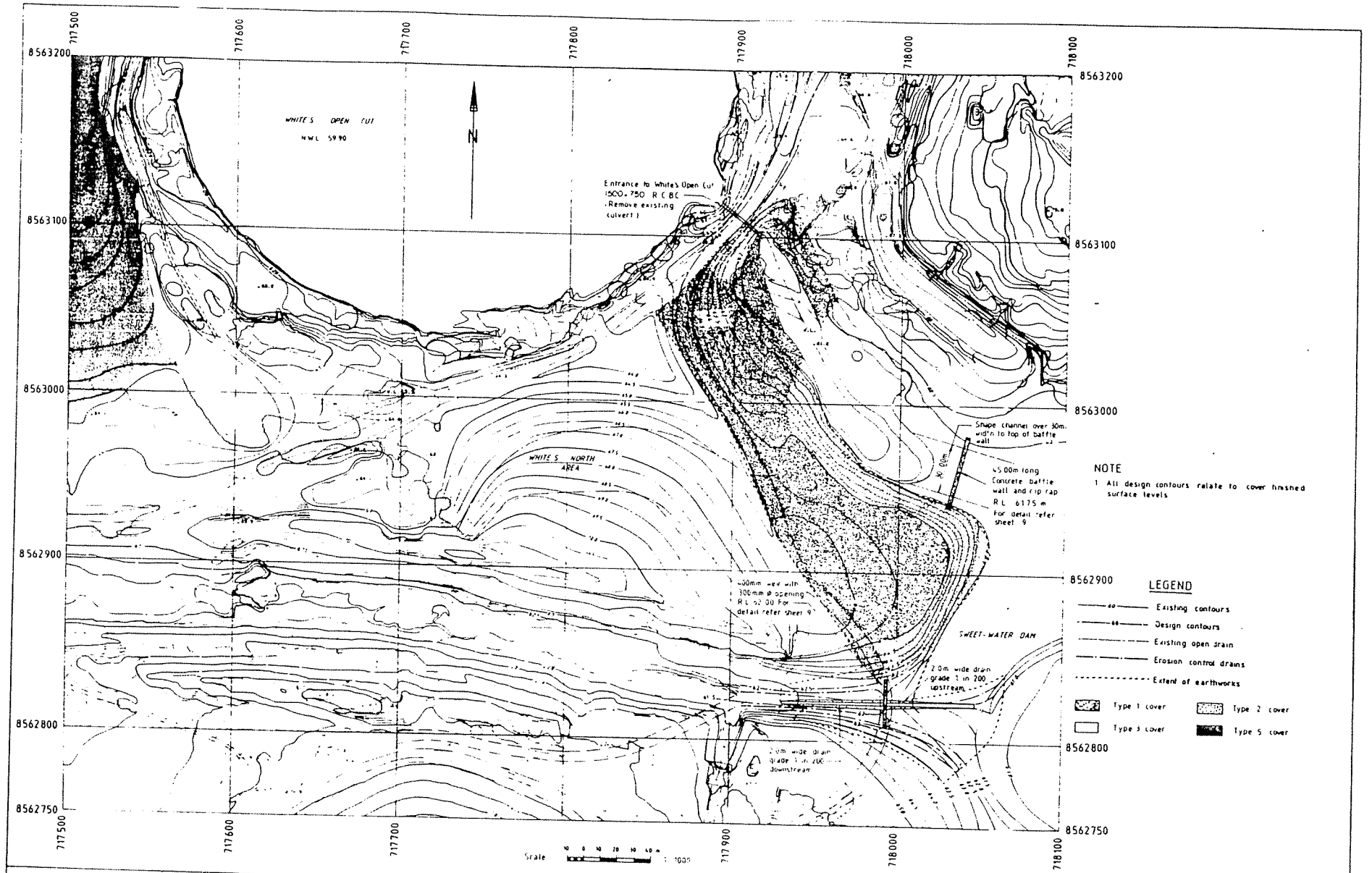
J B 4.85
B F G 5.85
J H B 5.85

RUM JUNGLE REHABILITATION
STAGE 4.2
INTERMEDIATE OPEN CUT/COPPER LEACH AREA
AND WHITE'S OPEN CUT
EXTENT OF WORKS

... AS SHOWN

W85-4049

SHEET 4 OF 17 SHEETS



NOTE

1 All design contours relate to cover finished surface levels

LEGEND

- Existing contours
- Design contours
- Existing open drain
- Erosion control drains
- Extent of earthworks
- Type 1 cover
- Type 2 cover
- Type 3 cover
- Type 5 cover

1 Extent of Works Amended

A H D
A M G

Cameron McNamara

WATER DIVISION
DEPARTMENT OF TRANSPORT AND WORKS

Job no 84-4511
Drawing no 71106

RUM JUNGLE REHABILITATION
STAGE 4.2
WHITE'S OPEN CUT / WHITE'S NORTH AREA / SWEET-WATER DAM

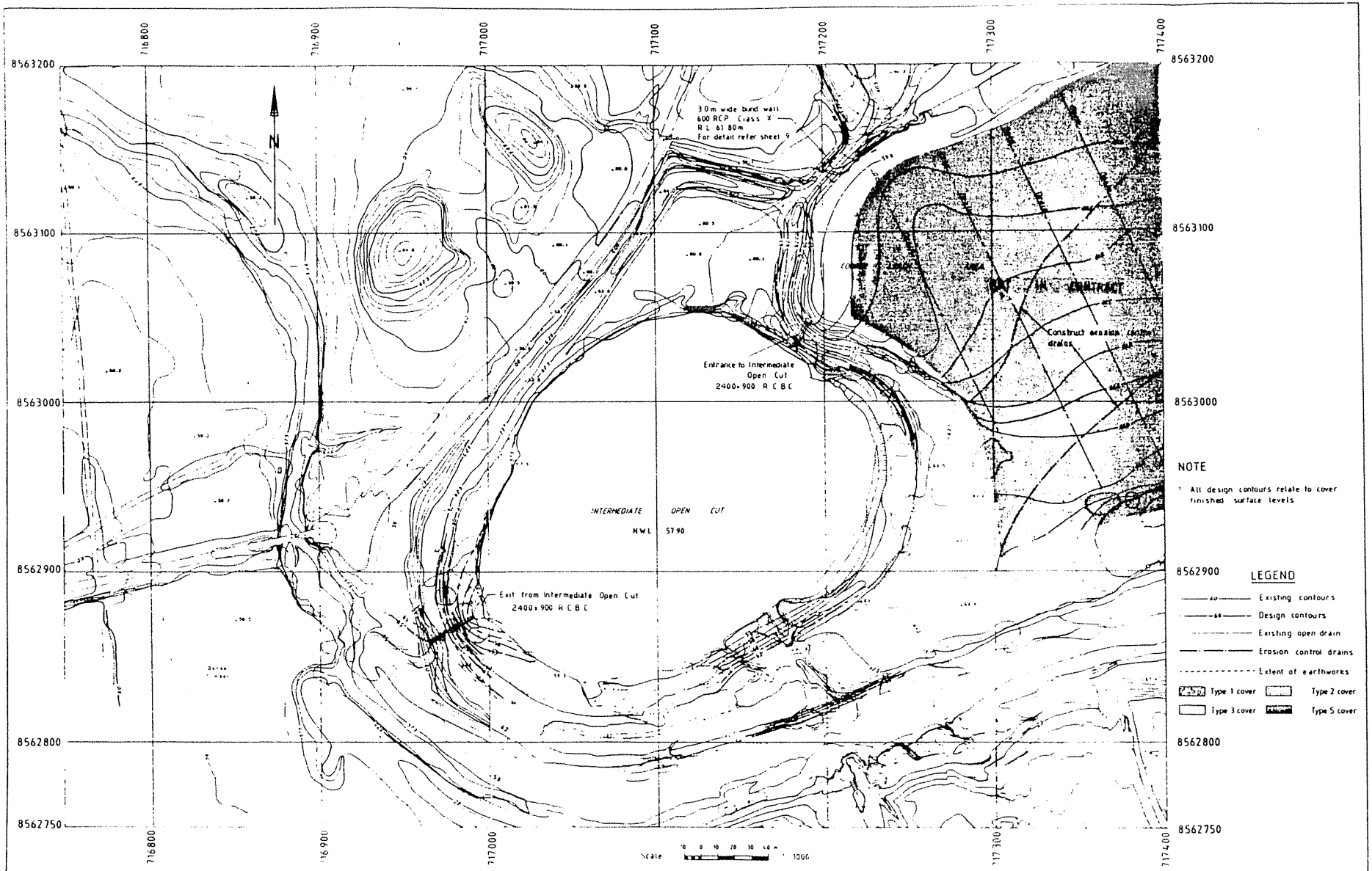
AS SHOWN

W85-1.01.9

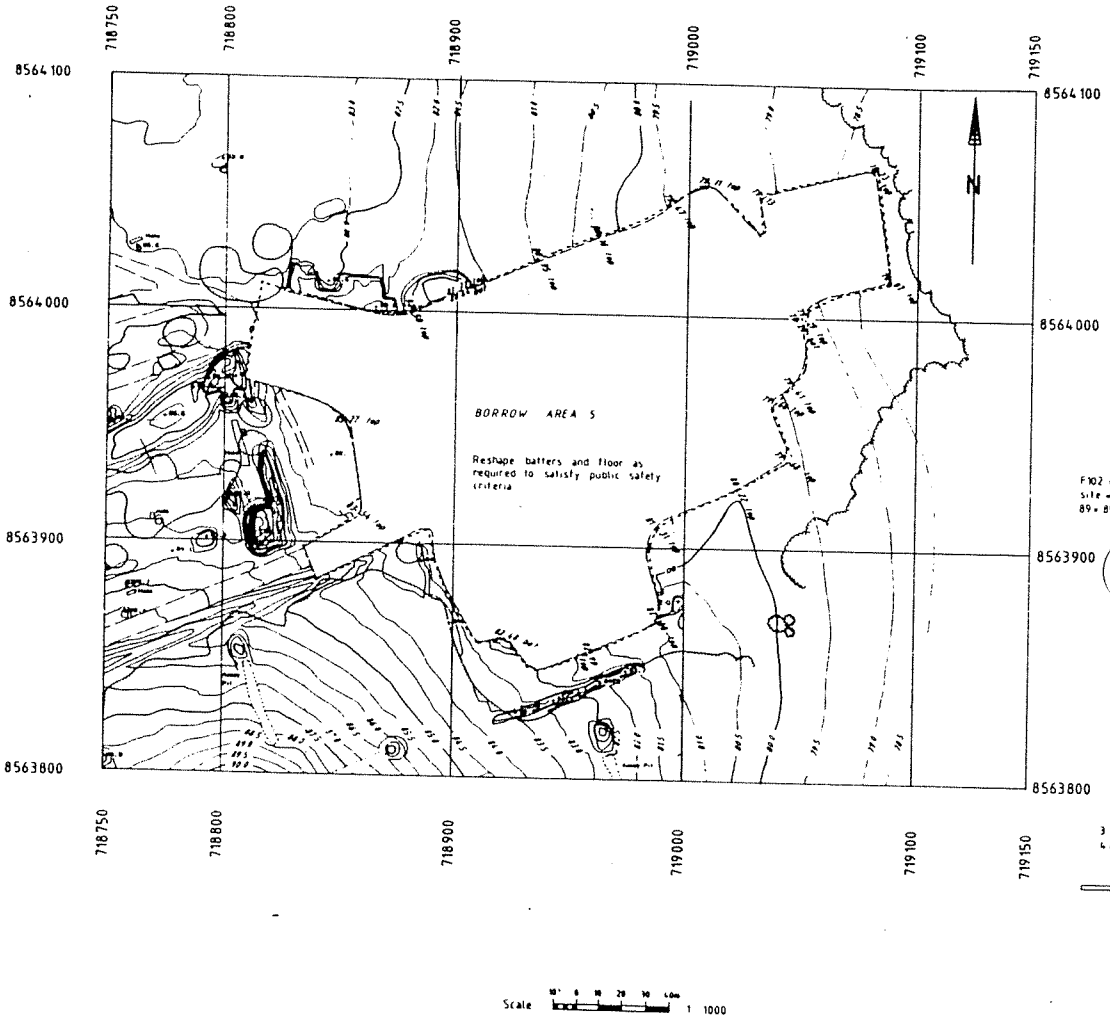
EXTEN W

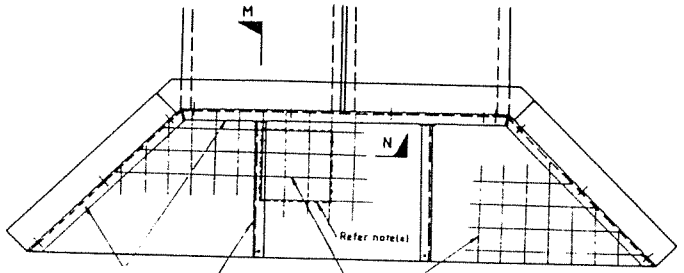
SHEETS

A1



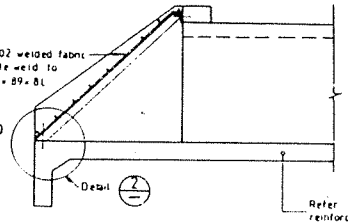
1 Extent of Works Amended	A H D	Cameron McNamara	WATER DIVISION DEPARTMENT OF TRANSPORT AND WORKS	RUM JUNGLE REHABILITATION STAGE 4.2 INTERMEDIATE OPEN CUT / COPPER LEACH AREA EXTENT OF WORKS	AS SHOWN
	A M G	Job No 84-4511	Drawing No 71107	J B 4.85 B F G 5.85 J H B 5.85	W85-4049 SHEET 6 OF 17 SHEETS





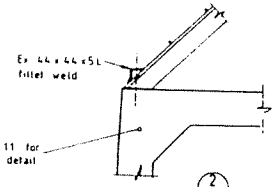
NOTE
(e) Cut 600 x 600 opening in F102 welded fabric Provide 600 x 600 door with F102 welded fabric hinged with welded W10 rings

ENTRANCE INLET GRATING DETAIL
(WHITE'S & INTERMEDIATE OPEN CUTS)



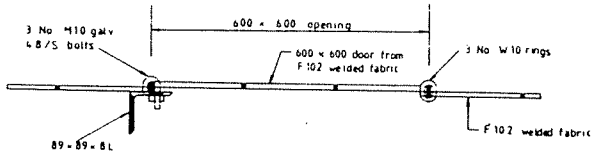
SECTION M – M

Scale 0.2 0 0.2 0.4 0.6 0.8m 1 20



DETAIL 2

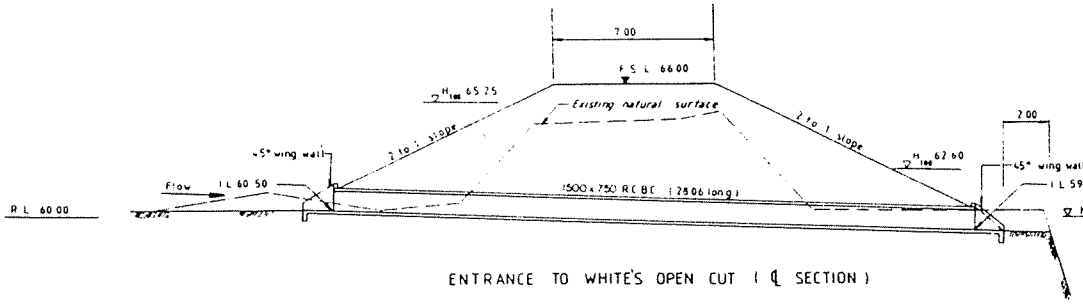
Scale 1 0 1 2 3 4m 1 100



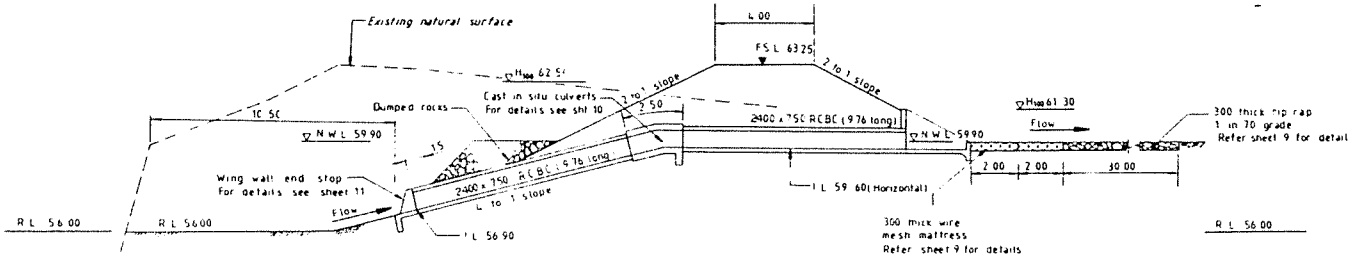
SECTION N – N

Scale 50 0 50 100 150 200 1 5

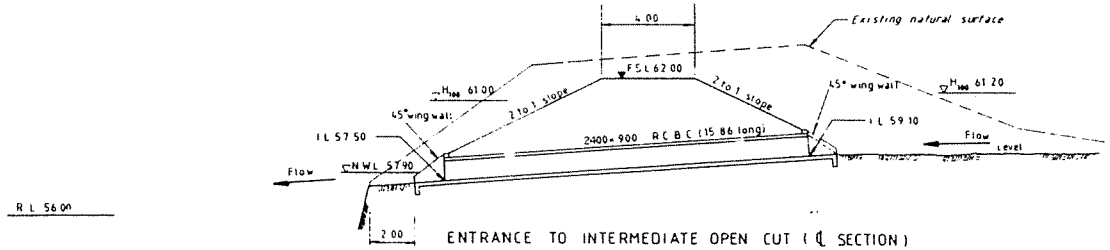
	AHD	Cameron McNamara	WATER DIVISION DEPARTMENT OF TRANSPORT AND WORKS	RUM JUNGLE REHABILITATION STAGE 4.2	AS SHOWN
	AMG	Job no 84	Drawing no 71108	BORROW AREA 5 EARTHWORKS/ENTRANCE STRUCTURES INLET GRATING DETAILS	W85-4049



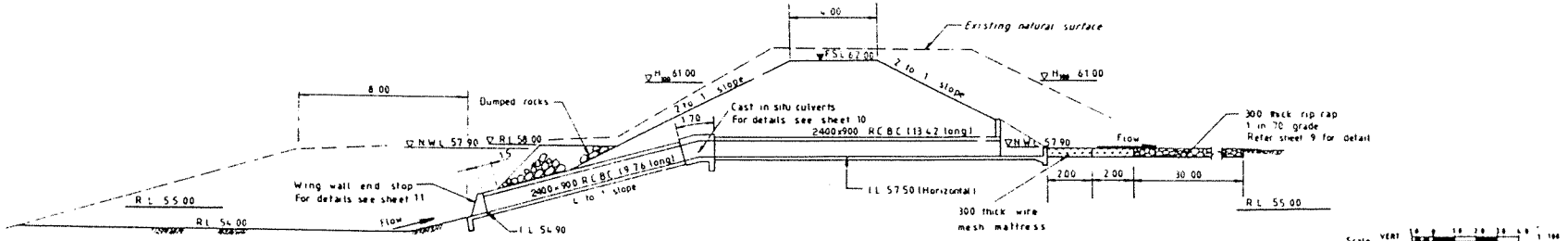
ENTRANCE TO WHITE'S OPEN CUT (℄ SECTION)



EXIT FROM WHITE'S OPEN CUT (℄ SECTION)



ENTRANCE TO INTERMEDIATE OPEN CUT (℄ SECTION)



EXIT FROM INTERMEDIATE OPEN CUT (℄ SECTION)

NOTES

1. All inlet and outlet excavations to match neatly to existing channels
2. Precast culverts on 4 to 1 slope shall be constructed with 2.44m long segments

Scale VERT 1:0 5 10 20 30 40 1:100
HORIZ 1:0 5 10 20 30 40

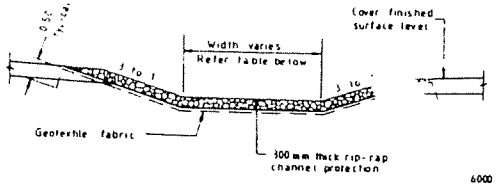
	1	Box Culvert Dimensions Amended Inlet Gratings Removed	C C A 4/Dec	DRAWN A M D CHECKED A M G	Cameron McNamara	WATER DIVISION DEPARTMENT OF TRANSPORT AND WORKS NORTHERN TERRITORY OF AUSTRALIA
					JOB NO. 84-4511	DRAWING NO. 71109
					DESIGNED BRAZIER & MOTTS 85	DRN J B 4.85 CHK B F G 5.85 CHK J M B 5.85

RUM JUNGLE REHABILITATION
STAGE 4.2
HYDRAULIC STRUCTURES TO WHITES AND INTERMEDIATE OPEN CUTS

AS SHOWN

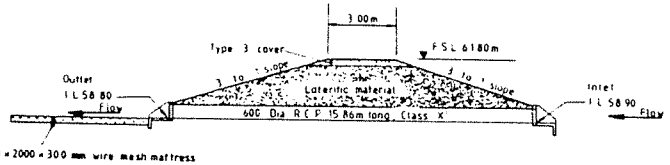
W85-4049

SHEET 8 OF 17 SHEETS



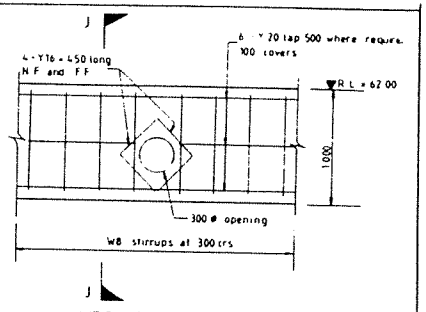
TYPICAL SECTION RIP-RAP PROTECTION

N T S

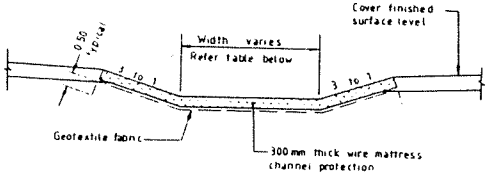


3.0m WIDE BUND WALL AND 600mm RCP

Scale 0 1 2 3 4 5 m 1:100

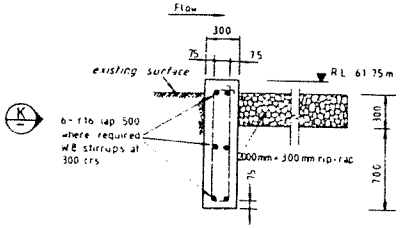


WEIR - TYPICAL SECTION



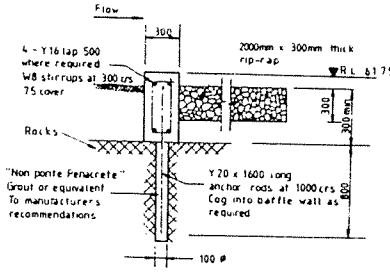
TYPICAL SECTION MATTRESS PROTECTION

N T S



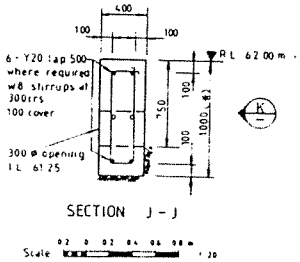
BAFFLE WALL DETAIL
(NON - ROCK FOUNDATION)

Scale 0.2 0 0.2 0.4 0.6 0.8 m 1:20



BAFFLE WALL DETAIL
(ROCK FOUNDATION)

Scale 0.2 0 0.2 0.4 0.6 0.8 m 1:20



SECTION J - J

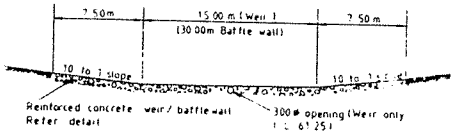
Scale 0.2 0 0.2 0.4 0.6 0.8 m 1:20

* Weir shall have an average depth of 750mm below ground level

NOTES

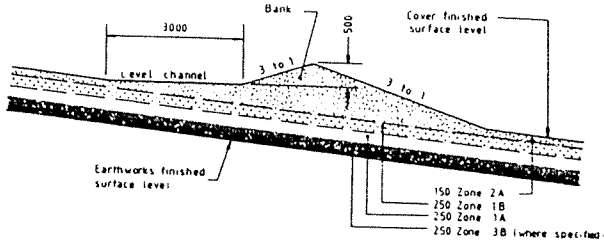
All mattresses shall be PVC coated galvanised wires the undersides of such structures shall be lined with woven geotextile fabric. Mattresses shall be tied to reinforcement prior to casting culvert cut-off walls and concrete apron

LOCATION	WIDTH ... CHANNEL BASE
Outlet of Exit from Whites Open Cut	28.00 mm
Outlet of Exit from Intermediate Open Cut	3000 mm



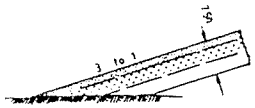
VIEW K

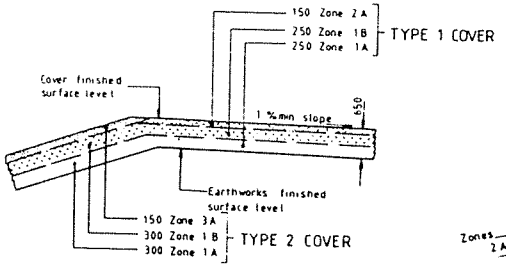
Scale 0 2 4 6 8 m 1:200



EROSION CONTROL DRAIN DETAILS

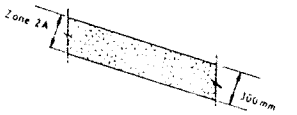
Scale 0.5 0 0.5 1.0 1.5 2.0 m 1:50





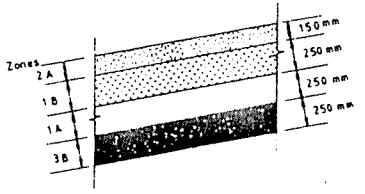
TYPE 1 AND 2 COVERS

N T S



TYPE 3 COVER

N T S



TYPE 5 COVER

N T S

3	Bund wall Material Amended		A H D
			A H G

ASSOCIATED DRAWINGS — AMENDMENTS

Cameron McNamara — Consultants

WATER DIVISION
DEPARTMENT OF TRANSPORT AND WORKS
NORTHERN TERRITORY OF AUSTRALIA

Job no 84-4511 — Drawing no 71110

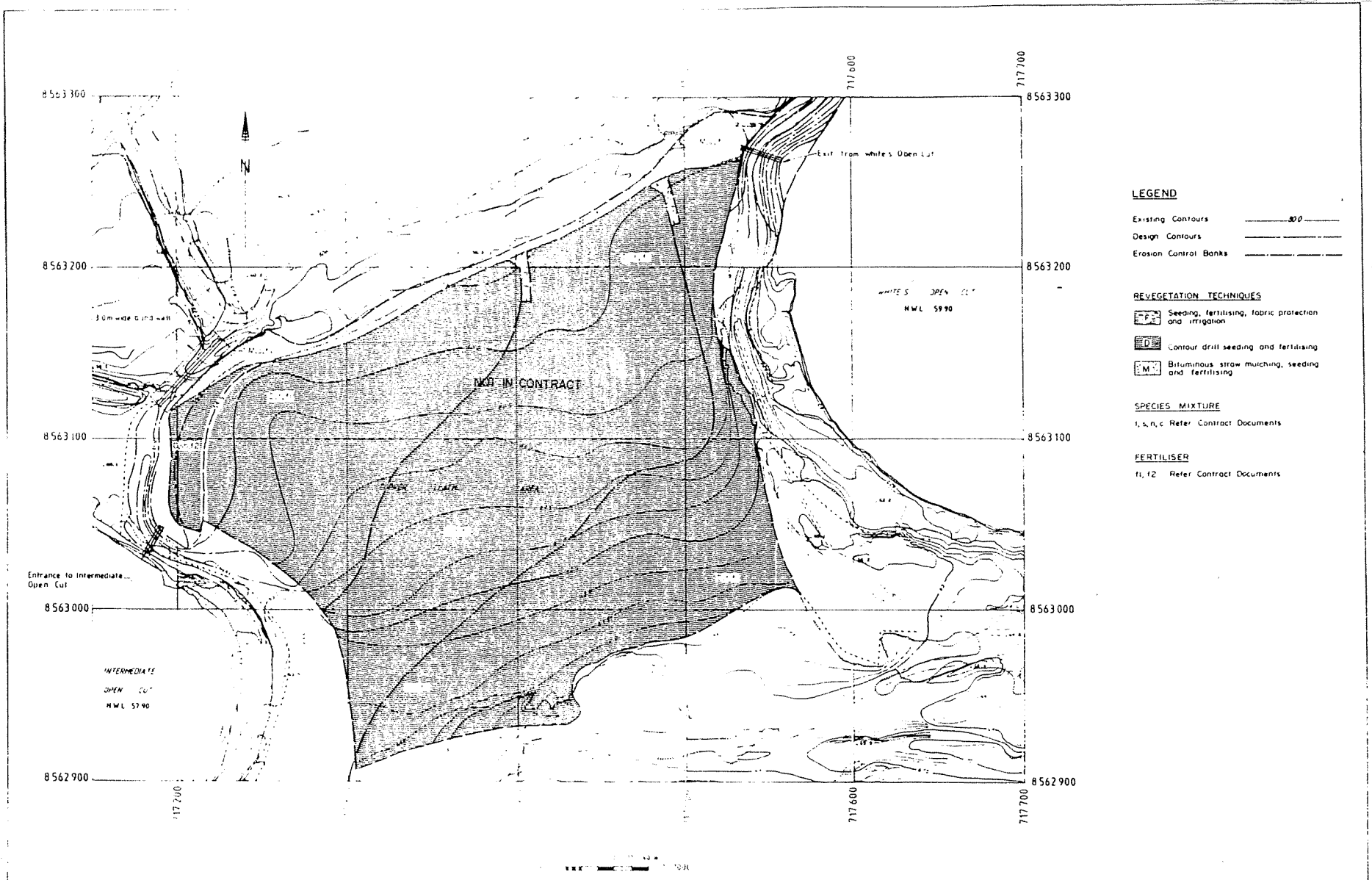
SUB: BRAZERS HOTEL — DES J B 4.85 — DRN B F G 5.85 — CHK J H B 5.85 — PROJECT ENG —

RUM JUNGLE REHABILITATION
STAGE 4 2

TYPICAL SECTIONS AND DETAILS

AS SHOWN

W85-1.01.9



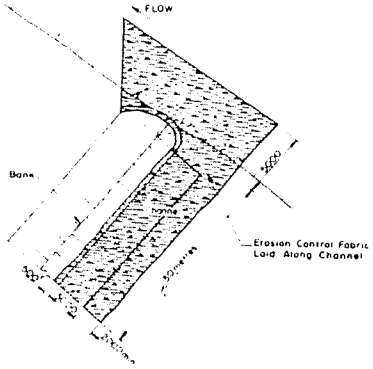
Cameron McNamara

WATER DIVISION
DEPARTMENT OF TRANSPORT AND WORKS

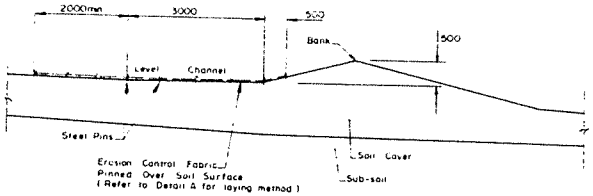
RUM JUNGLE REHABILITATION
STAGE 4 2
COPPER LEACH AREA
REVEGETATION LAYOUT

AS SHOWN

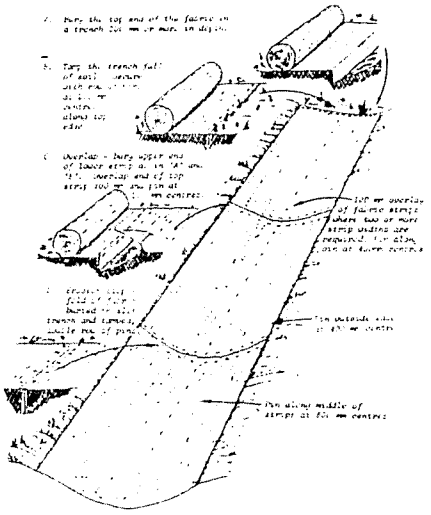
W85-4049
SHEET 12 OF 17 SHEETS



PLAN



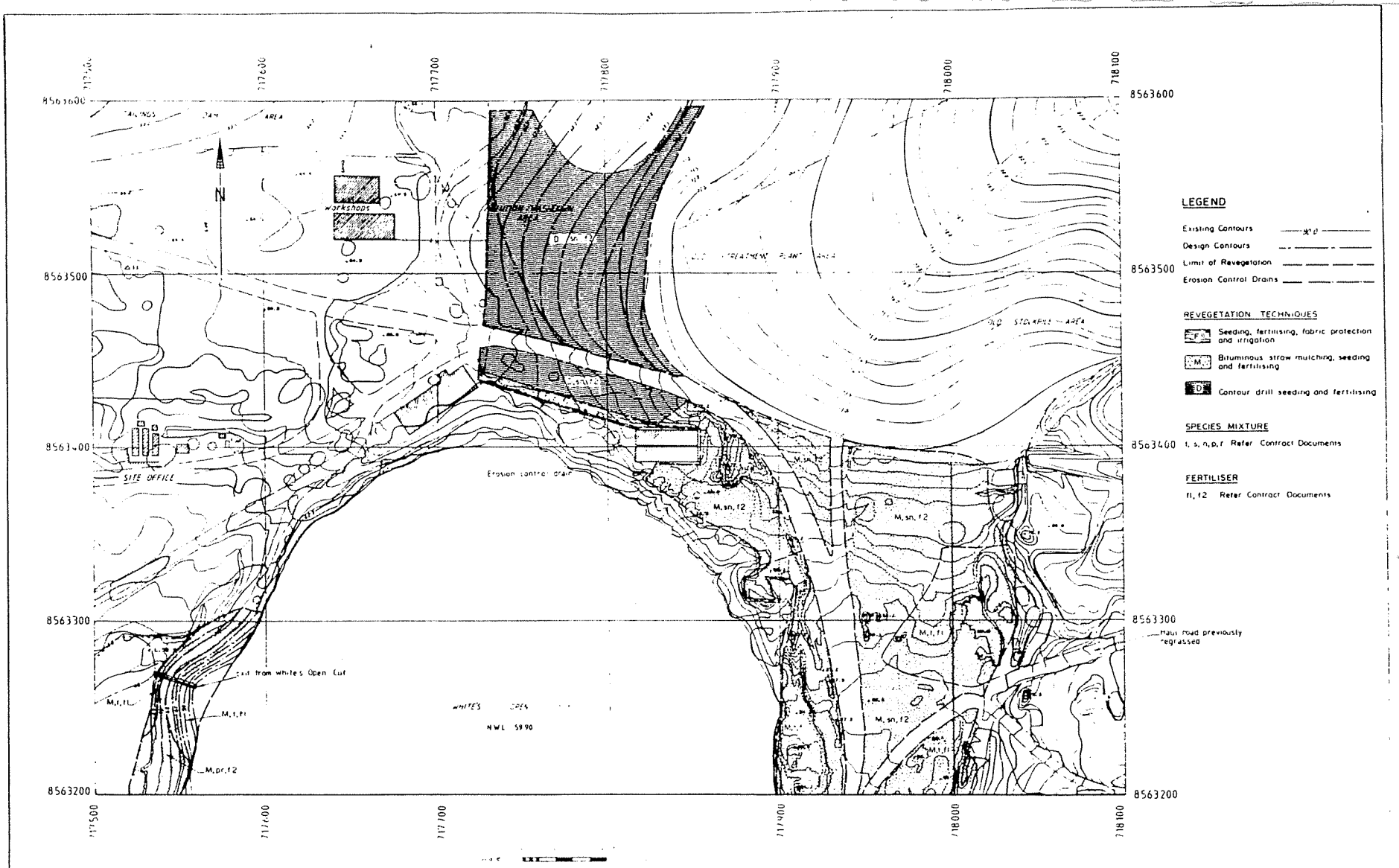
SECTION



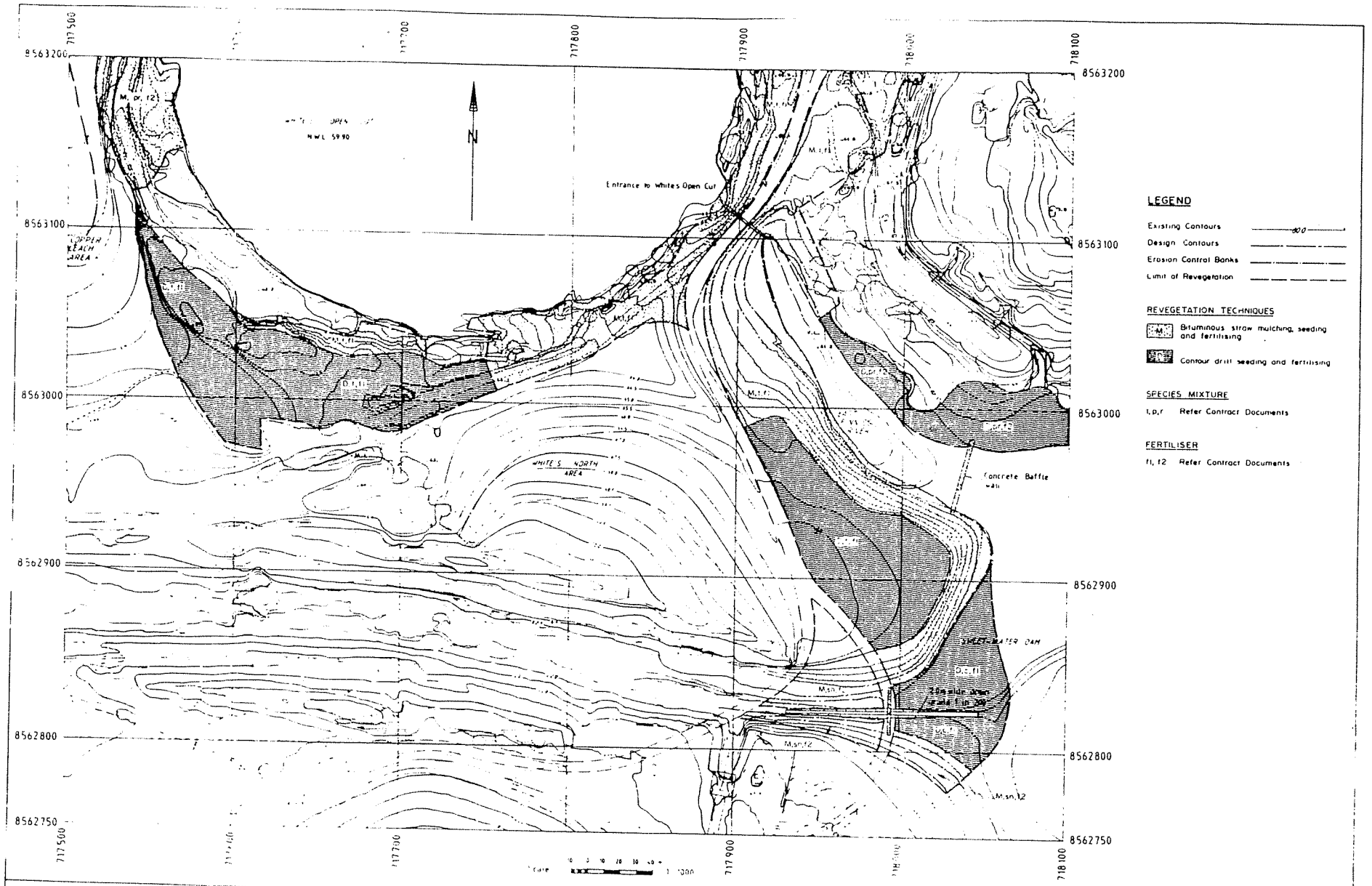
DETAIL A - LAYING EROSION CONTROL FABRIC ALONG DRAINS

TYPICAL LAYING OF EROSION CONTROL FABRIC IN DRAINS

DATUM: VERTICAL AHD; HORIZONTAL AMG	Cameron McNamara	DEPARTMENT OF TRANSPORT AND WORKS, WATER DIVISION	Job No 84-4511	Drawing No 71114	JMP 24.5.85; PAR 30.5.85; BAF 22.5.85	RUM JUNGLE REHABILITATION STAGE 4.2 ABLUTION - WASHDOWN AREA REVEGETATION CROSS SECTION & ... VIEW	SCALE AS SHOWN; W85-4049 ET 13



A H D A M G	Cameron McNamara	WATER DIVISION DEPARTMENT OF TRANSPORT AND WORKS	RUM JUNGLE REHABILITATION STAGE 4.2 ENVIRONS OF WHITE'S OPEN CUT / ABLUTION - WASHDOWN FACILITIES AREA REVEGETATION LAYOUT	AS SHOWN	W85-4049 SHEET 14 OF 17 SHEETS
	84-4511	71115	B A F 22.5.85 I M R 24.5.85 P A R 30.5.85		A1



Cameron McNamara

WATER DIVISION
DEPARTMENT OF TRANSPORT AND WORKS

Job no	Drawing no
84-4511	71116

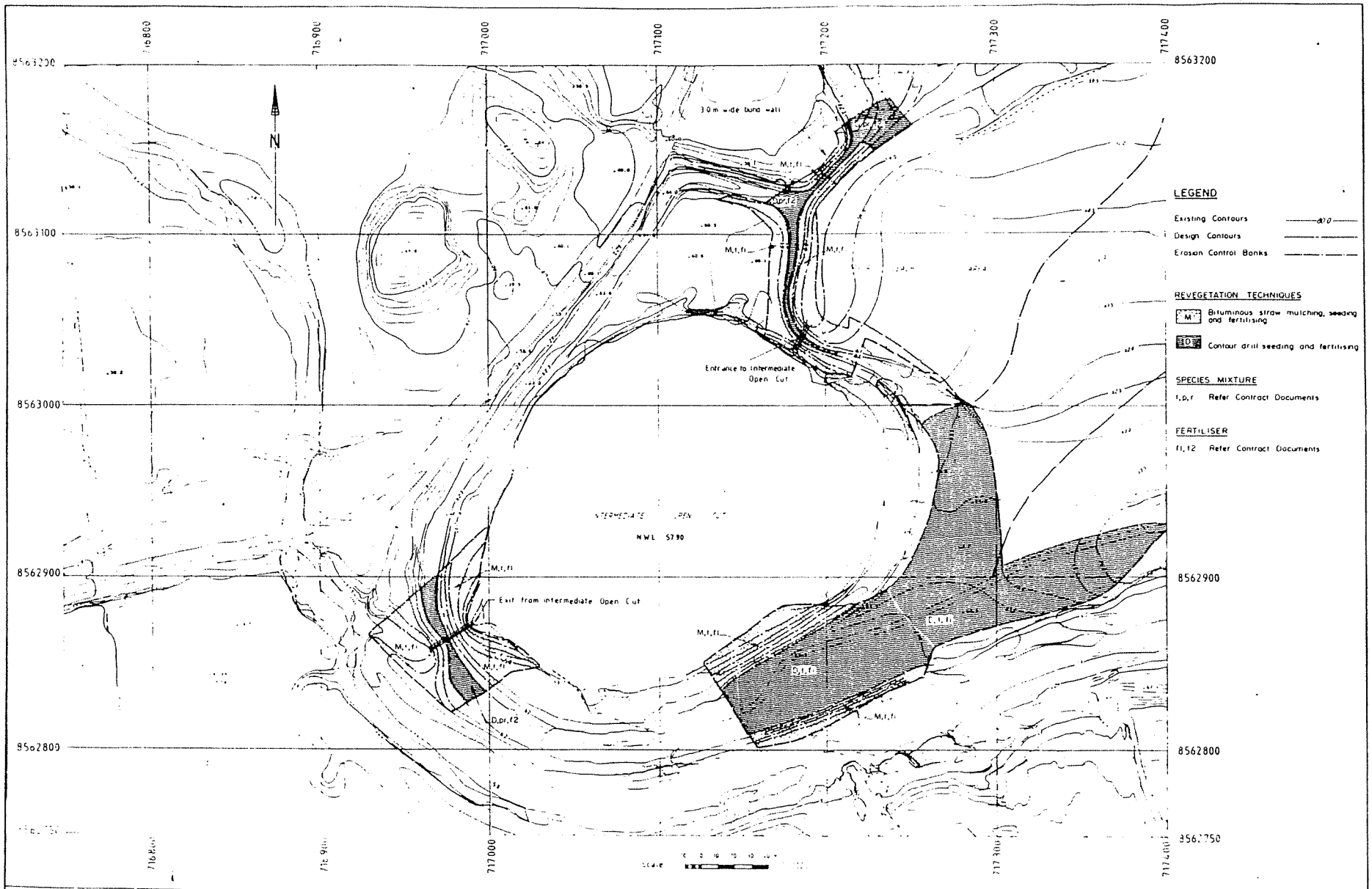
RUM JUNGLE REHABILITATION
STAGE 4.2
ENVIRONS OF WHITE'S OPEN CUT / EAST FINNISS RIVER
REVEGETATION LAY

AS SHOWN

W85-4049

SHEETS

A1



AMD

AMG

Cameron McNamara

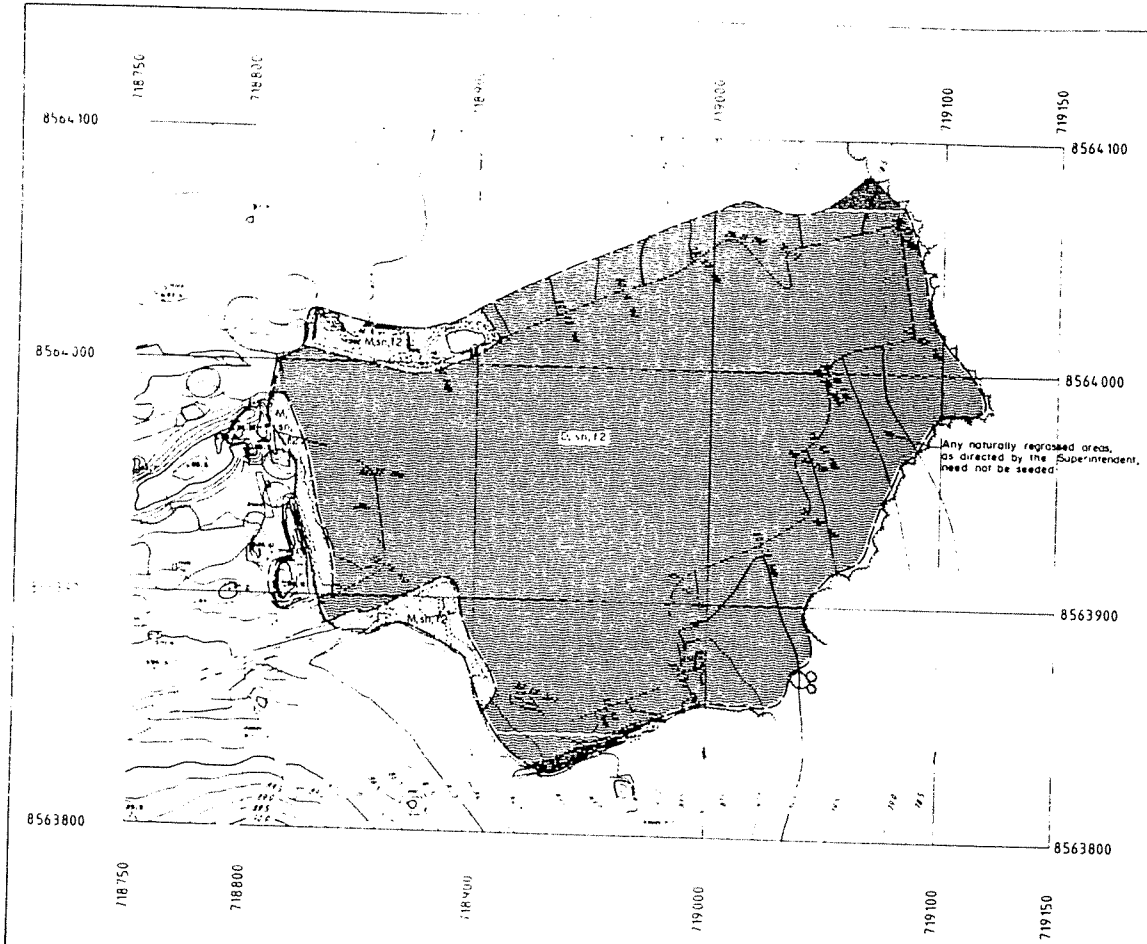
WATER DIVISION
DEPARTMENT OF TRANSPORT AND WORKS

84-4511 | 71117

B.A.F. 27.5.85
J.M.A. 29.5.85
P.A.R. 30.5.85

RUM JUNGLE REHABILITATION
STAGE 4.2
ENVIRONS OF INTERMEDIATE OPEN CUT
REVEGETATION LAYOUT

W85-4049
SHEET 16 OF 17 SHEETS



LEGEND

Existing Contours ——800——

Limit of Revegetation — — — — —

REVEGETATION TECHNIQUES

M Bituminous straw mulching, seeding and fertilising

CD Contour drill seeding and fertilising

SPECIES MIXTURE

s,n Refer Contract Documents

FERTILISER

f2 Refer Contract Documents

Cameron McNamara

71118

WATER DIVISION
DEPARTMENT OF TRANSPORT AND WORKS
NORTHERN TERRITORY OF AUSTRALIA

A. BRAZIER & HOTTI

B A F 27.5.85

J M R 27.5.85

P A R 30.5.85

RUM JUNGLE REHABILITATION
STAGE 4.2
BORROW AREA 5
REVEGETATION LAYOUT

W85-4049

17 OF ETS

Appendix H

Earthworks Statistics

Tabulated in this Appendix are the earthworks physical and financial statistics for the Rum Jungle Project. The financial statistics relate only to the direct cost of carrying out the works and do not include the costs of management of the Project. These management costs amount to approximately 20% of the total costs of the Project. Statistics are summarised in Table H.1, and detailed for each item of the Project in Tables H.2 to H.15.

Table H.1

TOTAL COSTS AND TOTAL AMOUNTS FOR CATEGORY A, EARTHWORKS

Item Description	Amount		Total $	Unit Rate $
Reshaping	1144Ø73	m^3	296Ø337	2.59
Chemicals	56Ø.5	t	56154	1ØØ
1A Covers	172354	m^3	538ØØ7	3.12
1B Covers	276711	m^3	622786	2.25
2A Covers	75741	m^3	237Ø75	3.13
3A Covers (inc.Dys.)	28ØØ4	m^3	28Ø991	9.89
3B Covers (inc.Dys.Filt.)	34355	m^3	127278	3.71
Drainage (Excavation Rip Rap Mattresses Geo Fabric)			694663	
Rock Blanket	46780	m^3	254624	5.44
Finger Drains	8585	m^3	115512	13.46
Gabions	3ØØ	m^3	219Ø5	73.Ø2
Rubble Drains	2141	m^3	8812	4.12
Culverts (Pipes Manholes Subsoil Drains etc.)			413Ø28	
Revegetation	125.9Ø	ha	469512	3729
TOTAL			$68Ø1Ø84	

Table H.2

STATISTICS FOR COPPER HEAP LEACH PILE
(INCLUDES COPPER CREEK)

Item Description	Amount		Total $	Unit Rate $
Reshaping	260850	m^3	471890	1.65
1A Covers	16483	m^3	51656	2.85
1B Covers	16483	m^3	55824	3.08
2A Covers	10015	m^3	33918	3.08
3B Covers	16483	m^3	70686	3.90
Finger Drains	321	m	3827	10.84
Rubble Drains	1939	m	6801	3.19
Revegetation	6.61	ha	4107	565
TOTAL			$698709	

Table H.3

STATISTICS FOR OLD TAILINGS DAM
(INCLUDING TAILINGS CREEK)

Item Description	Amount		Total $	Unit Rate $
Misc. Provisions (inc. Traffic Clearing Grubbing Haul Roads)			316320	
Reshaping	418900	m^3	1899690	4.12
1B Covers	89730	m^3	108354	1.10
Drainage (Excavation Rip Rap Mattresses Geo Fabric)			68362	
Finger Drains	1500	m	15009	9.10
Revegetation	30.9	ha	182731	5378
Liming	256.5	t	26089	92.50
TOTAL			$2300415	

Table H.4

STATISTICS FOR DYSONS OPEN CUT

Item Description	Amount	Total $	Unit Rate $
Reshaping	55ØØØ m^3	21387	Ø.35
1A Covers	1827Ø m^3	26117	1.3Ø
1B Covers	1827Ø m^3	22Ø99	1.1Ø
2A Covers	648Ø m^3	12826	1.8Ø
3A Covers	295Ø m^3	7623	2.35
3B Covers	17516 m^3	17516	5.4Ø
Rock Blanket	46780 m^3	254624	4.95
Drainage (Excavation Rip Rap Mattresses Geo Fabric)		73829	
Finger Drains	66Ø m	3483	4.8Ø
Gabions	28 m^3	1586	51.5Ø
Culverts (Pipes Manholes Subsoil Drains etc.)		219Ø9	
Revegetation	5.11 ha	3Ø219	5378
TOTAL		$493218	

Table H.5

STATISTICS FOR WHITES OPEN CUT

Item Description	Amount	Total $	Unit Rate $
Reshaping		36647	
Drainage (Excavation Rip Rap Mattresses Geo Fabric)		1317	
Culverts (Pipes Manholes Subsoil Drains etc.)		122439	
TOTAL		$16Ø4Ø3	

Table H.6

STATISTICS FOR INTERMEDIATE OPEN CUT

Item Description	Amount	Total $	Unit Rate $
Reshaping		13858	
Drainage		4322	
(Excavation Rip Rap Mattresses Geo Fabric)			
Culverts		12Ø668	
(Pipes Manholes Subsoil Drains etc.)			
TOTAL		$138848	

Table H.7

STATISTICS FOR DYSONS OVERBURDEN HEAP

Item Description	Amount		Total $	Unit Rate $
Reshaping	163ØØ	m^3	32559	1.5Ø
1A Covers	1465Ø	m^3	55991	2.87
1B Covers	1465Ø	m^3	41614	2.11
2A Covers	9496	m^3	36Ø4Ø	2.85
Drainage			81526	
(Excavation Rip Rap Mattresses Geo Fabric)				
Finger Drains	883	m	12747	1Ø.84
Gabions	32	m^3	7288	171.Ø3
Revegetation	6.Ø2	ha	32833	4719
TOTAL			$3Ø5148	

Table H.8

STATISTICS FOR STAGE TWO WHITES OVERBURDEN HEAP

Item Description	Amount		Total $	Unit Rate $
Reshaping	21ØØØØ	m^3	155595	Ø.46
1A Covers	477ØØ	m^3	1Ø7563	1.4Ø
1B Covers	327ØØ	m^3	73738	1.4Ø
2A Covers	182ØØ	m^3	41Ø41	1.4Ø
3A Covers	13ØØ	m^3	37691	1Ø.ØØ
Drainage (Excavation Rip Rap Mattresses Geo Fabric)			2ØØ393	
Finger Drains	121Ø	m	22324	11.45
Culverts (Pipes Manholes Subsoil Drains etc.)	31Ø	m	9437	18.9Ø
Revegetation	255Ø	m^2	1Ø697	2.6Ø
TOTAL			$658461	

Table H.9

STATISTICS FOR COMPLETION OF STAGE TWO WHITES OVERBURDEN HEAP

Item Description	Amount		Total $	Unit Rate $
Reshaping			12546	
1A Covers	29ØØØ	m^3	95121	2.95
1B Covers	42ØØØ	m^3	12ØØ56	2.6Ø
2A Covers	64ØØ	m^3	12821	1.3Ø
3A Covers	19ØØØ	m^3	46Ø74	2.3Ø
Drainage (Excavation Rip Rap Mattresses Geo Fabric)			88726	
Finger Drains	495	m	3653	7.ØØ
Gabions	24Ø	m^3	13Ø31	51.5Ø
Culverts (Pipes Manholes Subsoil Drains etc.)			1Ø5886	
Revegetation	29.78	ha	54769	1745
TOTAL			$552683	

Table H.1Ø

STATISTICS FOR WHITES NORTH HEAP

Item Description	Amount		Total $	Unit Rate $
Reshaping	2.4	ha	3265	516.67
1A Covers	6273	m^3	26720	2.87
1B Covers	6273	m^3	20091	2.16
2A Covers	3528	m^3	14920	2.85
Finger Drains	306	m	4922	10.84
Revegetation	2.53	ha	13823	3681
Liming	48	t	4943	69.40
TOTAL			$88684	

Table H.11

STATISTICS FOR WHITES NORTH

Item Description	Amount		Total $	Unit Rate $
1A Covers	4720	m^3	30145	4.77
1B Covers	4720	m^3	28565	4.52
2A Covers	2781	m^3	16458	4.42
3A Covers	75	m^3	1024	10.20
Finger Drains	108	m	3736	15.50
Revegetation	1.52	ha	6319	3112
TOTAL			$86247	

Table H.12

STATISTICS FOR INTERMEDIATE OVERBURDEN HEAP

Item Description	Amount		Total $	Unit Rate $
Reshaping	123929	m^3	32559	1.5Ø
1A Covers	19657	m^3	77764	2.87
1B Covers	2ØØ13	m^3	67132	2.44
2A Covers	6279	m^3	24627	2.85
3A Covers	5Ø79	m^3	188579	26.98
Drainage			1Ø4281	
(Excavation				
Rip Rap				
Mattresses				
Geo Fabric)				
Finger Drains	627	m	9354	1Ø.84
Revegetation	1Ø.43	ha	297Ø7	2Ø7Ø
Liming	139.5	t	13323	69.4Ø
TOTAL			$676789	

Table H.13

STATISTICS FOR ACID AND SWEETWATER DAMS

Item Description	Amount		Total $	Unit Rate $
Reshaping	24ØØØ	m^3	87169	2.65
Revegetation			1593	
TOTAL			$88762	

Table H.14

STATISTICS FOR OTHER AREAS
(TREATMENT PLANT, STOCKPILE AREA, BORROW PIT 3 AND OTHER AREAS)

Item Description	Amount		Total $	Unit Rate $
Reshaping	13548	m^3	44976	2.40
1A Covers	13217	m^3	5210 4	2.85
1B Covers	23488	m^3	71155	1.74
2A Covers	11432	m^3	35769	2.26
3B Covers	12538	m^3	21679	1.25
Drainage (Excavation Rip Rap Mattresses Geo Fabric)			65722	
Finger Drains	2329	m	34921	10.84
Rubble Drains	202	m	2011	7.20
Culverts (Pipes Manholes Subsoil Drains etc.)			11910	
Revegetation	31.73	ha	91782	2091
Liming	102.5	t	9840	69.40
TOTAL			$441869	

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Table H.15

FURTHER STATISTICS FOR OTHER AREAS

Item Description	Amount		Total $	Unit Rate $
Reshaping			18733	
1A Covers	2384	m^3	15226	4.77
1B Covers	2384	m^3	14428	4.52
2A Covers	1430	m^3	8655	4.52
3B Covers	2384	m^3	17397	5.45
Drainage			6185	
(Excavation				
Rip Rap				
Mattresses				
Geo Fabric)				
Culverts			20779	
(Pipes				
Manholes				
Subsoil Drains				
etc.)				
Revegetation	1.02	ha	5950	4372
Liming	14	t	1959	104.50
TOTAL			$110848	

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